1868

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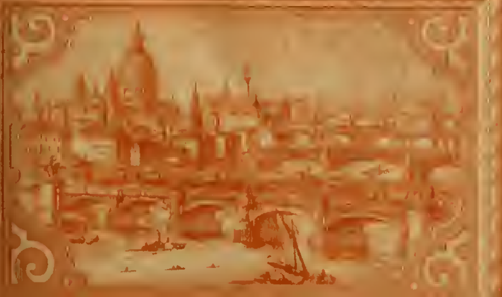
STEAM NAVIGATION SHIP BUILDING AND THE APPLICATION OF CHEMISTRY TO THE INDUSTRIAL ARTS

PUBLISHED MONTHLY.

## A MONTHLY RECORD of the PROGRESS of CIVIL and MECHANICAL ENGINEERING

ESTABLISHED 1843.

EDITED BY
Wm. SMITH, C.E.
F.C.S
F.C.S. F.R.G.S
&c



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# THE ARTIZAN:

## A Monthly Record of the Progress

OF

## CIVIL AND MECHANICAL ENGINEERING,

SHIPBUILDING, STEAM NAVIGATION, THE APPLICATION OF CHEMISTRY
TO THE INDUSTRIAL ARTS,
&c., &c., &c.

EDITED BY W$^{M.}$ SMITH C.E.
F.G.S., F.C.S., F.R.G.S., &c.

VOL. II.
FOURTH SERIES.
VOL. XXVI.
FROM THE COMMENCEMENT.
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# THE ARTIZAN, 1868.

## INDEX TO VOL II., FOURTH SERIES.

*Vol. XXVI. from the Commencement.*

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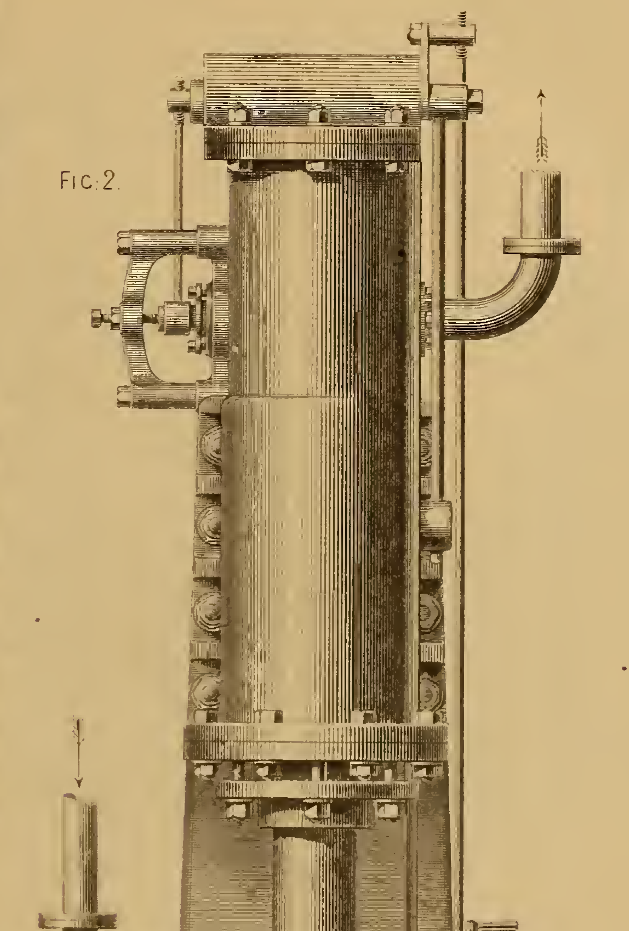
## LIST OF PLATES.

FIG: 2.



# F. BERRY & SONS 10 CWT STEAM HAMMER,

## WITH PATENT SELF ACTING AND HAND MOTIONS.

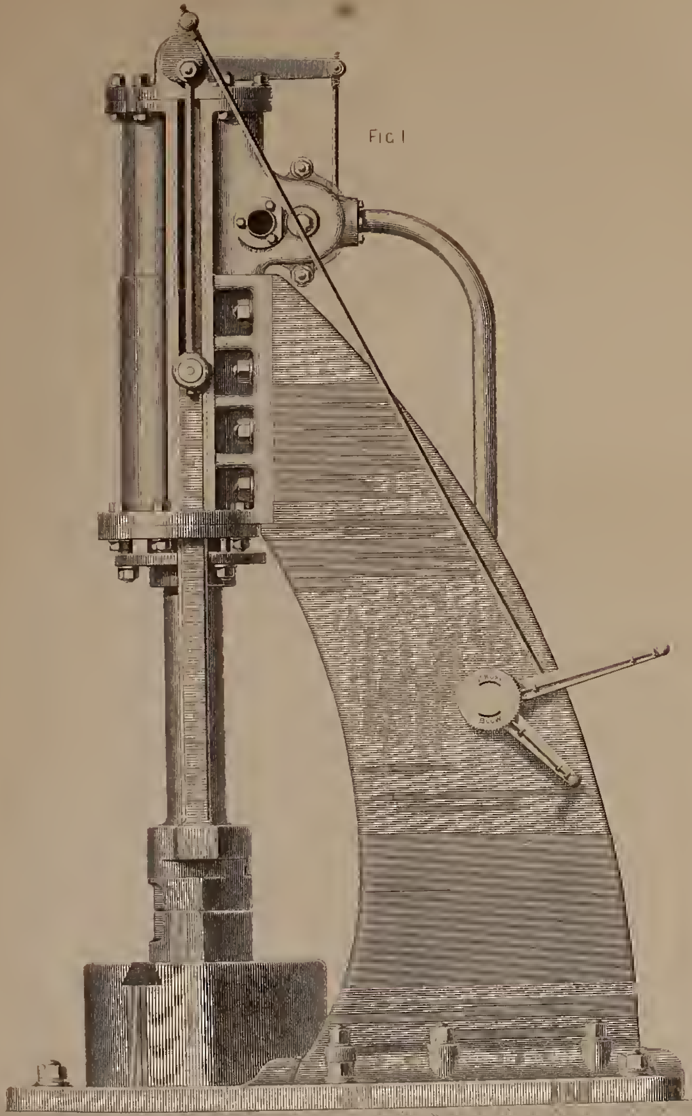


Fig. 1

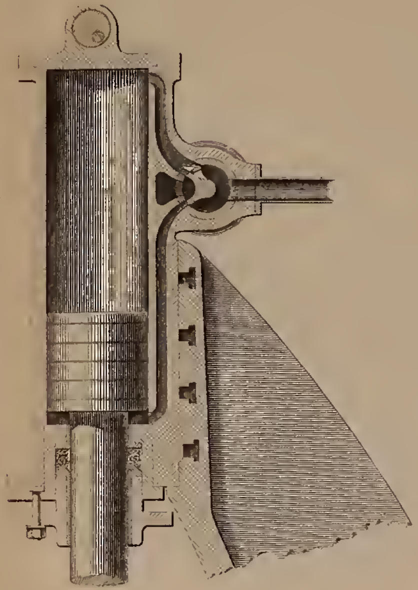


Fig. 4

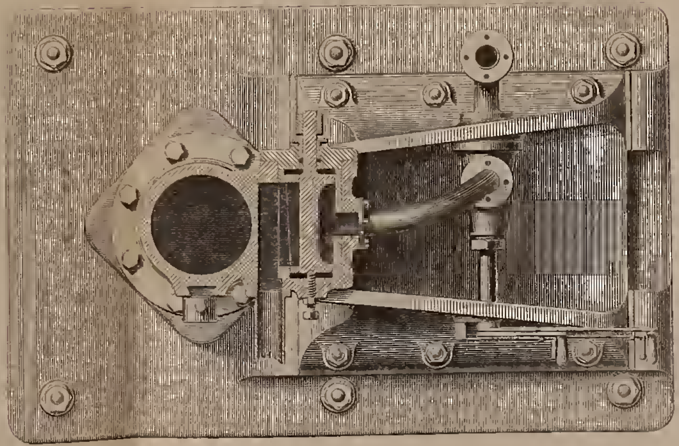


Fig. 3

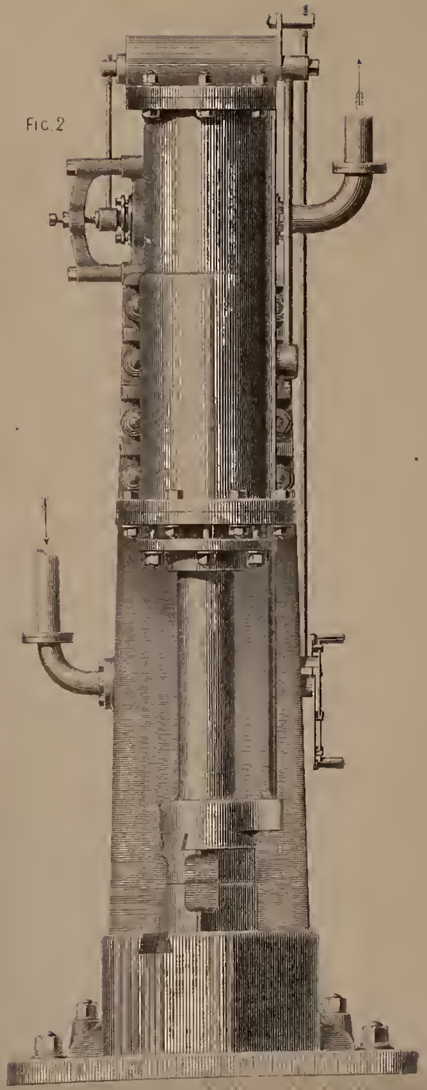


Fig. 2

# THE ARTIZAN.

No. 1.—Vol. II.—Fourth Series.—Vol. XXVI. From the Commencement.

1st. JANUARY, 1868.

## THE "ARTIZAN" ADDRESS, 1868.

The past year, which has completed the quarter of a century during which The Artizan has flourished, has been remarkable for the greatest exhibition of industry the world has ever witnessed, while, at the same time, the depression in all industrial trades has been greater and more universal than has been known for a long period. The almost total stagnation, both in civil and mechanical engineering, has operated as a bar to invention, and, consequently, comparatively few striking novelties have been recorded, the attention of engineers being chiefly devoted to the more economical working of existing machinery. Thus, in marine engineering, the principle of surface condensation has continued to occupy considerable attention, and the system introduced by Mr. Crichton in the Cork Steamship Company's vessel the *Bittern*, which was illustrated in The Artizan of February and March last, was a step in the right direction, as tending to simplify its application. Most modern marine engines are fitted with surface condensers, unless they are only intended for very short voyages, and although in some few instances they have given a great deal of trouble, more especially in the tropics, there is little doubt but that they will continue to be increasingly adopted. Endeavours have also been made to reduce the amount of fuel required by improving the form of the boilers, several examples of which have been given in The Artizan of last year, as, for instance, Lewis's marine boiler, made by Messrs. Walpole, Webb, and Bewley, for the City of Dublin Steam Packet Company, the evaporative power of which proved to be very high. A very favourable specimen of a land boiler, by Messrs. Howard, of Bedford, illustrated in September last, appears to be another considerable advance in the economic generation of steam. Again, in locomotive boilers, considerable economy has resulted in the use of coal in the place of coke, a favourable specimen of a coal-burning furnace, by Messrs. G. England and Co., Hatcham Iron Works, being illustrated in Plate 317. Not only has economy in the consumption of coal been studied, but several plans have been invented with the object of doing away with coals altogether, petroleum and other mineral oils being used as a substitute with varied success; up to the present time, however, it does not seem likely to be extensively adopted in England, whatever may be the case in America.

Every now and then some invention is brought forward which seems to upset all preconceived ideas, an example of which is furnished by Baker's patent anti-incrustator. The reason why this curious invention cleans a dirty boiler, or keeps a new boiler clean, does not seem to be perfectly understood, although it is pretty generally attributed to the action and reaction of positive and negative electricity. Whatever may be the true explanation of its action, there seems to be no doubt, if the various accounts of its perfect action be correct, that, like the Giffard injector, which also puzzled so many scientific men, it will be very extensively adopted.

Amongst the few novelties in engineering during the past ten years may be mentioned Mr. Fell's system of enabling locomotives to work on excessive gradients. It was expected that the railway over the Alpine range would have been a *fait accompli* before this, and, so far as making a successful trip, this has already been recorded in The Artizan of October last, but it seems that the locomotives destined to work the line were entrusted to a French firm to save the duty, and have not come up to Mr. Fell's expectations. Of course these difficulties will very shortly be overcome; but it is to be regretted that any hitch should have occurred in so novel an undertaking, as it tends very much to destroy public confidence. A locomotive engine for this description of work should be above suspicion, as a break-down in any of the difficult parts of the road would probably lead to terrible consequences in itself, and deter the entire travelling community from putting their trust in it for the future. Should it shortly be opened to the public, there is every reason to believe that it will be a success, and, if worked without any bad accidents, will prove a very formidable rival to the Cenis tunnel for the passenger traffic; as few persons, unless time was an important object, would choose to be shot through a tunnel in preference to enjoying the beautiful scenery of the longer route.

In telegraphy but little has been done during the past year, except the successful laying of the submarine cable from Florida to Cuba, thereby bringing the West Indies into direct communication with England. Already it has done important service in bringing news of the now celebrated hurricane in sufficient time to enable the distress occasioned thereby to be promptly alleviated. The Atlantic cables also continue in perfect condition, and absolutely improve in conducting power, while the cost of the transmission of messages is now so moderate as to leave nothing to be desired, and, as a natural consequence, the numbers of telegrams are largely augmented.

The progress of the Suez Canal has already been reported in The Artizan of last October; but since that time a curious incident in its history has occurred, viz., it has been first employed for war purposes by the British Government, a steam tug having been floated through it, which was intended to assist in the Abyssinian war. There was certainly not much to boast of the manner in which the tug was got through; and it is to be feared that, in spite of the immense amount of energy now being expended upon the salt water canal, the time when large vessels can pass through is yet very far in the distance.

The only branch of engineering upon which much money has been spent during the past year has been in the manufacture of war *materiel*. The only addition to our knowledge in this branch, however, seems to be that it is remarkably easy to spend enormous sums of money, and yet have nothing to show for it.

As regards the French Exhibition, most of the subjects relating to engineering have been already noticed in the columns of The Artizan, consequently nothing remains to be said except that, as it was undoubtedly the finest exhibition that has ever taken place, so it is not unlikely to be the last, at least for a considerable period. The expenses to which many manufacturers have gone in preparing for the various exhibitions since 1851, and the annoyances to which many have been subjected, have been so great, that it would be difficult to persuade them again to make similar exertions.

## PATENT SELF-ACTING STEAM HAMMER.

By Francis Berry and Sons, Calderdale Iron Works, Sowerby Bridge, Yorkshire.

(*Illustrated by Plate* 324.)

There is, perhaps, no machine upon which so much ingenuity has been expended during the last ten or a dozen years as the steam hammer, while, at the same time, it has been gradually growing into favour, until few shops are without one or more of these useful tools. One of the principal difficulties to be overcome for the regular working of the machine was the arrangement of the valve gear, and numerous schemes have been devised for this purpose, one of the latest and best of which is the subject of the illustration, Plate 324. It will be seen that in this case the self-acting motion is obtained by an easy sliding action, avoiding all cams or tappets, which are such a constant source of annoyance, from the knocking and jarring occasioned when working fast. The arrangement for working by hand also appears to be very convenient and simple, and, as the self-acting and hand motions are both worked from one lever without disconnecting; any variation in the stroke of the hammer, and thus a short stroke either at the bottom or the top, or a perfectly dead blow, can be given from one and the same lever. The importance and convenience of this arrangement will be immediately appreciated by those who have been accustomed to work steam hammers. Another improvement has been introduced by Messrs. Berry and Sons, in the method of preventing the hammer bar from turning round; this is effected by making the bar connected to the hammer head, and which works the self-acting motion, act also as a guide. This bar, which is firmly fixed to the hammer head, is planed flat, and works in guides fitted to the side of the cylinder, or to suitable projections on the framing, thus obviating the necessity for flattening the piston rod, which always entails so much trouble with the packing. It may also be noticed that the anvil face and hammer head are placed diagonally with the framing, so that the hammer can be worked from all four sides, an arrangement which for general work is extremely convenient. Referring to the Plate (324), Fig. 1 is a side elevation, Fig. 2 a front elevation, and Figs. 3 and 4 sections of the cylinder and valve. It will be seen that the frame or standard has a broad base, which is firmly bolted to a foundation plate. The steam cylinder is tongued and the framing groved, so that when it is bolted on to its place there is no possibility of its moving in a vertical direction. The hammer head is forged solid with the piston rod, and has a lug upon one side of it, into which a flat bar is fitted, and passes up through guides formed on the sides of the cylinder, as shown in Figs. 1 and 2, and thus, as will be easily seen, the hammer head is prevented from turning. The valve motion is also worked by this flat bar, and for this purpose it has an enlargement, or eye, at the upper end, into which is fitted a circular block free to revolve. In this block a hole is drilled to allow the lever which works the valve motion to slide freely through it at whatever angle it may be working, the upper end of this lever being fixed to the weigh shaft lying across the top of the cylinders. Thus, when the upper end of this lever is not in line with the stroke of the hammer, it is gradually forced sideways by the rise of the hammer, and thereby imparts the requisite motion to the weigh shaft. The weigh shaft works in a boss excentric to its axis, this boss working in a bearing cast on the cylinder cover and extending the whole breadth of it. Upon this boss or excentric a crank is formed, which is connected by means of a rod to the hand lever, as shown in Fig. 1; thus the excentricity of the boss may be regulated, and, consequently, the stroke of the hammer controlled. The steam valve, which is worked by the other hand lever, shown in Figs. 1 and 2, is for regulating the admission of steam. The valve levers are shown in the engraving in the position they would assume when the hammer is standing, the axis of the weigh shaft being in a line with the centre of the cylinder and, consequently, no motion can be given to the valve. By shifting the excentric boss by means of the hand lever, as described above, the weigh shaft is moved out of line with the cylinder, and the requisite valve motion is then imparted by the flat guide rod connected to the hammer head; the same motion also opens the valve to the bottom side of the piston. By regulating the amount of excentricity of the weigh shaft, the length of the stroke of the hammer is controlled; the greater the excentricity the shorter the stroke. The hand motion may be worked when required, similarly to the ordinary hand-worked hammer, and a single dead blow can be given. The steam valve, which is shown in section Fig. 4 and in plan Fig 3, is conical, having a double port for the top side, and is adjustable in its seat by means of centre screws shown in Figs. 2 and 3. From the above description it will be seen that all the requisite motions, either self-acting or hand, can be given with the greatest facility, and that the travel of the hammer and the strength of the blow is perfectly under control in either case.

## HOLT'S PATENT MARINE BOILER.

(*Illustrated by Plate* 325.)

The form and internal arrangement of steam boilers seem to be capable of endless variety. Within the last few months two descriptions of boiler have been illustrated in The Artizan, viz., Messrs. Walpole, Webb, and Bewley's, with its undulating flues, and Messrs. Howard's extraordinary production, which threatens to upset all preconceived notions as to what a boiler should be like. Another peculiar-looking boiler is now illustrated in Plate 325, the invention of Mr. Thomas Holt, of Trieste, and which has been designed for the purpose of obtaining the greatest possible amount of effecting heating surface in a given sized boiler. Upon referring to the Plate (325), it will be seen that the boiler is of the sheet surface type. This system has now been tried for many years by the Peninsular and Oriental Company, and others, and its durability thoroughly established; it has, however, been generally considered as rather an expensive description of boiler to manufacture. In endeavouring to overcome this objection, Mr. Holt has shown considerable ingenuity, and his various methods of fitting the sheet surfaces together, and building up the boiler, exhibit a thorough practical acquaintance with boiler making. Thus, by stepping the sheet surfaces, or placing each one a little further out than the one next to it, no difficulty is experienced in getting at the rivet heads when riveting them together, or in performing any repairs that may at any time be necessary. The staying of the sheet surfaces is also very simple, a few plain flat bars being laid between them at the required distance apart; these distances may at any time be varied should it be found desirable to alter the pressure of the steam, or, in consequence of the plates becoming thin, it is necessary to increase the stays. In some cases the sheet surfaces are made to stay themselves by bulging out the plates at certain points, as at A in the woodcuts, Figs. 1 and 3, sufficiently to bear against one another at those points; or they may be slightly hollowed, and balls fitted between them, as shown at B, Fig. 2. Another novelty is the arrangement of the sheet surfaces at an angle, so that the steam can escape freely, and the deposit is allowed to fall to the bottom of the boiler, while at the same time a very effective heating surface is obtained. At first sight it might be considered objectionable to have the sheet surfaces so close as those shown in the Plate (325), as being liable to choke up with deposit, but such has not been found to be the case in experience. One invention may frequently be assisted by another; and thus Baker's patent anti-incrustator might be applied to these boilers, when, if all that is said respecting the merits of that curious invention be correct, there need be no more fear of injury upon that account.

Upon referring to the woodcuts, it will be easily seen how Mr. Holt fits together the sheet surfaces, and but little explanation will be necessary. Fig. 1 shows the mode of lapping the bottom plates C, so as to get a flush surface for riveting and caulking when fixed in the boiler. The sheet surfaces are also shown shaped outwards, at D, so that, when put together, these elevations meet one another, and form a flame bridge, as shown in the Plate (325). Fig. 4 shows a very simple method of forming the sheet surfaces; each plate has one end shaped and the other end plain, when, by turning them end for end, the requisite space is obtained, with only half the amount of furnace work—a most important consideration as regards the expense.

FIG. 1.

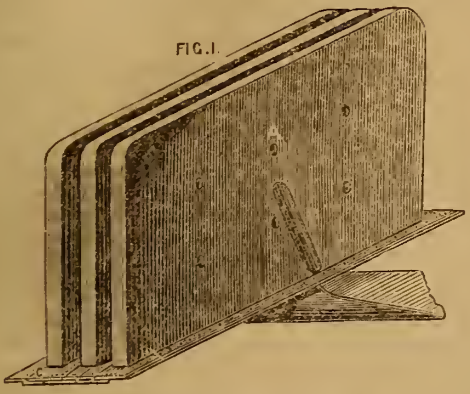


FIG. 2.

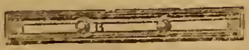


FIG. 3.

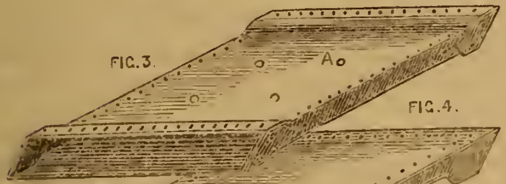
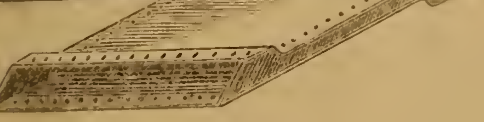


FIG. 4.



The evaporative power of these boilers appears to be very great, a very large proportion of the heat being abstracted, the temperature of the heated products of combustion passing to the chimney being only about 350°, a result no doubt due to the enormous amount of heating surface in this form of boiler.

In April last the Imperial Board of Admiralty of the Austrian Government appointed commissioners to test one of the steam boilers made upon Mr. Holt's patent, with the following results:—

| Date. | Length of Trial. | Consumption of Fuel. | Fuel used. | Quantity of Water evaporated. | Temperature of Feed Water. | Height of Water in Boiler. | Pressure. | Results. |
|---|---|---|---|---|---|---|---|---|
| | h. m. | lbs. | | c. ft. | Fhr. | Ins. | Lbs. | |
| April 24, 1867. | 15 00 | 802·75 | Cardiff. | 163·50 | 122 | 6·22 | 18·5 | 1 cubic foot of water evaporated by 19 lbs. of coal, or 1lb of coal evaporated 12·75lbs. of water |
| April 27, 1867. | 9 35 | 370·51 | Cardiff. | 70·37 | 68 | 6·22 | 18·52 | 1 cubic foot of water evaporated by 5·26 lbs. of coal, or 1lb. of coal evaporated 11·88lbs. of water. |

From this it will be seen that a cubic foot of water was evaporated by about 5lbs. of Welsh coal, a result rarely, if ever before, attained. An idea of the enormous amount of heating surface obtained by this system may be derived from the comparison of a marine tubular boiler with one of Mr. Holt's of a similar horse power, in which he shows that he obtains two-and-a-half times more than is usually allowed for that description of boiler.

## MINERAL OILS AND THEIR APPLICATIONS

In The Artizan of July last, we devoted an article to the important subject of the economical production of mineral and manufactured oils, referring more particularly to the process of distillation patented and experimentally worked by Mr. Chas. McBeath.

The subject of mineral and manufactured oils was very ably dwelt upon the other day by Dr. Francis H. Thomson, the President of the Philosophical Society of Glasgow, in the course of his introductory address to the members. We append a considerable portion of this part of the address, as it includes much valuable information as to what has been written and done in connection with mineral oils and their applications.

The subject of mineral and manufactured oils has now become one of great commercial importance, and it may not be out of place to spend a short time in considering its bearing on the future, and tracing the rise and progress of this new phase of scientific industry. In 1847 Dr. Lyon Playfair turned his attention to the artificial production of petroleum, or rock oil; but we owe the working out of the problem to our distinguished townsman, Mr. Young, who, after many years of patient and industrious experiments, elicited results astonishing from their magnitude and general utility. It is not my intention to trace the various struggles which have eventuated in this well-deserved success of Mr. Young, or to enter upon a description of his process of production; but it may be interesting to you if I put, in a condensed form, some statistics showing the importance of the trade, and add some information as to the qualities of this oil as a fuel. Although the introduction of the mineral oils of America has caused not a little damage to the producers in this country, and reduced the prices even below working expenses, insomuch that, with very few exceptions, our Scotch makers have been virtually put out of the field, yet, as time goes on, the sources in America will, in all probability, be lessened if not exhausted, whilst our shale is comparatively inexhaustible. The consumption of these oils in all probability must very much increase, for we are yet in the infancy of their utilisation. Add to this the increasing demand in America, and all over Europe, for the better class of refined oils—a demand which, for the present, is throwing into this country, to compete with our own products, much of the inferior inflammable oils, at such prices as to render competition impossible. Already the supply of the mineral oils of America has begun to fall off. In 1866 the production outstripped the consumption by 6,000 barrels of crude oil per day; whereas in 1867 the consumption exceeds the production by 7,000 barrels per day. In further proof of the importance of this material, it may be stated that during the last five years the annual yield of the American oil springs has been upwards of 500,000,000 gallons, averaging from 1s. 5d. to 1s. 6d. per gallon. Of late much attention has been drawn to the danger arising from the importation of the low class and highly inflammable mineral oils, and with regard to which the Americans have found it necessary to pass an act of a very stringent nature, as follows:—" And be it further enacted, that no person shall mix for sale naphtha and illuminating oils, or shall knowingly sell or keep for sale, or offer for sale, oil, made from petroleum, for illuminating purposes, at less temperature or fire test than 110° Fahr.; and any person so doing shall be held guilty of a misdemeanour, and on conviction thereof by indictment in any court of the United States, having competent jurisdiction, shall be punished by fine of not less than 100 dollars, or more than 500 dollars, and by imprisonment for a term of not less than six months or more than three years."

One result of this enactment has been to throw into this country those base unsaleable oils which are useless in America; and if we would avoid such a calamity as lately occurred at Bordeaux, where more than thirty persons were blown up by an oil explosion, with serious loss of life, we ought to urge upon Government the necessity of a stern restrictive enactment: for if we except the abortive Act of 1862, fixing the firing point at 100°, the honest trader in this country is totally unprotected. I believe that Government have had their attention drawn to this point, and it is hoped that ere long decided action will be taken. The oils made in this country, as also the American refined oils, invariably stand the test of 100°, and if we are to ensure safety, we cannot be satisfied with less. Insurance companies should see to this as a matter of self-protection: for in innumerable instances unknown risks are ignorantly taken, where false representations have been used as to quality, and when explosive oils have been substituted; and in this country, not less than on the other side of the Atlantic, it is well understood that a careful inspection of storage and sale of petroleum is absolutely required. A word or two further in illustration of the extent to which oil refining has been carried in this country. The refineries of Great Britain turn out something like 500,000 barrels in a year. In Scotland last year we had twelve refineries, whose production was 5,000 barrels weekly, but in 1867 the output amounted to only 1,500 barrels per week. Wales at the same date turned out 6,000 weekly, but reduced it to 1,000; and at this date, as before stated most of the Scotch refineries are at a standstill, waiting the tide of events. Unfortunately the parties who invested capital may not derive the benefit of any prosperity which may arise; but I believe the day is not far distant when, Phœnix-like, they will revive and lend their aid in fulfilling the destiny of this material, which ultimately has a mighty service to perform in supplementing our failing supplies of fuel. But before going into this question, we may refer shortly to one of the results of the distillation of these oils—that of paraffine, the solidified hydro-carbon—and here again we owe to Mr. Young the practical illustration of this comparatively new illuminating power. So far back as 1830, Baron Reichenbach exhibited to the German Association of Naturalists at Hamburg the first specimen of paraffine, and for some years he continued his experiments upon various vegetable oils, but found the quantity so small as to be non-remunerative. In the Exhibition of 1851, one paraffine candle was exhibited. In 1862, a pretty large block was shown; but Mr. Young, who was determined not to do things by halves, produced in the Dublin Exhibition a solid block weighing upwards of half a ton; and its purity was demonstrated by its freedom from colour, odour, and taste, and its beautifully translucent appearance. Paraffine candles now compete with the lowest class of tallow candles; and this may be easily understood from the fact that for each ton of oil refined, 32 lbs of paraffine is obtained. In almost every village paraffine candles can now be bought. Mr. Edward Franklin, in a lecture delivered at the Royal Institution "On Artificial Illumination," states that "illuminating equivalents, or the quantities of the different illuminating materials necessary to produce the same amount of light," are as follows:—

| | | |
|---|---|---|
| Young's paraffine oil ... ... ... ... | 1 | gallon. |
| American petroleum No. 1 ... ... ... | 1·26 | ,, |
| American petroleum No. 2 ... ... ... | 1·30 | ,, |
| Paraffine candles ... ... ... ... ... | 18·6 | lbs. |
| Sperm ... ... ... ... ... ... | 22·9 | ,, |
| Wax ... ... ... ... ... ... | 26·4 | ,, |
| Stearine ... ... ... ... ... ... | 27·6 | ,, |
| Composite ... ... ... ... ... .. | 29·5 | ,, |
| Tallow ... ... ... ... ... ... | 36 | ,, |

A curious statistical return, connected with the utilisation of these oils for illuminating purposes, occurs in the report connected with the industrial history of Birmingham, prepared by the Local Industries Committee of the British Association in Birmingham, 1865:—"In 1860 a lamp manufacturer produced in one year 247,431 lamps for the consumption of oil manufactured by Mr. Young. In 1861 the same manufacturer was producing at the rate of 1,200 per day, or 375,000 per annum. At the first introduction of paraffine oil these lamps were produced by Scotch houses engaged in the brass foundry trade; but in 1861 the trade was introduced into Birmingham by four lamp manufacturers. To these a new establishment was added, and the smaller manufacturers turned their attention to the production of burners. The Birmingham production of paraffine burners reaches 500,000 annually."

### HYDRO-CARBON AS FUEL.

Of late attention has been drawn to the probability of utilising the hydro-carbons as fuel, and as this is a matter of great practical moment, I shall mention some facts to illustrate to what extent experiments have been made, and with what results. Government in 1856 ordered certain experiat Woodwich Dockyard, with the view of testing the value of petroleum and shale oil, as a substitute for coal in raising steam in marine boilers. The experiments were carried out extensively by Mr. Richardson, upon American petroleum. English coal oil and shale oil, Burslem oil, and Torbane Hill mineral oil. Fifteen separate experiments were made, the duration of which varied from 2 hours 25 minutes to 10 hours 20 minutes. The total weight of oil used for getting up steam was 491lbs., and 4,755 for the whole experiments. Taking the average of the whole experiments, it appears that 13.2lbs. of water were evaporated per lb. of oil. The lowest results of the series were those given on two consecutive days by a mixture of American oil and coal oil once run, burned in three furnaces. On the 1st day 7.77lbs. of water were evaporated per lb. of this mixture, and on the second day 7·14 lbs. of water per lb., a result lower than that obtained from coal burned in the ordinary way. The result of these experiments was not very satisfactory, the combustion having been imperfect. The report gives a detailed description of each experiment, which although interesting enough in themselves, do not seem to have been very successful; but, on the whole, the experimenter seems to give the preference to the Torbane Hill mineral oil and Burslem oil, which evaporated the water at the rate of 18.38 lbs. per lb. of oil. The smoke was very moderate, and the tubes at the conclusion of each experiment were tolerably clean. The report concludes that the experiments, so far as they have gone, may be regarded as of considerable value, as showing the great evaporative power of these oils, and the practicability of their utilisation. In an economic point of view, there may be some doubts of the value of this application. At the present price of petroleum oils, it is not easy to suppose that any considerable saving could be effected; and so far Mr. Richardson's experiments, which, however, are only initiatory, do not promise much. But various parties are now turning their attention to this important subject, and certain experiments which were instituted by Mr. Barff, have resulted in the formation of a limited company in London, called Sim & Barff's Patent Mineral Oil Steam Fuel Company; and they introduce themselves by stating that they have taken out a patent for utilising the lighting and heating properties of petroleum, tar, oil, naphthaline, and other heavy inexplosive hydro-carbons that have hitherto been comparatively useless on account of the difficulty experienced in combining with them, at the burning point, sufficient air to cause perfect combustion. Some idea may be formed of the commercial value of the lighting and heating properties of these heavy oils, from their possessing three times the evaporating power of coal, requiring much less space for stowage, and thus effecting a great saving in labour. On this account Messrs. Sim & Barff affirm that these oils are doubtless destined to form the marine steam fuel of the future. They add that by their process no alterations of existing furnace arrangements are required.

In the *Times* of January 28, 1867, there was an elaborate report by Professor Bloxham upon experiments which were made at Messrs. Jackson and Watkins', Millwall, by the patentees; and although too extended to be more than alluded to in this notice, the results are satisfactory. He concludes by saying—"The boiler tested at Millwall was a return flue boiler, and, although of unfavourable proportions, some good results were obtained. With the boiler three parts filled, the pressure-guage indicated 25lbs.; in three minutes it was 30lbs., the safety-valve being eased at this pressure. With all these disadvantages to contend with, the gentlemen present expressed their complete satisfaction with the results; and, as a company has been already formed to work this patent, one looks with interest to the result of their future trials." The same gentlemen have also practically carried out a patent by J. Kidd for using the dead oil of tar, or any dead oil, for carburating the common coal gas. Mr. Barff writes me, stating that the gas engineer of the London and North-Western has reported upon it, and the company is to have the lighting of the departure platform of the Euston Station. A train of twelve carriages is at present running on the North-London between Broad-street and Chalk-farm, six of them lighted by Sim and Barff's process, the others working a patent by Professor Blagden. The latter gentleman uses, however, an explosive oil, which passes over the bag in which the gas is kept in the guard's van, whilst the others use essentially dead oils, which, for safety and economy, seem to carry the day. It may be interesting to devote a minute or two to the peculiar qualities of these oils, in combination with carburetted hydrogen, for lighting purposes, and to note some of the results which emerge in an economic point of view. The patentees state that one foot of coal gas will absorb from 20 to 30 grains of the oil, by which its illuminating power is increased upwards of 400 per cent. Thus, 1,000 cubic feet of coal gas, costing 4s 6d,, will absorb five pints of the prepared oil, costing about 11d.—total cost, say 5s. 6d. It will then give out an illuminating power equal to 5,000 cubic feet of gas, which costs 22s. 6d.

In the metropolis there are 45,000 public lamps, on which an immense yearly saving might be effected by the application of Kidd's process, as employed by Messrs. Sim and Barff. In proof of this, each street lamp in London and its vicinity is computed to consume five cubic feet of gas per hour, the average time of burning being twelve out of the twenty-four hours. Thus each lamp consumes 60 cubic feet of gas per night, which is equivalent to 22,000 feet per annum. The ordinary cost of gas for street lamps being, as before stated, 4s. 6d. per 1,000 cubic feet, and the average annual consumption being 22,000 cubic feet, this brings the annual cost of each street lamp to £4 19s.; whilst by the application of the carburator the expense is reduced to £2 7s., effecting a saving on each lamp of £2 12s., and giving a light 200 per cent. greater. Again, Messrs. George Miller and Co., of Rumford-street, have interested themselves to some extent in the question of the application of oil as fuel, and have now working a large furnace used in heating a steam boiler, heated entirely by the application of tar oil, the refuse of gasworks, and steam.

Many people have been working at this question; and, amongst others, Mr. Swan, of Edinburgh, has taken out a patent for a combination of hot air and petroleum, to be used in the smelting and forging of iron, and is about to carry out extensive experiments in the blast furnace. His experiments are interesting, as showing the importance of steam or air, in combination with these oils, to effect perfect combustion. He states that, in using the oil alone, a thick deposit was thrown down, and little heat obtained; but when the hot air was used in combination, little or no smoke was evolved, and an intense heat was got up at once. Again, Sir James Simpson, of Edinburgh, lately applied for a patent for improvements in the utilising of mineral oil and other oils for the production of heat, and for illuminating purposes. He claims the use of either steam or air forced through tubes, by blowing apparatus, the object being to break the jet of oil into minute spray, to facilitate ignition. The patent has not been proceeded with, in consequence, I presume, of the other patentees having forestalled him. The exact amount of saving, and the quantity of steam or air required for absolute combustion, has not yet been quite ascertained; but much has been done, proving that the right path has been entered upon, and the subject is in itself of sufficient importance to invite our attention.

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## AMERICA.

### DIMENSIONS OF STEAMERS "GREAT REPUBLIC" AND "CHINA," BELONGING TO THE PACIFIC MAIL STEAM SHIP COMPANY.

*Designed and directed by Wm. W. Vanderbilt, Chief Engineer of the Company. Hulls built by Henry Steers, and Engines by Novelty Iron Works, New York.*

Length on deck, 373ft.; ditto at load line, 360ft.; ditto for tonnage, 360ft.; breadth of beam, 47·4ft.; depth of hold to tonnage deck, 22·8ft.; depth of hold to spar deck, 30·7ft.; area of immersed section at load draft at 19ft., 875 square feet; hull, 2,400·37 tons; above tonnage deck, 1,481·46 tons; displacement at 19ft. 3in., 5,425 tons; co-efficient of displacement, ·594; description of engine, vertical overhead beam; description of boilers, return fire tubular; diameter of cylinders, 105in.; length of stroke, 12ft.; diameter of water wheel over boards, 40ft.; length of wheel blades, 12ft.; depth of wheel blades, 2ft.; number of wheel blades, 34; number of boilers, 4; length of boilers, 11ft. 6in.; breadth of boilers, 24ft.; height of boilers, exclusive of steam chest, 12ft.; number of furnaces, six in each; breadth of furnaces, 3ft. 4in.; length of grate bars, 7ft.; number of tubes above, 594; internal diameter of tubes, 3in; length of tubes, 7ft.; diameter of smoke pipe, 10ft.; height of smoke pipe from grates, 60ft.; draught, light, 14ft. 6in.; draught, loaded, 19ft.; date of trial, 1867; heating surface (fire and tube), 16656 square feet; consumption of fuel per hour at ordinary speed, 1¼ tons to 1½ tons; maximum pressure of steam, 20lbs.; point of cutting off, average 2ft. 6in.; grate surface, 560 square feet; maximum revolutions at above pressure, 15; speed in knots ordinary, 10; speed in knots maximum, 15; weight of engines, 400 tons; weight of engine frame and keelson, 100 tons; weight of boilers, 250 tons; weight of boilers with water, 350 tons; weight of coal bunkers, &c., 50 tons; frames molded 20in., sided 18in.; 36in. apart from centres, and strapped with diagonal and double laid braces 5in. by ⅞in. inside, and single strapped outside of frame; depth of keel, 6in.; independent steam, fire, and bilge pumps, 4; masts, 3; rig, barque; number of bulkheads, 3; intended service, San Francisco to China; remarks—saloon cabin and mess room upon deck; water wheel guards fore and aft; stowage—cargo, 2,500 tons measurement, or 1,500 tons in weight; passengers, 1,250; launching draft, 9ft. 8½in., equals 2,120 tons; weight of hull complete, 2700 tons.

### DIMENSIONS OF STEAMER "CAMBRIDGE."

*Owners, J. P. Sanford and others. Hull built by John Englis and Son, and engine by Morgan Iron Works, New York.*

Length on deck, 250ft.; length on deck for tonnage, 248ft; length on deck at load line, 247ft.; breadth of beam, 37ft.; depth of hold, 13ft.; depth of hold to spar deck, 13ft.; area of immersed section at load draft of 8ft., 265 square feet; hull, 735·31ft.; above tonnage deck, 601·96ft.; displacement at 8ft. draft, 950 tons; description of engine, vertical overhead beam; description of boilers, return flue; diameter of cylinder, 60in.; length of stroke, 11ft.; diameter of water wheel over boards, 35ft.; length of wheel blades, 8ft.; depth of wheel blades, 2ft. 6in.; number of wheel blades, 28; number of boilers, 2; length of boilers, 30ft.; breadth of boilers, 10ft. 6in.; height of boilers, exclusive of steam chest, 9ft. 6in.; number of furnaces, 2 in each; breadth of furnaces, 4ft. 7in.; length of grate bars, 7ft. 6in.; number of flues above, 16; number of flues below, 10; internal diameter of flues above, 9¼in.; internal diameter of flues below, four of 14in., two of 16in., two of 13in., and two of 11in.; length of tubes above, 22ft. 11in.; length of flues below, 15ft. 9in.; diameter of smoke pipe, 5ft. 6in.; height of smoke pipe above grates, 60ft.; draught, 8ft.; date of trial, July, 1867; heating surface, 3,760ft.; maximum pressure of steam, 35lbs.; point of cutting off, one-half; maximum revolutions at above pressure, 17; frames molded 15ins., sided 7ins., 24ins. apart from centres, and strapped with diagonal and double laid braces 4in. by ½in.; depth of keel, 9in.; independent steam, fire, and bilge pumps, 1; masts, 2; rig, schooner, number of bulkheads, 2; intended service, Portland to Bangor, Maine: remarks—water wheel guards fore and aft, saloon cabin upon deck; passengers, 250; cargo, 250 tons in weight.

### Table containing the Data and Results of two Round Voyages of the Pacific Mail Steam Ship Company's Steamer "Arizona," between the Ports of New York and Aspinwall, in the Months of May and June, 1866, in Smooth Water and Light Breezes.

*Elements submitted by Wm. W. Vanderbilt, Esq., Chief Engineer of the Line.*

#### Vessel.

| | |
|---|---|
| Average draft of water during the time of steaming ... | 16ft. 2in. |
| ,, immersed section ,, ... | 659·9 sq. ft. |
| ,, displacement ,, ... | 3,600 tons. |
| Greatest immersion of water wheel blades during the time of steaming ........ | 5ft. 6in. |

#### Engine.

Revolutions of the engine per minute, 11·93; pressure of steam in the boilers per steam gauge 21·3lbs. per square inch; throttle valve wide open; point of cutting off the steam, one fourth of the stroke of the piston; vacuum in condenser per mercurial gauge, 27in.; barometer, at 29·92in.

#### Effective Pressure in Cylinders per Indicator.

| | |
|---|---|
| At commencement of the stroke ........ | 34·7lbs. |
| At point of cutting off ........ | 32·6lbs. |
| At termination of stroke ........ | 9.7lbs. |
| Against the piston during its stroke ........ | 2·4lbs. |
| Mean gross effective pressure upon piston ........ | 18 4lbs. |
| Mean total pressure upon piston ........ | 20·8lbs. |
| Mean net pressure upon piston ........ | 17·1lbs. |

#### Combustion.

| | |
|---|---|
| Anthracite coal consumed per hour ........ | 3,710·8lbs. |
| Combustible coal consumed per hour ........ | 3,092·3lbs. |
| Anthracite coal consumed per hour per square foot of grate ........ | 7·73lbs. |
| Combustible coal consumed per hour per square foot of heating surface ........ | 6·46lbs. |

#### Speed.

| | |
|---|---|
| Of vessel in knots per hour ........ | 11·38. |
| Difference between the velocity of the centre of pressure of the water wheel blades, 38ft. in diameter, and the speed of the vessel in per cent. of the velocity ........ | 18·98. |

#### Condensation.

| | |
|---|---|
| Difference between the volume of water supplied to the boilers and the volume discharged in steam from the cylinder in per centum of the water supplied ... | 29·54. |
| Temperature of injected water ........ | 79·2°. |
| Temperature of discharged water ........ | 104·1°. |
| Temperature of water in reservoir or feed water ...... | 122°. |

#### Power Developed.

| | |
|---|---|
| Total horse power developed ........ | 1,554. |
| Gross effective horse power developed ........ | 1,375. |
| Net horse power developed ........ | 1,278. |
| Anthracite coal consumed per hour per total horse power ........ | 2·39lbs. |
| Anthracite coal consumed per hour per gross horse power ........ | 2 7lbs. |
| Anthracite coal consumed per hour per net horse power ........ | 2·9lbs. |
| Combustible coal consumed per hour per total horse power ........ | 1·99lbs. |
| Combustible coal consumed per hour per gross horse power ........ | 2·25lbs. |
| Combustible coal consumed per hour per net horse power ........ | 2·42lbs. |
| Number of hours steaming ........ | 696. |
| Number of revolutions of engine ........ | 498,196. |
| Number of knots ran ........ | 7,918. |
| Number of pounds of coal consumed ........ | 2,582,720. |
| Number of pounds of refuse in ashes, &c. ........ | 430,453. |
| Number of pounds of combustible consumed ........ | 2,152,267. |
| Per centum of coal in ashes, clinker, &c. ........ | 16·67. |

## INSTITUTION OF CIVIL ENGINEERS.

### DESCRIPTION OF THE VICTORIA BRIDGE, ON THE LINE OF THE VICTORIA STATION AND PIMLICO RAILWAY.

By Mr. W. Wilson, M. Inst. C.E.

It was stated that this bridge crossed the River Thames about 150 yards to the eastward of the Chelsea Suspension Bridge, at a point where the width of the waterway between the embankment walls was 740ft. It consisted of four segmental wrought-iron arches, each having a span of 175ft. at the springing, with a rise of 17ft. 6in., and a clear headway of 22ft. above Trinity high-water level. At the northern end there was a land opening of 70ft. span crossing the Grosvenor-road, and on the southern shore there was a corresponding opening of 65ft. span, crossing the wharves of the Brighton Railway Company.

In the first place, the gravel was dredged out of the bed of the river, down to the clay substratum, for a breadth of 100ft., and extending across the entire width of the water. Coffer-dams, constructed of two rows of whole timbers, waled and strutted in the usual manner, were then driven 4ft. below the level of the intended foundation. When the enclosed area was cleared of water, the clay was excavated to a depth of 40ft. below Trinity high-water. The space to be occupied by the foundations was next surrounded by permanent sheet piles driven to a depth of 8ft. below the lowest foundation level. Within this sheeting a bed of cement concrete, 4ft. in thickness, was formed, and on that the masonry of the piers was commenced, the concrete being afterwards carried up to the top of the sheet piles round the entire circumference of the piers. From the footings up to the level of 4ft. below low-water, the piers were built entirely of brickwork in lias mortar; thence to high-water level they were faced with rock-faced Portland roach stone, with one through course half way up. The core, or backing, was composed of pavior bricks, set in lias mortar, and the ent-waters, caps, springers, and other masonry above high-water were of tool-dressed Bramley Fall stone. The width of the piers at the springing line was 12ft. 4in., and from the extrados of the arch to the level of the cornice the width was 10ft.

The superstructure of each of the four principal openings consisted of six wrought-iron arched girders, springing from cast-iron bed-plates fixed to the masonry. Horizontal girders, resting on the piers and on the abutments, and riveted to the arch near the crown, formed the longitudinal bearers for the roadway. The spandrils, or intermediate spaces between the arched ribs and the horizontal girders, were filled with a wrought-iron framework radiating from the arch; and between the horizontal bearers cross girders, for carrying the roadway, were fixed at distances averaging about 3ft. apart.

A detailed description was then given of the ironwork of one of the principal spans, that of the others being precisely similar: from this it appeared that all the six ribs, of which each arch was composed, were alike in construction, but varied in sectional area: they were I shaped, the top and bottom tables and the central web being composed of flat plates, connected together longitudinally by flat angle irons, and vertically by T iron stiffening pieces. The two middle ribs, which might each have to carry half the load on one line of rails, had each a sectional area of 80in.; the ribs intermediate between these and the outer ribs had each a sectional area of 71.2in., while the sectional area of each of the face ribs was 53·4in. The horizontal girders were continuous over the entire length of the four principal openings, and in the centre of each pier a stiff expansion joint was provided, for the purpose of equalising the strains under different temperatures. The joints were made and the bolts screwed up at a mean temperature of 60°; and the girders, which rested on bed-plates on each side of the open joint, were perfectly free to expand or contract, the continuity of strain being always preserved by the elasticity of circular vulcanised India-rubber washers, two such washers being provided to each bolt.

A segmental cast-iron shoe was bolted to the end of each rib, and rested in a concave bearer, working loose in a cast-iron frame fixed to the masonry, and provided with wrought-steel keys and cotters, for adjusting the arched rib in position. By this arrangement the whole compressive strain was distributed over the entire sectional area of the arch, whatever the state of the temperature. Each pair of ribs and horizontal bearers were connected together, so as to form, as it were, the two into one box-girder. In addition, there was a complete system of vertical and transverse bracing and strutting to both the girders and the spandril filling.

The total cost of the bridge, including the land arches and abutments, was about £84,000. The superficial area of the roadway, between the parapets, being 31,690ft., the cost per square foot was £2 13s.; while the total length being 930ft., the cost per lineal foot per single line was £45 3s. Only twelve months were occupied in the erection of this important structure.

The works were designed by Mr. Fowler (President Inst. C.E.), and were carried out under his supervision by the Author. Mr. John Kelk, M.P. (Assoc. Inst. C.E.) was the contractor, and the iron-work was sublet to Messrs. Bray and Waddington; the wrought iron-work was supplied by the Monkbridge Iron Company, and the cross-girders and angle-irons by the Butterly Company.

After the arches were erected and the supports were removed, the iron-work was subjected to severe tests, by loading each arch with a moving weight of 350 tons, placed on the two lines of way, being equal to a load of 1 ton per lineal foot on each pair of rails. Commencing at the north end, the load was placed on the 70-ft. openings, extending over the abutment up to the centre of the first arch; the deflection of the 70-ft. girders was 0·48 of an inch in the centre, the greatest deflection of the arched rib was 0·58 of an inch at a point 60ft. from the abutment, and 0·38 of an inch at the crown, and the horizontal girder showed a deflection of 0·78 of an inch at 60ft. from the abutment; while a rise was produced in the adjoining arch of 0·12 of an inch at the crown, the third and fourth arches showing no movement. The load was next moved over the entire span of the first arch, when there was a deflection of 0·71 of an inch at the crown, and of 0·56 of an inch at points 35ft. on each side of the centre; at the same time the deflection of the horizontal girder was regular throughout its entire length, commencing with 0 over the piers and increasing gradually to 0·71 of an inch at the centre; the adjoining arch, which was unloaded, showed a rise in the centre of 0·16 of an inch, and at 30ft. nearer the load of 0·17 of an inch; the horizontal girder also rose 0·24 of an inch midway between the pier and the centre of the arch, but no change was perceptible in the third and fourth arches. The load was then passed on to the centre of the first pier and extended from crown to crown of the first and second arches, when a depression of 0·41 of an inch was produced at the crown of each arch, and of 0·36 of an inch and 0·24 of an inch in the horizontal girders midway between the piers and the centres of the arches. The second arch was then subjected to the whole strain, and subsequently the third arch. The loads were then removed, and a train of engines, weighing 1 ton per lineal foot and 175ft. in length, was run at full speed over one line of way; this produced deflections of 0·40, 0·48, 0·45 and 0·45 of an inch in the four arches respectively. After the experiments were completed, the permanent set was ascertained to amount only to 0·10 of an inch in the first and second arches, and to 0·12 of an inch in the third and fourth arches. In conclusion it was remarked that every part of the ironwork took its fair share of duty, and that the extreme strains, produced by the most unfavourable combination of circumstances, in no case exceeded 4½ tons per inch of section.

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### ON NEW RAILWAYS AT BATTERSEA, WITH THE WIDENING OF THE VICTORIA BRIDGE, AND APPROACHES TO THE VICTORIA STATION.

By Mr. C. D. Fox, M. Inst. C.E.

The system of railways, designed by Sir Charles Fox, M. Inst. C.E., in the year 1862, for the purpose of improving the access to the Victoria Station, by providing additional lines, and avoiding the sharp curves and steep gradients of the then existing railways, comprised:—the widening of the Victoria Station and Pimlico Railway, and of the Victoria Bridge over the Thames; the high level line from the south end of the Victoria Bridge to near Clapham Junction, with a branch to the Wandsworth-road; the diversion and raising of the West End and Crystal Palace, and West London Extension Railways, the Longhedge Junction, and the two level lines from the Victoria Bridge to Stewart's-lane; and the connecting link between the London and South Western, and the London, Chatham and Dover systems at Clapham Junction.

In widening the Victoria Station and Pimlico Railway, the chief work was the removal of the retaining wall from one side of the existing line,—an operation of some difficulty, from the excellent character of the concrete and brickwork originally used, as on account of trains so frequently passing, blasting could not be employed. A girder bridge was successfully substituted in place of an arch over the line, by cutting away a narrow strip of the arch, and inserting one girder at a time.

It was originally intended to construct an independent bridge over the River Thames, to carry three lines of way for the London, Chatham, and Dover traffic; but it having been determined to add, at the same, a third line for the London, Brighton, and South Coast Railway Company, it became necessary to make arrangements for joining up the new work with the Victoria Bridge. The new bridge, in common with the original one, consisted of four river spans, of 175ft. each, having arched ribs, with a rise of 17ft. 6in., and of two land openings, carried by plate girders, one of 70ft., the other of 65ft. span. Its width, from the outside of the original bridge to the parapet, was 100ft., giving, with the old work, one structure 132ft. 6in. wide between the parapets. The total length of the piers and abutments just below the springing was 158ft. The excavations of the abutments were got out by means of coffer-dams, the enclosed area being afterwards covered with cement concrete, 3ft. in thickness, then with brickwork in cement, also 3 feet in thickness, surmounted by outside and cross walls of brick in cement, the pockets being filled with lime concrete. In consequence of the proximity of the original bridge, it was impossible to drive the coffer-dams so as to include the whole of the work, and a portion of the face was therefore carried on strong cast-iron girders, put in at low-water mark, resting at one end on the old, and at the other on the new work. By the use of cement, and the care taken to keep the joints thin, the abutments, though bonded up with the old work, had not shown the least sign of movement. The foundations of each pier were carried down by means of four cast-iron cylinders, each 21ft. internal diameter; temporary wrought-iron cylinders, 19 feet in diameter, being used for the top. About 100 tons of kentledge were used in sinking them; this was laid upon stages slung within the cylinders, as being less liable to tilt them than when placed outside, and more easily thrown off when the requisite depth was reached. The cylinders were all sunk to an average depth of 45ft. below Trinity high-water, of which 13ft. were into the London clay, the total time occupied in sinking being on an average eight days. The cylinders were filled with cement concrete for a depth of 12ft., and then with brick in cement up to low-water mark. The brickwork was then tested, and afterwards the masonry was commenced. The stonework face, between the cylinders and forming the connection between the old and the new work, was carried on strong cast-iron framework.

The superstructure of each of the river-spans was precisely the same, and consisted of eight main ribs, with provision for a ninth. Of these, the rib nearest the existing bridge, was only one-half the strength of the others, which were each calculated to carry a single line of way. These arched ribs were of wrought-iron, 3ft. 4in. deep, and the flanges were 18in. wide; but for 38ft. in the centre of the span, they merged into one with the horizontal girders, thus giving a total depth at the centre of 4ft. 6in. The flanges of the ribs gradually diminished from a thickness of 3in. at the centre to $1\frac{1}{2}$in. at the springing, the webs being of plates $\frac{3}{4}$ of an inch thick throughout. The sectional area of the rib at the centre was 166·9 square inches, or, deducting rivets, 142·5 square inches; the sectional area of the rib at the springing was 102·4 and 86·5 square inches respectively. The horizontal girder was 4ft. 6in. deep. with flanges 18in. wide, and was continuous throughout, the whole bridge being riveted up for a length of 913ft. It was firmly connected with the cast-iron standards at the piers and at the abutments, in order to obtain the full advantage of continuity for the land spans, and was anchored by a plate running from the top flange down to the cast-iron skew back. The main ribs were braced by transverse girders and by vertical diagonal bracing; the four middle ribs being further cross-braced horizontally.

The calculations of the strains, from which the superstructure was designed, led the Author to the conclusion, that whilst cast iron was the best material for arched bridges of single spans, similar bridges of several spans, having piers whose perfect stability under horizontal stress could not be relied on, were under certain circumstances exposed to tensile strains which rendered the use of wrought-iron most desirable. The bridge was severely tested on several occasions by Major Rich, R.E., on behalf of the Board of Trade. Each rib, where practicable, with the exception of those adjoining the original bridge, was tested with eight of the heaviest locomotives and tenders, weighing 360 tons, or thereabouts, which were allowed to stand on, and also to run over at speed; and the whole structure was then tested with twelve locomotives and tenders, weighing 530 tons, or thereabouts. The ribs deflected uniformly, when fully loaded, to the extent of $\frac{7}{8}$ of an inch at the centre; the corresponding ribs in the adjacent spans at the same time showing a rise of $\frac{1}{8}$ of an inch at the centre. The girders over the land spans, when fully loaded, showed a deflection in the centre of $\frac{1}{2}$ an inch The cross-girders, when a pair of driving wheels rested exactly upon them, showed a deflection in the centre of $\frac{3}{8}$ of an inch. The permanent set in each case was scarcely appreciable. Careful observations had been made for nine months as to the effect of changes of temperature upon the structure. This effect was limited to a rise and fall of the crown of the arches, amounting to a maximum of $1\frac{1}{2}$in., and a movement at the free ends of the land arch girders of $\frac{11}{16}$ of an inch.

The total cost of the bridge, including the land spans, had been £245,000, which was equal to about £2 13s, per superficial foot of space covered, or about £38 per lineal foot of single line. The bridge was completed in seventeen months; the whole of the ironwork having been supplied and fixed by Messrs. Ormerod and Grierson, the sub-contractors.

The high level line of the London, Brighton, and South Coast Railway Company, with a branch line from the Wandsworth-road, consisted mainly of a viaduct of brickwork, which was described. The bridges were of a heavy character, comprising eighteen spans in wrought iron, ranging from 26ft. to 150ft., three spans in cast iron of from 60ft. to 70ft. and nine spans of brick in cement. The bridge over the London and South Western Railway had a central span of 1[illegible]0ft. and two side spans of 47ft. each, and had two main girders of lattice construction, continuous throughout. The centre-span was erected without the use of scaffolding, by putting together the bottom flange and lifting it into its place, supporting it by temporary truss-rods, and then, erecting the remainder of the girder upon it, inserting the tension bars from either end till they met in the middle.

An adjoining bridge, of 120ft. span, was of similar construction. The main girders, weighing 106 tons each, were built on the viaduct, and, when put together complete, were each rolled over into their places during the night, an operation occupying but four hours.

The other lines of this system were afterwards described, and it was stated that these works, which were three years in progress, comprised a length equal to 9 miles of double line, of which 5 miles were on viaduct, and had cost for works only, including the bridge over the Thames, the sum of £910,000. The high level line of the Brighton Company, which was entirely on viaduct, had cost, including permanent way, stations, and signals, and the numerous heavy bridges, £45 per lineal yard of double line. The whole of the works had been executed from the designs and under the superintendence of Sir Charles Fox, M. Inst. C.E., and the Author, Mr. Edmund Wragge, being the resident engineer. The contractors were Messrs. Peto, Betts, and Crampton, Messrs. Lucas Brothers, and Messrs. W. and J. Pickering, Mr. J. Heywood, jun., executing the ironwork for the Brighton Company.

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At the ordinary general meeting on Tuesday, the 19th November, Mr. John Fowler, President, in the chair, it was announced that the Council, acting under the provisions of Section IV. of the Bye Laws, had that day admitted the following candidates as Students of the Institutions: James Abernethy, junior; Francis Henry Ashhurst; Edward William Baylis; Edward Bazalgette; Nathaniel St. Bernard Beardmore; Henry Percy Boulnois; Edwin Lane Campbell; David Alexander Carr, Frank Cheesman, John Charles Coode, Charles Edward Cowper, John Harcombe Cox, James Murray Dobson, Edwin Noel Eddowes, John Breedon Everard, Charles Richard Fenwick, Charles Flood, Walter Foster, Thomas Robert Gainsford, John Baron Hyde Gandy, Herbert Thomas Hare, Owen Jones, William Hubert Kinch, Charles Henry Grey Jenkinson, Charles Le Lievre, Frederick Gother Mann, William Joseph Marshall, Henry Thomas Munday, John Newman, Philip Algernon Herbert Noyes, William Partridge, George James Perram, John Kirby Rodwell, Robert Baxter Rose, William Shield, George Shortrede, Richard Hombersley Tomlins, Douglas D'Arcy Wilberforce Veitch, William Henry Venables, Richard Warburton, Walter Frank Waterfall, Thomas Robert Watts, Hubert Frederick Eardley Wilmot, and Francis Wentworth Smijth Windham.

## THE ANNUAL GENERAL MEETING.

The Council in their Report stated that it was a source of gratification that the interest taken in the ordinary general meetings by the members of all classes continued to increase. It would be remembered that a principal, if not the primary motive, which led to the establishment of the institution, was to afford an opportunity for the free and mutual interchange of individual observation and experience in the various branches of engineering. This object had been steadily kept in view during the fifty years which had elapsed since the foundation of the society; and it was satisfactory to observe that the value and importance of the original communications, and of the discussions, had been fully sustained.

The premiums awarded for some of the communications brought forward last session (and which were presented after the reading of the report), included Telford medals and Telford premiums of books to Messrs. J. T. Chance, M.A., and E. Byrne; a Telford medal to the Astronomer Royal, F.R.S.: a Wyatt medal to Colonel Sir W. Denison, K.C.B., R.E.; a Watt medal and a Telford premium of books to Mr. John Bourne; Telford premiums of books to Captain W. H. Tyler, and Messrs. W. H. Preece and W. A. Brooks, and the Manby premium of books to Mr. C. D, Fox. It was noted that Colonel Sir W. Denison, Captain Tyler, Mr. W. A. Brooks, and Mr. W. H. Preece had previously received Telford medals from the institution. In the adjudication of the premiums, Mr. W. H. Barlow's description of the Clifton Suspension Bridge was not taken into account, the Author being a member of Council; but the thanks of the institution were eminently due to Mr. Barlow for his interesting communication, and for the suggestions he had made in regard to the materials to be employed, and the principles to be adopted, in bridging wide spans, which led to so useful and practical a discussion.

A record of these papers and discussions was contained in Volume xxvi. of the Minutes of the Proceedings, for the Session 1866-67, which had been issued to the members in a complete form. The publications of the institution were at present limited to the printing of the papers and the reports of the discussions upon them. But the members were reminded that they had been invited to contribute, not necessarily for reading at the meetings, the details and results of any experiments or observations, on subjects connected with engineering science and practice, for the purpose of forming an Appendix to the Minutes of Proceedings.

It was stated that many circumstances, beyond the control of the Council, had prevented a satisfactory conclusion being arrived at, as to the plans that ought to be adopted for providing additional accommodation. Having regard, however, to the increase in the number of members of late years, and the fuller attendance at the meetings, it was trusted that the subject would receive the early consideration of the new Council.

The establishment of a class of students, to be attached to the institution, but not to form part of the corporation, in lieu of the old class of graduates, was next touched upon; and the mode of admission to and the privileges to be enjoyed by this new class, as set forth in the bye-laws adopted at a general meeting of members in June last, were detailed. Although not specifically mentioned in the rules, it was contemplated to organise supplemental meetings for the reading and discussion of papers by the students, and possibly also for the delivery to them of lectures upon special subjects. Already seventy-eight students had been enrolled, and the number was likely to be still further increased. The graduate class had ceased to have any existence in the institution.

Having been informed that a petition had been addresed to the Queen in Council for the grant of a Charter of Incorporation to a "Society of Engineers," the Council of the institution unanimously arrived at the conclusion that, both in the interests of the profession and of the institution, it was advisable to present a counter-petition against the grant of a second charter to the same profession, especially to a metropolitan society dealing, or proposing to deal, with precisely similar objects. The petition of the institution was given at length in the report. A deputation from the Council was subsequently received by the President of the Board of Trade; and after the matter had been fully considered by the Lords of Her Majesty's Council, the "Society of Engineers" was informed that their lordships could not recommend the grant of a Royal Charter of Incorporation to that society, under a name which was liable to be confused with that of "The Institution of Civil Engineers."

During the past session 48 members and 79 associates had been elected, while the deceases, resignations, and erasures together amounted to 33, leaving an effective increase of 94, or at the rate of 7·02 per cent. on the present number of members of all classes. There were on the books on the 30th of November last, 18 honorary members, 589 members, and 826 associates, making a total of 1,433, exclusive of students. The gross numbers, at intervals of five years, for the last quarter of a century, commencing on the 30th of November, 1842, stood thus: 525, 610, 745, 835, 1,000. and 1,433 the actual increase in each of the periods referred to being 85, 135, 90, 165, and 433 during the last five years.

The deceases announced during the year had been: Dr. Michael Faraday, and the Earl of Rosse, honorary members; Nichol Baird, John Cass Birkinshaw, William Carpmael, James Combe, Alexander Gibb, William Gilbert Ginty, James Cramond Gunn, Robert Hawthorn, Edward Humphrys, Parkin Jeffcock, Alfred King, George May, Auguste Perdonnet, and James Cobby Street, members: John Bethell, Christopher Joseph Cato, Edward Magdalen Joseph Delaney, Frederick Samuel Houtray, Captain Mark Huish, Edward Loysel, William Jopling Nesham, Thomas Richardson, Ph. D.. Lieut.-Colonel William Drummond, Alexander Robertson Short, R.E., and Henry Stone, associates.

With respect to the sources of income, and the way that income had been disbursed, a brief summary of the receipts and expenditure for the year ending the 30th of November, 1867, showed that the subscriptions and fees (exclusive of the Building Fund fees) had amounted to £1,513 6s. 6d., the interest on investments on the general account to £484 5s. 8d., and the miscellaneous receipts to £548 7s. 4d., making together £5,545 19s. 6d.; while the Building Fund fees and dividends had realised £844 1s. 7d. and the Trust Funds £371 15s. 5d., bringing up the gross receipts to £6,761 16s. 6d. In the same period the disbursements, including the payments on account of the arrears of the Minutes of Proceedings, had been £4,850 8s. 8d. and for premiums under trust £163 10s. 3d., while there had been invested on different accounts a sum of £1638 1s. 3d., in the purchase of Reduced Three per cent. Annuities. The cash balances exceeded by £109 16s. 4d. the sums in hand at the same date last year, making up the difference between the two sides of the account, as presented in the foregoing analysis.

There had recently been transferred into the name of the corporation of "The Institution of Civil Engineers" in the bank books £287 15s. Consols, and £227 8s. Reduced Annuities, being, as it was understood, the final sums payable out of the estate of the first President, Thomas Telford, whose decease occurred in September, 1834.

By the will of the late Mrs. Locke, the institution was bequeathed the well-known portrait by Sir Francis Grant (President of the Royal Academy) of Mr. Joseph Locke, M.P. (Past-President Inst. C.E.), and a sum of two thousand pounds, free of legacy duty. The portrait had been received, and was placed in the meeting room; and the amount of the other legacy would be paid by the executors in due course.

The nominal value of the realised property belonging to, and under the charge of, the institution, now consisted of:—I. General Funds, £12,845 6s. 8d.; II. Building Fund, £4,287 14s. 7d., and III. Trust Funds, £12,119 15s. 11d., making, together with the cash balances of £583 0s. 10d., a total of £29,835 18s., as against £26,709 11s. 2d. at the date of the last report.

In conclusion, the Council stated, that in their opinion, and they trusted also in that of the general body, the institution during the past session had fairly fulfilled its obligations, had been the means of imparting much valuable information, had tended to stimulate the growth of knowledge, and generally to advance the status of the profession.

The thanks of the meeting were unanimously accorded to the President for his zealous efforts in the interest of the institution; to the vice-presidents and the other members and associates of Council for their co-operation with the President, and their constant attendance at the meetings; to Mr. Barlow, for his paper on the Clifton Suspension Bridge; to Mr. Charles Manby, honorary secretary, and to Mr. James Forrest, secretary, for the manner in which they had performed the duties of their offices; as also to the auditors of the accounts and the scrutineers of the ballot for their services.

The following gentlemen were elected to fill the several offices on the Council for the ensuing year:—Charles Hutton Gregory, President; Joseph Cubitt, Thomas Elliot Harrison, Thomas Hawksley, and Charles Vignoles, Vice-Presidents; James Abernethy, William Henry Barlow, John Frederic Bateman, Joseph William Bazalgette, Nathaniel Beardmore. Frederick Joseph Bramwell, James Brunlees, George Willoughby Hemans, John Murray, and George Robert Stephenson, members; and John Horatio Lloyd, and Captain Henry Whatley Tyler, associates.

The meeting was then adjourned until Tuesday, January 14th, 1868, when it was announced that the monthly ballot for members would take place, Mr. Charles Hutton Gregory, the President elect, would deliver an inaugural address, and, if time permitted, the discussion would be resumed upon the papers on "The Victoria Bridge," by Mr. W. Wilson, and on "New Railways at Battersea, etc.," by Mr. C. D. Fox.

## INSTITUTION OF ENGINEERS IN SCOTLAND.

The first general meeting of the eleventh session of the Institution of Engineers in Scotland, with which is incorporated the Scottish Shipbuilders' Association, was held in the Philosophical Society's hall, on Wednesday evening. Mr. J. M. Gale, engineer to the Water Commission, in the chair.

The report of the Council having been read, Mr. J. M. Gale, the president, proceeded to deliver his introductory address.

The origin of the institution dates from a very successful meeting of the "Institution of Mechanical Engineers," held in this city in 1856. It was formed in March of the following year, and, under the presidency of Professor Rankine, held its first meeting on the 28th October, 1857, and at once took a high position. At the end of the first session, the number of members of all classes was:—first session, 1857-58—members, 118; associate, 1; graduates, 8; hon. members, 0; total, 127; and at the end of the tenth session, 1866-67—members, 311; associates, 57; graduates, 18; honorary members, 10; total, 396. This rapid increase is highly satisfactory, and augurs well for the future. The funds of the institution are in a satisfactory position. The subscription fees now amount to £550 per annum, while the revenue last year was more than sufficient to cover the expenditure, and the capital account shows a balance in our favour of about £675. The amalgamation of this institution, as originally constituted, with the "Scottish Shipbuilders' Association," which was effected during the eighth session, has, and I believe will continue to conduce very much to the benefit of both societies. Of the value of such an institution as this to men engaged in designing and constructing large works we have the best possible proof in the increasing number and importance of similar societies throughout the country, and in their transactions contributing so largely to our professional literature. Everything new in principle and arrangement is brought under review, the cause of failure of plausible theories is explained, and anything unsound in received ideas is exposed. That there has been great progress made in engineering science and practice within the short space of ten years since the institution was formed is quite evident to us all. A simple enumeration of the great works that have been executed, and of the improvements that have been made in mechanics and engineering within the last ten years, improvements resulting in substantial saving of time and money, and increase of production, would, were I capable of making such a list, occupy more time than the limits of an address would admit; but there are a few large undertakings to which I would refer, and some things which have either been used for the first time since this institution held its first meeting, or which have been much improved or more largely used since that time.

And, first, in the steam-engine, we have surface condensation, which, though early proposed, but few were in use in 1861, when the subject was brought under the notice of this institution by Mr. Thomas Davidson. It is now largely applied, and its benefits thoroughly understood, and it must be a source of satisfaction to those gentlemen who, along with Mr. Davidson, advocated at that time the adoption of the principle to see it now employed so much. Its advantages are a saving of fuel, brought about by supplying the boilers with the pure water obtained by the condensation, instead of with salt water, and so avoiding to a great extent the forming of the scale of lime and magnesia inside the boiler; the saving of a great part of the power necessary to work the air-pumps, and the obtaining of a more perfect vacuum. In steam-engines of all classes the advantages of using high-pressure steam, and a high rate of expansion, are now generally admitted and acted upon. Double-cylinder engines, which allow of the use of high steam without risk of breakage of the working parts, and of a high rate of expansion at the same time, are now largely used, and some very fine examples of these compound engines have lately been made in this city by members of this institution. In pumping-engines, the old single-acting non-rotative Cornish engine, to which Watt gave so much attention, and brought to such a high state of perfection that no substantial improvement has been made in it since it left his hands, is now giving way to the double-acting condensing rotative beam-engines, where there are no pump-rods to absorb the first blow of the steam on the piston, with, however, all the means of economising fuel retained, which are so prominent in the Cornish engine, including the Cornish boiler, a slow rate of evaporation, a high pressure of steam, a great expansion, and jacketed cylinders. The use of high steam cut off at an early part of the stroke in the Cornish engine as applied to raise water for the supply of a town, involved repeated breakages of the pump-rod, piston-rod, and other principal parts of the engine; and these accidents led to the use of lower steam and less expansion, and a consequent reduction in the efficiency of the engine. In first cost it is more expensive than the double-acting engine, as it only does duty one way, and the flow of water in the main is thus made irregular. The engines at present being erected, and those that have been erected during the last four or five years in connection with the main drainage of London, amounting in all to upwards of 2,300 horse power, are all expansive, condensing, double-acting, rotative beam engines, and from these engines a duty of 80,000,000 foot-pounds per cwt. of Welsh coal is obtained. As good results have been obtained by the use of high-pressure, condensing, double-cylinder engines, and even with single cylinder double-acting engines, as with the Cornish engine. A pumping-engine with double cylinders and large fly-wheel is as satisfactory a machine as can be made, and expansion can be carried farther with it than with the Cornish. A good many engines of this class have lately been put up in connection with the different works supplying London with water.

Within the last ten years great progress in railway works has been made, both on the continents of Europe and America and in India. In this country the most prominent extensions of the railway system have been within the more densely built portions of London, executed at vast expense, and in the face of difficulties calling for the highest effort of engineering skill. Among these we have the highly successful underground railways, for which Mr. Fowler is the engineer, and at least three magnificent bridges across the Thames. The means adopted for regulating the immense traffic on these railways is most complete and efficient, and the new passenger stations are of great extent. The subject of adapting locomotives for the working of steep gradients has received a great deal of attention within the last few years, with a considerable amount of success; and a good climbing engine has at length been invented by Mr. Thomas Page for the Alpine locomotion. The driving-wheels of the locomotive are made broad, and bite into a broad tramway of roughened stone laid alongside the rail, affording great friction. Tramways of wood have also been successfully tried, and in this shape it would make a cheap road applicable to a rough country where moderate speeds only are wanted. But the most successful adaptation of the locomotive to steep inclines is the railway recently opened over Mont Cenis, and constructed under the direction of Mr. Fell. The railway is laid down on the bed of the road over the pass by Mont Cenis from France into Italy, and close to the tunnel already described. The gauge is 3ft. 7½in., and the space left for the road traffic is in no place less than 16ft. The length of the line from St. Michel, on the French side, to Susa, on the Italian side, 48½ miles, and the whole work was completed in eighteen or twenty months. The distinguishing feature of the Fell railway is its central rail, which is raised 9in. above the other rails, and is gripped by four horizontal wheels, with which the locomotives are furnished, in addition to the usual vertical wheels, and which can be acted upon by the steam from the same boiler and in the same manner as the vertical wheels and thus affording a greatly increased adhesion. In connection with railway construction, I may further mention the extended use of cast iron cylinders for the foundations and piers of bridges in soft material, a fine example of which has lately been very successfully erected across the Clyde in this city; and of the cast-iron tressel-girder, which seems about to supplant entirely the plate girder for large spans. We have also the fish-joints, and the introduction on a large scale of steel rails, which of itself is sufficient to mark an epoch in engineering science. Before leaving this subject of railways, I would wish to make a single remark about a subject that at present must present itself to every one's mind when railways are mentioned. I mean the fact that there are at present five of the large railway companies of this country in a state of bankruptcy, and that the value of our railway property is less by about £150,000,000 than it was eighteen months ago. We have the satisfaction of knowing that this state of matters has not been brought about by any shortcoming on the part of the engineers. It is not because viaducts are coming down, or bridges being washed away, or that a permanent way and rolling stock sufficiently strong and durable cannot be manufactured; it is not that the works designed by the engineers have been found totally inadequate to meet the requirements of railway traffic, but it is from causes which, I am happy to say, do not form any part of the functions of this institution to discuss.

Notwithstanding the great development of railways, canals will always hold a first position, as a means of transit, because of the economy attending the transmission of heavy materials along them, where speed is not an object. The subject of introducing the screw upon the canals, now so general, was brought before the institution during the first session, by Mr. Neil Robson, who described the first successful trials on the Forth and Clyde and Monkland Canals of the steam-lighter *Thomas*, which may be looked upon as a corollary to the *Charlotte Dundas*. The most important canal work of the present day, or indeed of any previous age, is the Suez Canal, which, notwithstanding the forebodings of commercial failure by many eminent engineers of this country, is rapidly approaching completion. It is a scheme to connect the Mediterranean with the Red Sea, on the main route from Europe to India and the East, by a ship canal of colossal dimensions, without locks. The distance between the two seas is 90 miles, about 30 of which are through lakes and depressions below the level of the sea. The greater part of the earthwork is being removed by dredging, and the canal is to be of sufficient depth and width to allow ships of the largest class to pass freely through, and is to have basins or harbours at each end. About £8,000,000 has already been expended upon works alone, while the total expenses of the Company amount to upwards of £15,000,000, and other £4,000,000 are wanted to complete the enterprise. The objections urged against this project were many and various, but the principal were, that the drifting sands of the desert through which it passes would fill up the canal, and that the moving sands on the coast would fill up the entrances, especially that on the Mediterranean side; but the experience of some years warrants the engineers of the undertaking in stating that a moderate amount of dredging will keep the canal clear of drifted sand, and that sand does not travel past the entrance to it on the Mediterranean side; and there, therefore, seems every prospect of this extraordinary undertaking being brought to a speedy and successful completion.

As regards shipbuilding, I can do no more than refer to the great improvements in form, in speed, and in construction that have taken place within the last few years, to the enlarging of the size of ships, the increasing use of iron, of steam, and of the screw, and to the vast increase of iron shipbuilding on the Clyde. The last ten years have mainly contributed to the total abolition of wooden ships of war, and to the almost total renewal of the navies of the world, in many strange shapes, in which the old shipwright is not recognised, and in which propulsion by steam and thick iron-plating form the new means of attack and defence. In ordnance, too, there has been a great increase in the size, weight, and power of the guns; while in small arms the field of Sadowa aroused the world eighteen months ago to the fact that a revolution had taken place in the manufacture of the rifle. Harbours are being enlarged in almost every part of the kingdom; and those works executed within the last few years upon the Clyde by Glasgow engineers will not suffer in comparison with any in the country. Among improvements in harbour works, I may mention the double steam-dredger, discharging over the side, and the conveying of the dredged material to the open sea, at a great saving of money over the previous methods pursued; the improvements in pile-driving, and in getting foundations for quay walls and docks in deep water without coffer-dams.

The progress of sanitary engineering has also been great within the last ten years—the old cesspool system has, we may say, entirely disappeared, the mistakes at first committed in using tile pipes of improper size have been rectified, and almost every town of note has been properly and efficiently drained. This, together with the increase of water-closets in dwellings, has, in the fouling of our rivers and streams, produced an evil almost as great as that removed. The largest drainage operation of the last few years, and, in fact, the greatest ever executed as a whole, is the main drainage of London, which has for its object the efficient drainage of the low lying parts of London, and the purifying of the Thames by intercepting the sewage and carrying the refuse of the population to a distance from the city. The works consist of lines of intercepting sewers on both sides of the river, with pumping-engines of 2,400 horse power to raise the low-level sewage to a sufficient height to carry it to the outfall, which is twelve or fourteen miles below the city. The works are capable of discharging 400,000,000 gallons a day in time of flood, and their cost has been £4,100,000. These works have been quite successful in diverting the sewage and purifying the Thames as it passes through London; but the general question of how the pollution of our rivers is to be arrested, and what means are to be adopted to purify those already so foul, as some of them are, as to be dangerous to the public health, is the only great engineering question of the day which remains without a definite solution, at least, a solution based upon a great practical example. Many attempts have been made to extract from town sewage the valuable ingredients it contains, sometimes at great cost, and often at considerable loss; and it has been shown that a portable manure cannot be manufactured from ordinary sewage water, and that its application by hose and jet in small quantities over a large area of land cultivated in the ordinary manner is impracticable. The immense volume of sewage water is one of the principal difficulties of the case, and the idea of separating the offensive parts from the ordinary house drainage, and from the rain-water, by a double set of drains has been proposed again and again. If our houses and cities had originally been constructed on this principle, it is possible that the water-closet refuse would have been more valuable than it is in its present state of dilution; but whether in the majority of our towns a sufficient fall could have been given to those drains from which rain water is excluded, that they would keep themselves clean is a matter of great doubt. To carry out this system now would involve not only a double set of street sewers, but a double set of house drains also, and an amount of disturbance of internal house arrangements, at a vast expense, which makes the proposal altogether impracticable. The Paris system, that of collecting the water-closet refuse in an air-tight tank attached to each block of houses, has been advocated very frequently and with various modifications; but the fact that the tanks are not air-tight, and that the manufacture of a manure from their contents is not attended with profit, makes it, apart from the expense—which would be nearly as great as a double system of sewers—as impracticable as the other. We must deal with the sewage in the state of dilution in which we find it; and after a most lengthened inquiry it is now pretty generally acknowledged that, taking the cost of works into account, the system of irrigation practised at Edinburgh, Croydon, and elsewhere, is the only possible solution of the question. It is probable that in a city like Glasgow there may be waste products from some manufactories which are inimical to vegetable life. Such products will very generally be hurtful to animal life also; and I think communities would be quite justified in demanding that these peculiar operations should be performed at a distance from dense masses of population, or that the refuse matters should be treated in such a manner as to render them innocuous before they are discharged into the sewers of a city.

The last class of works I shall mention are those for supplying towns with water, and the last ten years have given us a good example from each of the four sources available for this purpose. These are—1st, the Loch Katrine Works, which draw their supply from a lake; 2nd, the Aberdeen Works, which draw from a river; 3rd, the Dublin Works, with their large artificial storage reservoir; and 4th, the Passy artesian well at Paris. The Loch Katrine Waterworks for the supply of this city have been so frequently described, and are so well known, that I need say little of them here. It is the largest work of the kind which has been constructed since the days of Imperial Rome. Those approaching it in extent are the New River Waterworks in London, which supplies about 27,000,000 gallons a day; and the Croton aqueduct, which supplies New York, can deliver 35,000,000 gallons a day; but the Loch Katrine aqueduct could supply Glasgow with 50,000,000 gallons a day. The extent to which the lochs embraced in the scheme can be drawn upon affords a storage capacity of 9,000 million gallons, the total length of the aqueduct is 34 miles, and the whole works were completed in four years at a cost of about £900,000. The new works for supplying Aberdeen with water draw their supply from the river Dee, at a point about twenty miles above the city. The water of the Dee is remarkably soft and pure even in time of floods, as the water-shed of the river consists principally of granite, and, as the flow of the stream is sufficient at all times for the purposes of the works, large artificial storage reservoirs are not required. The principal feature of the new waterworks for Dublin is the large storage reservoir on the Vartry, at Roundwood, 24½ miles from Dublin. The embankment, which is an earthen one, with a puddle wall in the centre in the usual way, is 2,000ft. long, 28ft. wide at the top, 66ft. high, and contains 320,000 cubic yards of materials. The reservoir will have a water surface of 409 acres, will be 60ft. deep at the embankment, and will contain 2,400 million gallons, or 384,000,000 cubic feet. The top water level is 692ft. above the sea. The gathering ground is principally mica slate, and is the same geologically as that surrounding Loch Katrine. The water is to be filtered near the reservoir, and after passing through a tunnel 2½ miles long through very hard rock, and for the construction of which twenty-one shafts had to be sunk, it is conveyed for about 17½ miles by a cast-iron pipe, 33in. diameter, to receiving reservoirs, capable of containing ten days' supply, at Stillorgan, five miles from Dublin, from which it is led to the town by two lines of pipes, each 27in. diameter. The works will supply about 12,000,000 gallons a day, and they have been executed at a cost of a little over £500,000.

I have endeavoured to indicate some of the many substantial advances that have been made by our engineers since the institution was first founded, and to enumerate a few of the large undertakings which have been or are being brought to a successful completion; but I know that many more, and probably many more important subjects, will present themselves to the minds of members of the institution. From the comparatively limited extent of our coal-fields, and the certainty that coal will ultimately become costly to get, the economy of fuel in the steam engine and in the arts and manufactures will in future years be forced upon the attention of engineers, and a variety of new applications and combinations will be demanded for this purpose. The fact that good steel can now be produced at a cheap rate will also tend to modify many of our existing machines and tools, and the process of Bessemer, itself a great means of saving fuel, may yet change the dimensions of every iron structure. Vast railway works are still wanted in Europe, in India, and throughout the whole world; and as the importance of great Europe and Asiatic main trunk lines develop themselves, the magnitude of the undertakings and the dimensions of the works will increase, and greater skill will be continually called for, for the great iron horse must yet force its way over both the Balkan and the Bosphorus. New problems in naval architecture are continually presenting themselves, both for war and commerce. Our rivers must be purified at whatever cost short of crippling the manufactures that give life and wealth to the country. In waterworks we seem to be upon the threshold of greater works than were ever attempted by any nation or at any time. London is looking to South Wales, at a distance of 183 miles, for 220,000,000 gallons a day, at a cost of £8,000,000 or £10,000,000, to supplement or supersede its supply from the Thames; and Liverpool to Bala Lake, in North Wales, a distance of 78 miles, for 60,000,000 gallons a day. In this country we do not experience the evils of a deficient or irregular rainfall, or the barrenness of a soil continually parched by a burning sun, neither do we know the extraordinary fertility and productiveness of the soil of some countries, when water can be obtained for irrigation. In Spain, in Algeria, in Australia, and in India irrigation works are only in their infancy. To these and to similar questions, which are continually becoming more complex and more extensive, requiring increased knowledge and study, must the future attention of engineers be directed. It is through institutions such as this, and the means they afford to their members of becoming acquainted with all that is new in theory or in practice, and the incentives they present to emulation, that the engineers of this country have, unaided, been hitherto able to cope with and surpass those of any nation; and that this institution may fulfil the high objects for which it is founded, and the duties it has to perform to the engineers of Scotland, we must be careful that it advances with the requirements of the age and see that no obstacles are presented to its embracing engineering students of all classes, and particularly those young men to whom the country looks forward to perpetuate its good name for mechanics and engineering, and to support its place among the empires of the world.

# BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

## ON A NEW MODE OF CONSTRUCTING THE SURFACE OF STREETS AND THOROUGHFARES.

By Joseph Mitchell, F.R.S.E., F.G.S., C.E.

The wear and tear of an ordinary macadamised road, and, consequently, its cost of maintenance, are very great.

The explanation appears from experiments which show that a cubic yard of macadamised stone, when well pressed down in a box with a capacity of 27 cubic feet, contains 11 cubic feet of vacuities; and that a roadway covered with 12in. of metal, before it is consolidated into a smooth and useful surface, has a large portion of its stones crushed into small particles, and that more than one-third of its dimensions consists of mud and sand. When heavy rains occur, combined with heavy traffic, disintegration of the stones in such a roadway takes place, and quantities of mud are generated in proportion to the amount of traffic.

In the new mode of constructing a roadway which I propose, the vacuities in the metal are filled with cement grout, which, when hardened, forms a concrete, binding together the macadamised stones into a mass impervious to water, and, unlike asphalte, unaffected by heat, while at the same time it preserves entire the original size and dimensions of the stone.

Again, every one must have noticed the tear and wear of the causeway stones in an ordinary street pavement, and the irregularities of the surface of the streets, after six or twelve months' traffic. Granite and other stones of the hardest quality appear to give way under the weight of the traffic. The explanation of this waste may be found in the ordinary mode of constructing street pavement. The stones are laid on a bed of loose sand some 2in. or 3in. deep above the soil, and are then beaten down into an approximately even, but really irregular, surface. They are laid three-fourths of an inch to one and a-half inch apart, and the intervals between them are filled up with sand, which is soon reduced to mud. Thus, each stone is insulated, and made to rest on a yielding surface.

In a street so constructed the ends of the causeway stones are found, after twelve months' traffic, to be worn down from one half to three-quarters of an inch. This arises from the percussion of the wheels of carts and carriages falling from the centre of one stone on to the joint of the two adjoining, which, being on a yielding surface, and the wheels striking on the ends, sink a little from the pressure. When a stone has sunk bodily from half an inch to an inch, or when a little hollow occurs in the pavement of the street, it will commonly be found that the adjoining stones are much worn, the hollow on the surface increasing the force and effect of the percussion of the wheels. The greater the hollow the greater is the tear and wear from the strokes of the wheels.

The source of waste is seen to be the yielding surface on which the stones are laid. To prevent their tear and wear, what was wanted seemed to be a rigid and perfectly regular surface, by which also the traction might be greatly improved.

These defects in the construction of causeway have long been noticed, and the only remedy hitherto used, and which has been in very general use, but which has always failed, has been, to lay a body of lime concrete 6in. deep below the stones, and to fill with lime grout the joints or intervals between them. The lime, it has been found, has never consolidated, owing to the stones being beaten down when it is half set, and to the tremor subsequently caused by the traffic. Thus, on the best paved streets, after heavy rain or watering, much mud is generated from the wet unconsolidated lime and sand. Where there is much traffic, as in London, this mud on the surface, in drying, proves slippery and dangerous, and many serious accidents occur in consequence.

The irregularities of the surface, and consequent mud, are increased by 2in. of sand being placed between the bed of lime concrete and the bottom of the paving stones.

In the new mode of constructing street pavement which I have proposed there is first laid down a bed of cement concrete 3in. deep (gravel may be used instead of macadamised stone where abundant and cheaper), and to the requisite convexity in the cross section. This concrete quickly consolidates and entirely excludes moisture or water from below.

On this foundation the paving stones, 5in. deep and 3in. wide (a width of 3in gives a better hold to the horses' feet than a width of 4in. or 4½in., which are the common sizes), are built, and, when brought to a perfect form, the joints are filled with cement grout. When the whole is consolidated it forms a surface perfectly immovable by traffic and impervious to moisture. The wear and tear of the stone arises from the attrition of the traffic only. If the causeway be well made there should be no irregularities on the surface. Where such irregularities exist they are due to defective workmanship.

Three experiments have been made to test the merits of the new or concrete road, and two to test the merits of the new form of causeway.

The first trial road and pavement were laid down in Inverness early in 1865. They have been under traffic for upwards of two years, being passed over by the whole goods traffic of the Highland Railway. The road is now perfectly sound, and it has required no repairs; whereas the macadamised roadway adjoining it has constantly required repairs, and is now full of irregularities and ruts.

The second trial new road was laid in London. As it was important that this plan of road-making should be subjected to the test of severe traffic on some of the London thoroughfares, I applied to, and obtained permission from, the Right Hon. William Cowper, Chief Commissioner of Works, to lay down 100 yards of it in length, by 35ft. in width, on the Mall in St. James's Park, at the foot of the Green Park. The whole traffic between the district of Regent-street, Piccadilly, Pall Mall, Buckingham Gate, and the Victoria station passes along this route, which is, apparently, subjected to as heavy traffic as any thoroughfare in London.

Subsequently this road proved a failure, the surface breaking up under the traffic. My explanation of the failure, which was very puzzling at first, is as follows:—The roadway at each end of the experiment was macadamised at the time the experiment was made, and the contractor's men, who were crushing the macadamised road with a heavy roller of three to four tons weight, were inadvertently permitted by the person in charge to pass their heavy roller from end to end continuously over the experimental road before it had properly consolidated. The crystalline structure of the cement was injured by this, and, in consequence, the surface yielded to the incessant cab traffic and the month of continuous rain to which it was immediately thereafter exposed. The surface was repaired by the trustees by a coating of 2in. of macadamised stone, which was rapidly ground down on the hard concrete by passing vehicles. As the bottom was entire and consolidated, had a coating of 2in. or 3in. of new concrete been laid down, with the required time to consolidate, it would have answered all the purposes contemplated; but the surveyor deemed it his duty to remove the concrete surface entirely, which was only done at great trouble by means of levers and iron crowbars. The experiment was certainly a failure; but, in attempts of realising new conceptions, it is in the nature of things that there must be repeated failures before success is reached.

The third experiment was made in Edinburgh, and has, in my opinion, proved very satisfactory and successful. A length of 150ft. of concrete road by 45ft. in breadth, and a similar extent of street pavement, were laid down last summer at George IV. bridge, where the traffic is heavy and continuous. One half of the street was laid down with the concrete at a time, and the traffic was rigidly kept off that portion for a month. The other half was then laid down. The whole roadway has since been under traffic for twelve months and has proved perfectly sound and immovable, not a stone turning up all that time. After the road had consolidated, and had been under traffic during the winter, it was observed that some small hollows had shown themselves at the joinings along the centre of the roadway, and arose from our inexperience in laying down the concrete, and will in future be avoided. These hollows were cut out, and made up with new concrete, and opened for traffic in a week. The result has been that the surface is now perfectly smooth and regular.

The street pavement on the south end of the concrete road was then laid down on a bed of cement concrete 3in. deep.

The cement concrete was permitted to consolidate for about ten days, and thereafter the pavement was built on it with cement mortar; and when the stones were regularly set, the joints were filled up with cement grout.

This pavement has also been perfectly successful, the water running off it as from a foot pavement, leaving no mud; and the only wearing of the surface is from the attrition of the traffic.

It has been stated that the noise of vehicles on the pavement is greater than on the ordinary pavement. I do not consider it greater: the blows arising from the irregularities on the ordinary pavement are noisy, as well as destructive to the road and to carriages; but the noise on the concrete pavement, though not greater, is different, it having more of a ringing sound, like that on a street bound up with frost.

In point of wear and tear, and freedom from mud and dust, this street pavement has many undoubted advantages over that now in common use, particularly where there is heavy traffic; but I anticipate that a road consisting of a good body of concrete should supersede even this species of street pavement.

The following is an extract from a report made by me to Mr. William Duncan, secretary to the Edinburgh road trustees:—

"The concrete road cost 6s. 9d., and the paved road 17s. per square yard. A sum of 1s. 8d. per square yard was incurred for excavating and removing the materials of the old road, and for watching; but I calculate that the value of the old material would go to meet these outlays. The small experiment that has been made, however, is not a good criterion of the cost. In a work on a large scale the cost ought to be less.

"The advantages offered by this mode of construction on a road under heavy traffic, as far as our experience has gone, are, first, diminished tear and wear—the general surface is apparently not worn in twelve months more than one eighth of an inch: secondly, superior cleanliness—the road is almost wholly free from mud and dust; thirdly, diminished cost and annoyance from repairs. The road has required little or no repairs for twelve months. It requires no scraping or watering, and its maintenance is almost nominal, while the coatings, scrapings, and waterings of a macadamised road under similar traffic in Edinburgh cannot be done under 1s. to 1s. 6d. per square yard, besides the great inconvenience and discomfort they cause to the public. The original cost of a macadamised road 9in. deep, which, before it is consolidated, is crushed into 6in. of available material, is about 2s. per square yard, or say somewhat less than one third of the concrete road. In London, where the metal is 20s. the cubic yard, instead of 6s., as in Edinburgh, and where the cement is cheaper, the cost of a road of 9in. of metal will nearly amount to the cost of a concrete road. It thus appears that the cost of the concrete road will be proportionally less, and its advantages proportionally greater, in London and towns similarly situated, than in Edinburgh. The cost of the concrete, which is 17s. per square yard, is higher than it should be, as the stone was procured from Aberdeen instead of the neighbourhood of Edinburgh, and gravel would have served for the concrete bottom quite as well as the more expensive macadamised stone. In conclusion, I consider that the experiment which, through the liberality and public spirit of the road trustees, I have been permitted to make on this important subject, has been successful—the road having sustained the traffic on George IV. bridge without a stone being moved for twelve months, and that it only requires further experience in the manipulation and laying down of the concrete to accomplish all that I anticipated from this new mode of road-making."

Since the date of this report Messrs. Wylie and Slight, engineers in Edinburgh, have been good enough to make experiments which show that the new road possesses another advantage over the old. It was natural to anticipate that, from the superior evenness of the new road, the traction would be less upon it than on common roads, and these gentlemen have found that the traction on the concrete road of a wagon two tons in weight, against a gradient of 1 in 80, was 70lb., while, on a common macadamised road of the same grade, wet and muddy, was 140lb., or double that on the concrete road. On a road with wheel tracks through new metal it was 340lb., and on a road newly covered with metal 560lb. The gradients of these several roads were 1 in 80.

The experiments are to be further prosecuted as the dynamometer got injured, and I have every confidence that they will establish the very great superiority of the new road as regards traction—a circumstance affecting the preservation of horses and carriages and the comfort of travelling. Many experiments will yet have to be made before the merits of the new road and pavement can be held to have been conclusively tested. In particular it will be necessary to have an experiment on a large scale before the cost of construction and maintenance of the new road can fairly be put in comparison with the cost of construction and maintenance of the roads now in use. But, in the meantime, as far as my experience has gone, I feel entitled to sum up the advantage of the new roadway over the old in the four following propositions—viz.: First, the tear and wear are less on the new road than on the old; second, the cost and annoyance of repairs are less; third, the mud and dust are a minimum quantity, and there is superior cleanliness; fourth, the traction is less, as has already been proved.

It must be observed, however, that the entire efficiency of this mode of road-making depends on the quality of the cement, which should be the best Portland cement, tested to bear a tensile strain of 500lb. to 600lb. on a bar of one and a-half inch square. Time, after the road is made, is a great element of efficiency, as the hardness of the concrete gradually doubles in the course of twelve months; but further experiments are necessary to determine the precise time the road should be left for consolidation before it is opened—a month I found quite sufficient in Edinburgh.

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## ROYAL GEOGRAPHICAL SOCIETY.

The second meeting of the present session of this Society was held at Burlington House, on Monday evening, the 25th Nov., Sir R. I. Murchison, Bart., President, in the chair.

The following new Fellows were elected:—W. F. Allen (Lord Mayor of London), G. Andrews, G. Armitstead, the Duke of Buccleuch, Sir David Baxter, Bart.; W. J. Best, A. M. Bethune, J. F. J. Cuttance, G. E. Dalrymple, J. Donald, J. Edward, G. E. Forbes, R. M. Kerr, Lord Kinnaird, W. Lawson, Colonel Lloyd Lindsay, M.P.; J. Mackinglay, C.E.; D. M'Gregor, F. M. Metcalfe, Thomas Muir, jun.; John Paterson, Colonel Sir Arthur Phayre, C. A. Pierce, A. Raliegh, D.D.; A. J. Rhodes, E. Spicer, Lieutenant Steel, R.E.; Lieutenant O. B. C. St. John, R.E.; J. G. Taylor (H.B.M. Consul in Kurdistan), J. H. Tritton, Captain F. J. S. Venner, Rev. J. Waite, M. J. B. Ward, B. Washbourne, M.D.; R. S. Watson, M. Woodifield, M.I.C.E.

A letter was read from Dr. Kirk, of Zanzibar, relative to Dr. Livingstone. It stated that that a Banian trader of Bagamoyo (on the mainland opposite Zanzibar) had brought to Dr. Kirk a native who had recently returned from the interior in company of a caravan, and who had seen a white man whom there was reason to suppose was Dr. Livingstone. The story of the native, related without questions being put to him, was as follows. He had left Bagamoyo with the rest of the caravan, and passed along the usual trade route to Wemba and Marungu. When in one of the villages under Marungu, a white man arrived with a party of thirteen blacks, who spoke Suahili. All had firearms, and six carried double-barrelled guns. The white man was of moderate height, not stout, dressed in white, and wore a cloth wrapped round the head. He gave the chief a looking-glass, and was offered ivory, which he declined, saying he was not a trader. He then went northwards. Dr. Kirk added that there was no doubt the white man, of whom he had written formerly, as having been seen on one of the lakes by an Arab, was a Turk, one of the traders from Gondokoro, who have been met with in Uganda by Zanzibar merchants; the route opened up by Speke had thus been quickly followed by traders, who had now met, some from Egypt and others from Zanzibar, in the centre of Africa. On a second interview with the native of the caravan, Dr. Kirk showed him his albums of photographic portraits. In the first book he did not recognise the likeness of the man he saw in the interior, although it contained a very fine side view of Livingstone. In the second, he at once pointed to a staring likeness of Livingstone, which had been kept as a caricature, and said "that is the man." "But," he added, "come to Bagamoyo, and see my master and the other men; they have seen him also, and will tell you all they know." Mr. Churchill, the consul, and Dr. Kirk intended to proceed to Bagamoyo two days after the despatch of the letter, and glean what further information they could; meantime, Dr. Kirk begged of those at home to suspend their opinion. Mr. Churchill, in a despatch to Lord Stanley, further states that Marungu, where the white man was seen, was 650 miles distant from the coast, and that the date of the occurrence was seven months previously (about the end of 1866). The native had pointed out the likeness of Dr. Livingstone amongst a hundred portraits.

In the discussion which followed, Sir Roderick Murchison read a letter from Mr. Price, Church missionary of Bombay, in which the writer expressed his belief that the nine educated negros taken from his establishment by Dr. Livingstone would not be likely to desert their master. Mr. Horace Waller, who had been on the Shiré, and had had the care of two of these young negroes, also expressed his confident belief that if any disaster had happened to their master in the interior, they would have long ago found their way to the coast, and sought the English Consul.

A paper was read on a recent survey of a line of route through Nicaragua, between San Miguelito, on the Lake, and Pim's Bay, on the Atlantic coast, by J. Collinson, Esq., C.E. The author narrated the incidents of the survey which he had made through the untrodden forests of the eastern part of Nicaragua during the present year. The country near the shores of the lake consisted chiefly of open savannah land; but on crossing the watershed, and touching the streams which flow towards the Atlantic, a dense virgin forest commenced, with a great change in the vegetation. Part of the journey was made on rafts down the Rama River, and two magnificent waterfalls were discovered. The summit-level was found to be only 619·86 feet above the level of the lake, which showed a great break in the Andean ranges in this part of Central America.

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## MANCHESTER ASSOCIATION FOR THE PREVENTION OF STEAM BOILER EXPLOSIONS.

The last ordinary meeting of the executive committee of this association was held at the offices, 41, Corporation-street, Manchester, on Tuesday, November 26th, 1867, the President, W. Fairbairn, Esq., C.E., LL.D., F.R.S., &c., in the chair, when Mr. L. E. Fletcher, chief engineer, presented his report, of which the following is an abstract:—

During the past month 248 visits of inspection have been made, and 577 boilers examined, 454 externally, 13 internally, 2 in the flues, and 108 entirely, while in addition 5 have been tested by hydraulic pressure. In these boilers 167 defects have been discovered, 6 of them being dangerous.

*Purchase of Second-hand Boilers.*—It may prove of service to the members to address them a word of caution on this subject, since the experience of the association shows that it is a most short-sighted economy to be tempted by the low price of second-hand boilers to purchase them, and that doing so constantly leads to expense and disappointment. Boilers are very seldom pulled out unless there is good reason for condemning them, and there is no economy in working those of old-fashioned construction and equipment. Two illustrations in point may be given, which have been met with during the present month.

One of the members of the association had three boilers, which were condemned as unfit for use on account of malconstruction. These boilers had two furnaces running into an oval flue tube, which was made of light plate and with sides of an irregular and very weak form. Several cases of explosion having occurred on account of this malconstruction, the particulars of two of which were given in the association's monthly reports, the owner was induced, at the persuasion of the association, to pull out these three boilers, and lay down new ones in their places. It appears that one of these condemned boilers, if not all of them, was sold to a broker, who succeeded in passing it off upon another member of the association, representing the boiler to be nearly new, though sixteen years old, and that it had been taken out merely because it was too small for the work, and to be replaced by a larger one. The association knew nothing whatever of this re-purchase, until it transpired, on the first examination of the boiler, after it was reset in its new position, when it was recognised as one of the old ones previously condemned on account of malconstruction, and it became the painful duty of the association to report to its recent purchaser the true history of the boiler, and inform him that it was unsafe at the pressure he required, and had better be at once removed.

Another steam user, not under inspection, suffered more severely. He purchased an old second-hand boiler, and had it set on his premises, when, almost before it had got fairly to work, the boiler exploded, killing four men and laying the place in ruins, further reference to which will be made in this report under the head of No. 27 explosion.

Cases of difficulty arising from the purchase of second-hand boilers are so constantly occurring that it was thought well to bring the above before the notice of the members, and at the same time strongly to urge upon them to have nothing to do with the purchase of second-hand boilers, except in those few cases where there has been a good reason for their previous removal, and they have been originally made by a boiler maker whose name is a sufficient guarantee for the quality of the plates and soundness of the workmanship.

### EXPLOSIONS.

The list of explosions for the past month is a heavy one, as many as six having occurred, by which fifteen persons have been killed, and fifteen others injured. Particulars of four of these have been already obtained, and it has been found as before, that there is no mystery whatever as to their ca[illegible] Not one of the boilers in question was under the inspection of this association. The following is a tabular statement;—

Tabular Statement of Explosions, from October 26th, 1867, to November 22nd, 1867, inclusive.

| Progressive Number for 1867. | Date. | General Description of Boiler. | Persons Killed. | Persons Injured. | Total. |
|---|---|---|---|---|---|
| 23 | Nov. 6 | Portable Multitubular wagon-shaped. Internally-fired ...... | 2 | 2 | 4 |
| 24 | Nov. 7 | Plain cylindrical. Externally-fired ...... | 0 | 0 | 0 |
| 25 | Nov. 11 | Plain Cylindrical, egg-ended. Externally-fired...... ..... | 3 | 8 | 11 |
| 26 | Nov. 14 | Agricultural .................... | 3 | 2 | 5 |
| 27 | Nov. 14 | Double-furnace "Breeches." Internally-fired ......... | 4 | 1 | 5 |
| 28 | Nov. 21 | Particulars not yet fully ascertained ................. | 3 | 2 | 5 |
| | | Total.................. | 15 | 15 | 30 |

No. 23 explosion occurred at a farm, at nine o'clock on the morning of Wednesday, November 6th, and resulted in the death of two persons, as well as in injury to two others.

The boiler, which was a portable multitubular one, employed for driving a thrashing machine, was not of the locomotive type, as such boilers usually are, but of wagon shape, the bottom being arched up into a horse-shoe shape sufficiently high to contain the furnace within it, the flat sides being strengthened with seven stays, three-quarters of an inch diameter, passing through the water space, while the small flue tubes, eight in number, were placed above the furnace, the chimney being at the firing end of the boiler. Its size was very diminutive. It measured only 6ft. 5in. in length from end to end, including the smoke box, 3ft. in height, and 2ft. 4½in. in diameter at the wagon head, while the plates were thin, being only a quarter of an inch in the shell and furnace.

The explosion occurred as the engine was at rest, which it had been for some ten minutes, to afford an opportunity of adjusting its position, the fire burning meanwhile, and no steam escaping from the safety-valve. The boiler gave way in the external shell, rending from end to end, immediately above the longitudinal seam of rivets at the bottom of the water leg on each side of the furnace, and also through the ring seam of rivets at each end of the boiler, so that the outer casing was completely stripped off from the furnace, smoke box, and flue tubes.

The explosion was attributed at the inquest to the carelessness of the attendant, who, it was said, had worked the boiler with too little water, and too much steam, the coroner and jury contenting themselves with censuring the poor man who had been killed by the explosion, while they hinted in addition that had he survived it would have been their duty to have brought him in guilty of manslaughter. Abuse of the poor fireman, however, is by no means an exhaustive treatment of this explosion; there are other points to be considered. The boiler was ill-adapted to bear high pressure, though it had been warranted when purchased, as stated by the owner at the inquest, to work up to a pressure of 100lbs., and to bear one of 200lbs., while it had been worked at times up to 70lbs. Also the complement of fittings was defective, since, although there should have been two safety-valves, there was but one, and that of a most dangerous construction, as frequently pointed out on previous occasions, since it was weighted with a spring balance, not fitted with any ferrule to prevent its being overscrewed, and is reported to have been found locked fast after explosion. Had this boiler been suitably constructed and equipped, the explosion would not have occurred, and the lesson to be drawn from it is not the carelessness of engine drivers, but the danger of turning out badly-made and badly-equipped portable agricultural boilers, and more especially so since they do not receive the most skilled attendance.

No. 24 explosion took place at a screw bolt manufactory, at a quarter-past one o'clock on the afternoon of Thursday, November 7th, and though the walls of the engine and boiler-house were brought down, fortunately no one was either killed or injured.

The boiler was of the plain cylindrical externally-fired class, and both ends were originally hemispherical, but the front one had recently been removed, and a flat plate substituted for it, strengthened with four gussets radiating toward the centre, and carried down to within 8in. of it, each attached with single angle irons, and secured with three rivets. The length of the boiler was 12ft. and the diameter 4ft., while the flat end-plate, which was in one piece, measured half-an-inch in thickness, and the remainder of the shell three-eights of an inch; the ordinary blowing-off pressure being about 20lbs on the square inch.

The boiler failed at the front end-plate, which was blown out like the bottom of a pill-box, rending all the way round at the root of the angle iron, and tearing away from the rivets attaching it to the gusset stays. On the occurrence of this rupture the flat end-plate was blown forwards for a distance of about 100yds., and the remainder of the shell backwards, passing through the boiler-house wall, knocking down the chimney, and embedding itself in an embankment. Fortunately no one but the foreman was near the boiler at the time, and he, hearing a report from it, had time to make his escape, so that happily no one was injured.

With regard to the cause of the explosion:—The construction of this boiler was certainly not adapted for high pressure, with a flat end-plate relying entirely on four gussets with single angle irons each attached with three rivets. These were found after the explosion to be drawn through the front end-plate, and from the fact of the foreman's hearing a report, and being able to make his escape, it would appear that one of the rivets failed in the first instance, and then others followed. Unless, however, the rivets had been very inferior, a pressure of 20lbs. would, it is thought, scarcely have been sufficient to tear them asunder, and it appears not improbable that the pressure of steam was higher than that stated, and possibly without the engineman's knowledge, since the safety-valve lever admitted of a load of about 70lbs. on the square inch, and the explosion took place during the dinner hour, when the engine was standing. While, however, it may be difficult now to decide the precise pressure at the moment of rupture, there need be no mystery about this explosion, and there is no question that it was due simply to neglect, and would not have happened had due care been paid to the construction of the front end-plate, and condition of the safety valve.

No. 25 explosion, which was of a very destructive character, is of special interest to colliery proprietors. It occurred at about one o'clock on the afternoon of Monday, November 11th, at a coal mine, and resulted in the instantaneous death of three men, as well as in injury—in some cases very severe—to as many as eight others,

The boiler in question was the centre one of a series of three set side by side, and working in conjunction one with the other, all of them being of the plain cylindrical, egg-ended externally-fired class, so generally adopted at collieries. The three boilers were very similar in dimensions and equipment, and all set with direct or flash flues. The exploded one was as nearly as may be 40ft. in length, 6ft. in diameter, and from three-eighths to seven-sixteenths of an inch thick in the plating, while each of the boilers was fitted with a couple of open 5in. safety-valves, weighted with a cast-iron ball 8in. in diameter, hung at the end of a lever, having a proportion of 15 to 1; so that the load was a little above 50lb. on the square inch, though the pressure, as shown by the steam-gauge fixed in the engine house and connected with the series of boilers, was stated not to exceed 41lbs. when the valves began to blow. It frequently happens that the blowing-off point, as indicated in the steam pressure gauge, is lower than that arrived at by a calculation of the proportions of the safety valve. This arises from a difficulty in ascertaining the precise area of the valve on which the pressure of the steam acts, and depends in each case on the condition of the faces, since, if the angles of the bearing surface of the valve and of the seating be not precisely identical, the steam will insinuate itself between the two, and thus act on a larger area than that due to the diameter of the valve. Whether, however, the blowing-off pressure was 40lbs. or 50lbs. is not a question of importance in the present case. A pressure of 50lbs. would not have been excessive, and the explosion is due to other causes, as will be explained below.

The boiler failed at the fourth ring seam of rivets, counting from the firing end, that is to say, at the back of the third belt of plating, the fracture occurring in the outer overlap, and passing from rivet hole to rivet hole, till it ran entirely round the boiler and divided it into two parts. On the occurrence of this fracture, the two sections of the boiler were blown asunder in opposite directions, adhering in their flight as nearly as may be to the longitudinal centre line of their original seating. The front portion soared from the pit in which the boilers were set, and flew forwards to a distance of about 30 yards, where it pitched into a small brick house and laid it in ruins. This house was used by the workmen as a cabin and meal room, and, as the explosion happened during the dinner hour, there were unfortunately a number of men in the cabin at the time, most of whom were injured, two of them fatally. The remainder of the shell flew in a backward direction, and embedded itself in the heart of a new chimney in process of erection, having passed in its flight through the old one, and reduced it to a heap of ruins, which fell on the boiler and nearly buried it; added to which, the side wall of the engine house was brought down, the roof dismantled, the engine covered with the ruins, and the connections of the boiler severed, though happily the two boilers alongside escaped comparatively unhurt, whereas, in other cases of the explosion of one of a series of plain cylindrical externally fired boilers, the whole number have been known to explode simultaneously. Unfortunately the fireman did not escape. He was engaged on the top of the boilers opening the steam junction valves, all of them having been closed during the dinner hour to admit of the stuffing boxes being packed. He had already raised the valve on the central boiler, the one that exploded, and was in the act of opening another on the boiler next to the engine house, and had lifted it about a quarter of an inch from its seat, as was found on subsequent examination, when he was suddenly overtaken by the explosion and killed on the spot.

With regard to the cause of the explosion, I saw no reason, on visiting the scene of the catastrophe, to attribute it to shortness of water or excessive pressure of steam, while it is stated that the safety valves were blowing freely shortly before it occurred; but I found on examining the fragments that the rent which had cut the boiler in two was not exactly a new one, but had existed at the bottom of the shell for some time. The surface of the fracture at the top of the boiler presented a sharp and fibrous appearance, while that at the bottom was smooth, and the edges rounded; added to this, the plate in the vicinity of the rent at the bottom of the boiler was eaten by external corrosion to a depth of one-sixteenth or one-eighth of an inch, the rivet heads also being affected, and it appears most probable that this corrosion was due to continued leakage through the old fracture. Whether, however, this corrosion was due to this cause, or to any other that escaped observation, an examination of the plate left no room for doubt that a portion of the rent, which eventually cut the boiler in two, had been of long standing and gradually developing, so that the boiler had been tottering on the eve of explosion for some time, and merely needed some trivial exciting cause, such as the turning on of the steam, or feed, the opening of the furnace door, or a slight increase of pressure to bring about the catastrophe already reported.

Externally-fired boilers are very prone to these treacherous fractures at the ring seams of rivets, and they may occur at any moment without warning. Hence one of the great objections to these boilers. The introduction of the feed-water has much to do with the rending of these boilers at the ring seams, and in the present instance the arrangement was not judicious. The feed was pumped into the boilers cold from an adjoining reservoir, and carried down nearly to the bottom of the shell, by means of a vertical internal feed-pipe placed but a few feet behind the fire bridge, so that the cold water impinged directly on to the plates at one of the hottest parts of the boiler, and it was at the nearest seam but one to this point that the rupture occurred. Sometimes merely opening the furnace doors and admitting a rush of cold air is sufficient to rend these boilers at the ring seams of rivets, near to the fire bridge, and in the present case the boilers had just been fired up but a few minutes before the explosion occurred.

I cannot conclude the report on this explosion without urgently repeating the appeal to colliery owners so frequently made on previous occasions, that they would give up the use of these treacherous and uncontrollable plain cylindrical externally-fired boilers, and adopt the internally-fired double furnace boiler instead; while, as temporarily remedial measures, I would recommend that the feed should be dispersed on its introduction by means of a horizontal perforated pipe, carried near to the surface of the water and heated if possible before being pumped into the boiler. Also, that the two ends of the boiler should be lashed together longitudinally, to prevent transverse rupture resulting in explosion.

No. 27 explosion was of a very disastrous character, resulting in the death of four persons, as well as in injury to another, while the works at which it occurred have been reduced to a perfect wreck. On making a personal visit to the scene of the catastrophe, the parts were so buried in the ruins as not to be accessible till dug out, so that I have not yet had an opportunity of acquiring full particulars, but expect to do so in time for next month's report. It may be stated, however, in the meantime, that the boiler was a second-hand one, had but just been laid down, and exploded the first day of setting to work. It was of double furnace breeches construction, and the explosion was due to the bottom of the combustion chamber collapsing upwards, in consequence of which the flue tube was severed, the furnaces, with the end-plate, blown forwards, and the shell backwards; while four men, as already stated, were killed, and the whole works disorganised.

## THE LATE PARIS EXHIBITION.

*(Reports continued.)*

### TELEGRAPH APPARATUS AND PROCESSES.

By Robert Sabine, Telegraph Engineer.

The telegraph apparatus shown in the late Paris Exhibition contained few novelties, but indicated satisfactorily the quiet progress which had been made in this art-science in the five years which have elapsed since the last London Exhibition. Were it not for such exhibitions as these, the task of tracing the advancement made in telegraphy within certain periods would be an almost impossible one.

In 1851, Wheatstone's single needle instruments were used, almost exclusively, on the English lines, Morse's electro-magnetic recorders upon the American and Swiss, Bréguets dial telegraph upon the French railway, and Froment-Chappé's double pointer upon the French State lines. The great telegraph novelty, in 1851, was the copying system, of which specimens were shown by both Bain and Bakewell. The public attention was attracted to them in admiration of their performances whilst experience had not yet shown their impracticability. After the Exhibition, the idea of telegraph engineers became more generalised; and we find the fruits of this in the Paris Exhibition, four years afterwards, where the Morse apparatus was shown in a state of transition from the form in which it left the hands of its inventor towards the high degree of perfection which it has subsequently reached. In 1862 the honours were divided between the Morse and the dial telegraphs. The Morse, adopted by almost all the administrations of Europe, had offered inducements to the manufacturers to devote their energies to its perfection, such as we see it to-day from the workshops of Siemens and Digney. The dial telegraphs had received an impulse from the growing employment of private lines in the metropolis under the energetic influence of Professor Wheatstone.

In the Paris Exhibition of 1867 there is a significant inclination on the part of the French inventors to bring forward type-printing telegraphs. This is the result of the great success which has been attained by Mr. David Hughes's telegraph—the only instrument of similar importance which has not figured in previous exhibitions. This system, introduced from America, promises ere long to rival the Morse in the extent of its employment.

Every day we are advancing towards the possession of standards of merit. Telegraphy is growing, from stage to stage, more practical, because those inventions which do not come up to the established standard find their level sooner than they did before these standards existed. Thus the single needle telegraphs, which, during long years, held their own in England, have almost entirely died out. The infinite host of fantastical schemes of submarine cables and methods which we heard of in 1862 have been frightened out of existence by the great reality of the Atlantic cable. And with such a standard as the Hughes type-printer, the numerous inferior schemes which emulation has called or recalled into being in this Exhibition will, infallibly, in a short time retire into oblivion.

The writer proposes to classify the subject-matter of the following report in sections, each containing a special group of materials or apparatus, and not according to the order in which they appear in the catalogues. A similar classification was adopted in the jury report on electrical instruments in the London Universal Exhibition, 1862, and was found to have the advantage of facilitating comparison and reference.

#### Construction of Telegraph Lines.—Submarine Telegraphs.

The submarine telegraph is not so well represented in the Paris Exhibition as the brilliant success which this branch of art has achieved within the past year would have led us to hope. It is sincerely to be regretted that the public, in this Exhibition, have been denied the gratification and advantages of learning the methods and seeing the apparatus employed in making, laying, and testing the Atlantic cables. The engineers engaged in this scheme have not only laid the Atlantic cables, but have, at the same time, established the future fortunes of telegraphy, which is, perhaps of still greater importance. In exhibiting their remarkably beautiful appliances they might not have found, it is true, any direct pecuniary profit to themselves; but they would have had the satisfaction of knowing that they were enlightening thousands of inquiring minds on a subject of universal interest.

William Hooper, London, exhibits a case containing various specimens of his vulcanised indiarubber cables. Mr. Hooper's process consists in the consolidation of a coating of pure—underneath a coating of vulcanised—indiarubber. He attains this by covering the conductor first with two coatings of pure rubber, then with a coating of some substance called a separator; and, lastly, with vulcanised indiarubber. The duty of the separator is to prevent the sulphur of the outer coating penetrating the rubber of the interior. The whole is then submitted to a temperature of from 135° to 140° cent., by which the rubber is reduced into a compact coating.

The lengths of cable which have been made by this process have behaved, so far, very well. Their insulation resistances are great; a result, however, ascribable not so much to Mr. Hooper's peculiar process as to the repeated coatings, laid one upon the other, which compose his cables, and to the specific resistance of the material itself. Any other manufacturer using the same thickness of rubber would obtain the same insulation; but the advance made by the method in question is in the favourable conditions under which the dielectric is applied to ensure its durability.

To the practical telegraphist so high a degree of insulation is not necessary. To the electrician, however, it is a great boon, enabling him, when the insulation of the whole wire is uniform, to determine the place of a very minute fault with great accuracy and ease, as he can neglect, in his calculations, the shunt-resistances due to the leakage between the fault and the ends.

The physical properties of indiarubber are such that it may be heated to a higher degree than is possible with gutta-percha without materially altering either its molecular or electrical conditions. This is in favour of its employment in cables which are liable to be exposed to heat in transport or otherwise. The self-heating by oxydation of the iron covering, which was found, in 1860, to have injured the core of a length of the Malta-Alexandria cable during the time it was stowed in the tank at Greenwich, would have been without any detrimental effect had the cable been insulated with indiarubber. In stowage in dry tanks during transport cables frequently become spoiled, as was the case with four or five experimental lengths of cables of different manufacture, destined by the Government for submersion in the Persian Gulf in 1863. In such a position the cable proposed by Mr. Hooper would, no doubt, be found to be of great practical value.

Until Mr. Hooper introduced his peculiar process of insulation by pure, and protection by vulcanised, indiarubber, the difficulty of joints had been the greatest drawback to the employment of this material. The difficulty, has now been got over, and it remains for time to show if indiarubber which, in air is not more durable than gutta-percha, behaves equally well under water. If so, this material may have an important future in submarine work.

In gathering data for the establishment of the merits of his system, Mr. Hooper has made a series of quantitative measurements of the electrical conditions of a compound indiarubber covering under different conditions of heat. Thus, a coil of 3,394 yards was tested at different temperatures, between 14 and 100° cent., at intervals of 5° to 6°. The results of the series is the establishment of a constant for calculating the effects of temperature on the insulation of indiarubber. This constant is found to be equal to an increase of the conducting power of the 0.1034 part for every 1·66° cent. (= 3° Fahr.)

Mr. Hooper does not exhibit the apparatus which he proposes to use for making joints, nor does he state whether it would be applicable at sea, where it is sometimes necessary to make a joint between deep-sea and shallow-sea ends in a small boat.

Rattier and Co., Bezons, near Paris, show various specimens of submarine cables, insulated with gutta-percha and protected by hemp and iron wires. The first cable made by Messrs. Rattier for submarine purposes was that laid, in 1859, for the semaphore telegraph on the coast of Brittany, and which is still at work. Messrs. Rattier likewise show specimens of the cables, with one and two conductors, made for the colony of Senegal in 1861, and for Cochin-China in 1860 and 1864.

The gutta-percha core made by Messrs. Rattier is of excellent quality. That made for the French administration of telegraphs contains, per knot, 22 kilogrammes of copper and 33 kilogrammes of gutta-percha, in two coats, with intermediate compound. The writer was allowed to test the electrical conditions of some lengths of this core which were awaiting approval by the Government electrician. The resistances were extremely uniform, and in no case was the insulation less than 700 millions-units per knot, in water at 14° cent. The wire resistances were also such as to show that the French manufacturers are in a position to procure copper of high conducting power.

W. T. Henley, North Woolwich, shows a case of cable samples with sections. In addition to the cables shown in the London Exhibition of 1862, we have the following:—

| Cables. | Laid. | Conductors. | Length in miles. | Weight in tons. |
|---|---|---|---|---|
| Denmark ...................... | 1863 | 4 | 12 | 134 |
| Norway ......................... | 1863–6 | 1 | 50 | 177 |
| Persian Gulf .................. | 1863–6 | 1 | 1615 | 690 |
| Ramsgate ...................... | 1864 | 6 | 23 | 207 |
| Italy and Turkey ............ | 1864 | 1 | 61 | 186 |
| England and Ireland ...... | 1865 | 7 | 26½ | 307 |
| Prussia and Sweden......... | 1865 | 3 | 55 | 405 |
| Wrexford ..................... | 1865 | 4 | 17½ | 321 |
| River Plate .................. | 1866 | 3 | 30 | 473 |
| Cooke's Strait ............... | 1866 | 3 | 53 | 440 |
| Behring Sea .................. | 1866 | 1 | 601 | 784 |
| Norway ......................... | 1866 | 1 | 7 | 10 |
| England and Hanover ...... | 1866 | 4 | 240 | 2465 |

Siemens Brothers, London, also show a case of cable samples amongst which are lengths of heavy as well as of light cables. A fine shallow-sea cable is shown by these manufacturers, made by them for the Egyptian Government. It consists of six separate conductors, each of one copper wire, 1·6mm. diameter, covered to 5·5mm., with gutta-percha; the whole being protected with tarred hemp and sixteen galvanised iron wires, each 5mm. diameter. For war purposes Messrs. Siemens show a cable, of which considerable lengths have been made for the Austrian Government. It consists of a single conductor, a strand of three steel wires, 0·75mm. diameter, covered with gutta-percha to 3·5mm., and protected with hemp and copper sheathing. As a further protection, sometimes the exterior of this cable is taped, and painted with white lead.

S. E. Morse, New York, exhibits a model to illustrate a new method of laying and picking up submarine cables. The inventor is a brother of the celebrated inventor of the recording-apparatus which bears his name. In order to overcome the inconvenience of not being able to raise a deep-sea cable to the surface at any point, Mr. Morse proposes to provide special points of slack, which can be raised to the surface and the cable underrun. The way in which he proposes to do this is by laying the cable to a certain distance, where a second ship supports it, whilst the cable-ship continues the paying out. When the cable-ship is clear away, and the cable considered to be well down upon the ground on each side, the second ship is to proceed in a straight line, at right angles to the direction of the cable, easing it down gradually at the end of a rope or chain, to which a buoy is afterwards to be attached. The buoy is intended to facilitate the refinding of the cable, if it should be wanted. The writer thinks that Mr. Morse has scarcely been well advised in selecting a buoy for the purpose in question, because it would, in all probability, be hauled up by some passing ship, and thus not only the trace lost, but possibly also the cable, if it were a light one. To lay a cable in this way would cost a great deal of extra line; but it would at least have slack—a most essential point for the successful laying of a cable—and would increase the chances of hauling the cable on board without breaking it.

### UNDERGROUND TELEGRAPHS.

Referring to the jury report of the London Exhibition, 1862, we see that, whilst other systems were strongly represented, one underground system only was shown. In this Exhibition, five years afterwards, there are six exhibitors of underground lines, plainly indicating the increased attention which is being devoted to this branch of telegraphy and, therefore, a growing necessity for it.

The telegraph-posts in the metropolis are becoming overcrowded. To erect new wires endangers them; to erect new posts beside the old ones is still more offensive to the eye than the present ones. The evils of this system were made evident during the snowstorm in February of last year, when nearly all the lines were down upon the roofs. Were we in possession of an efficient method of underground telegraphy such accidents could not occur; and, indeed, we may, before long, see line after line disappear in tubes, in cables, in sewers, anyhow that is safe, underneath the surface.

Underground lines, almost abandoned in 1862, have since that date been creeping gradually again into favour. The reason is, that the difficulties which formerly barred the progress of this branch of telegraphy have, one by one, been materially lessened, whilst the inconveniences of the overhead system have become more apparent.

The principal difficulties which underground lines have had to contend with have been the carelessness with which the wires were laid and the decay of the insulating materials. These difficulties have been met more completely in France than elsewhere. The prejudice which the French have against wires crossing their streets in all sorts of inelegant angles has necessitated the employment of the underground system in their towns, and has shown that, when sufficient care is taken in burying the wires and in ensuring perfect cables before they are buried, their electric conditions will last unimpaired for years. The underground cables in Paris are composed of seven cores of copper wire, insulated with gutta-percha. They are placed in the sewers, in the catacombs, and in iron tubes under the streets. The cables which are carried through the sewers are inclosed in lead tubes to prevent the gases developed there destroying the gutta-percha. In the catacombs, which are free from any development of gas, the seven insulated wires are simply wrapped with a tape serving, prepared with sulphate of copper. Eight such cables, supported in a zinc trough, 100mm. deep and 50mm. wide, are led along these dark passages. The temperature of the catacombs seldom varies from 12° cent.; the atmosphere is damp, the floor being generally only a few feet above the level of the wells, and water percolating always through the rock. These are the best conditions possible for the preservation of gutta-percha covered wires in air. For the lines underneath the streets iron tubes are employed to protect them against mechanical injury, whilst they also prevent the circulation of air and retard the deterioration of the gutta-percha by oxydation. The tubes are like those used for gas, of cast iron, in lengths of 2·3 metres, the diameters being proportioned to the number of wires in them. They are planted in a trench 1 metre deep. The separate lengths are connected up with lead joints, and at distances of from 50 metres to 150 metres a tube is inserted of larger diameter, which slides over the ends of the two neighbouring tubes, so that by pushing it back the lines can at any time be got at. These places are also used for drawing the cables through. This is done in lengths of 400 metres, the cables being well covered with powdered talc, to reduce the friction against the sides of the tubes. Five men are employed to plant the lines, and are said to be able to complete a statute mile per day.

The average cost to the French Government of a line of sixty-three wires, in nine cables of seven wires each, contained in an iron tube 120 mm. diameter, is as follows:—

| | |
|---|---|
| 1. Cast iron tubes, including trench, laying down, and covering up | 8,000f. |
| 2. Nine cables (of each seven conductors), at 2,900f. per kilometre | 26,100f. |
| Total......... | 34,100f. |

Taking sixty-three wires, therefore, per kilometre of wire, 541f., or less than £35 per statute mile.

Rattier and Co., Bezons, exhibit cables of two different kinds for underground work—1. Gutta-percha-covered wires, protected with tape and tarred hemp. 2. Cables which, in addition to these, are protected with an outer tube of lead. The cotton-covered cables are employed largely by the French telegraph administration on their lines; the lead-covered are mostly employed by the railway companies for tunnels and crossing stations.

Léon Delperdange, Brussels, exhibits specimens of the tubes used in Belgium for the protection of underground lines. They are of wrought iron, with a slit three-fourths of an inch broad along the upper side for laying in the cables and saving them from the chances of injury by being pulled through. When the cables are placed in the tube a length of ⊥-iron, broader at the bottom than the slit, is put into each of sections and fastened there by means of three iron wedges, passing through holes in the upper rib of the ⊥-iron. The space above the latter to the height of the top of the tube is then filled in with some water-tight cement, which seals it up completely, but can at any time be removed with a chisel in order that the cables may be taken out and examined, if necessary. The joint between two separate lengths of tube is made by a ribbed clip, which presses a collar of vulcanised indiarubber over two slightly-elevated rings in the neighbouring ends of the tubes. At regular distances, the tubes enter round the testing-boxes, formed by cylindrical chambers covered by flat lids, with packing of indiarubber.

Donald Nicoll, Kilhorn, exhibits specimens of his system of rigid sections for underground lines. The wires are of copper, No. 16, B.W.G., placed parallel, two inches apart, in troughs of wrought iron, 11ft. in length, and insulated with a bituminous compound. The wires protrude, about an inch from each end, for the purpose of making the necessary joints between two sections. At one end of each section the wires are twisted in hollow coils; at the other they are straight. In planting the sections, the straight ends of one section are intended to be pushed into the coils of the neighbouring ones. The ends are to be previously tinned, so that the joint is made electrically perfect by simply applying a hot soldering iron for a moment to the outsides of the coiled ends. When the wires are connected up, an iron trough, which embraces the ends of both troughs, is put under them and the space filled up with melted asphalte, by which means the insolation of all the wires at the junction is effected at once, requiring little skill or practice on the part of the workmen employed. This is certainly a great point in favour of the proposed system. Mr. Nicoll has adopted a simple and sure method of keeping his wires apart in the melted bitumen. He covers them with coarse hemp, well dried, through the fibres of which the melted bitumen penetrates. Mr. Nicoll believes that the transport of these rigid sections with any number of wires insulated by this method would be a matter of no difficulty whatever, and that the planting, joining up, &c., could be done much more rapidly than the same length of overland line could be erected.

A. Holzmann, Amsterdam, exhibits a length of line resembling the above in general appearance. Instead of planting rigid sections, however, M. Holzmann lays down his troughs first, then places the wires in them, divides them by glass supports, and, lastly, pours in melted gas tar. The trough is afterwards covered up with a lid, which is wedged in. Half a mile of such line is at work between Amsterdam and Abconde, and is said to work very satisfactorily. But the method of dividing the wires by glass supports seems objectionable.

These systems are not new; they have been tried repeatedly in France and in England, but failed, partly because the material employed for the insulation was too brittle, partly because insufficient care was taken to keep the wires apart. But, with the benefit of all the experience and failures of other inventors, it is to be hoped that both Mr. Nicoll and M. Holzmann may succeed in their endeavours to give us cheap underground lines, by which they will be doing a most welcome service to telegraphy.

### Overhead Telegraphy.

The Prussian Telegraph Direction, Berlin, exhibits two complete lines, with station introductions. One of these is wire of 5·3mm. diameter, the other of 4mm. The insulators used on the Prussian lines are the porcelain bells of Mr. Clark, the groove of which is made deeper and narrower, in order make the escape of the current over the surface as difficult as possible. The bell is provided with grooves at the side and on the top. The wire passes sometimes by the one and sometimes by the other. Specimens of these connections are shown, and also of the manner in which thick wires are joined to thin ones.

The French administration of Telegraphs, Paris, exhibits also complete lines insulated and connected in the French style. The insulators are of two kinds—those of which the porcelain is formed in a flange, screwed directly to the post, used as line supports; and those which are held by an iron stalk underneath, used as stretching insulators. The latter are the better of the two, but are not so good as either the German or the English insulators. The administration shows also an iron post, of which the upper part is rolled, + section iron, and the lower part a socket of cast iron. These posts are very strong, notwithstanding their light appearance. They are being introduced in great numbers in France; and, as is natural, are found much more practical than the wooden ones. That wood is cheap and iron dear is no reason for employing the one and rejecting the other for telegraph posts. Let an iron post cost four times as much as a wooden one, it lasts ten times as long, and is therefore, in the long run, twice as cheap.

Siemens Brothers, London, show specimens of their tubular iron posts and the insulators used with them. The posts are composed of three parts—an upper, conical, welded iron tube; a cast iron socket, and a buckled plate forming the base. These posts are stronger, and in every way preferable to the French ones. They are largely used in India and elsewhere, and are justly celebrated. The insulators shown by Messrs Siemens consist of cast-iron bells, with flanges by which they are fixed against the posts. Inside the bell, a porcelain cup is cemented; and inside the cup, a hook to support the wire. Sometimes two bells are cast upon the ends of a cross-arm, with a hole in the middle, by which it is fixed to the top of the post. This insulator is made fast to the post by a single screw.

John Bourne and Son, Derby, exhibit specimens of red earthenware insulators, mostly of the double-cup form known as Varley's. For a light, cheap, well-insulating support, in the writer's opinion, there can be nothing better than that made of two cups of good, close glased earthenware cemented together. It gives a greater guarantee against faults in the material than the best porcelain in the form of a single cup. These insulators are extensively used in England, but very little abroad.

The Spanish Telegraph Direction, Madrid, exhibits two insulators of peculiar construction attached to what is intended to represent the top of a wooden post. They are the suggestion of Mr. T. M. Zapata. This insulator consists of a taper-shaped porcelain tube, which carries an iron hook in the central hole, and is supported by a wrought iron collar, allowing the hook to project underneath. The construction allows the porcelain to be easily changed in case of a fault.

Meoans and Co., Paris, show specimens of French telegraph wire. A coil of 3mm. diameter, with welded joints, is shown, measuring 1,234 metres and weighing 68 kilo. The breaking strain is 438 kilo., or 62 kilo. per square millimetre section. Amongst the best telegraph wires exhibited are those of Messrs. Johnson and Nephew, of Manchester. The single lengths drawn by those manufacturers exceed those of any others. They measure as follow:—

Gauge No. 3=530 yards, weighing 281lb.
" " 8=900 " " 200lb.
" " 11=790 " " 95lb.

Long lengths of line-wire without weld or joint are important for overhead lines, reducing the danger of the wire parting either when stretching the line, or in winter, when the wire contracts.

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## LIGHTHOUSES AND COAST ILLUMINATORS.

By Captain M. Close (Trinity House).

In the necessarily-contracted space to which a report on the lighthouse department of France and England, as shown in the Universal Exhibition of Paris. is restricted, many objects of interest may only be enumerated, and much interesting detail of those reported on will have to be omitted.

### France.

The handsome iron lighthouse, erected on rockwork, nearly surrounded by water, on the park entrance from the Pont d'Jena, is to be placed on a dangerous reef off the north coast of Brittany called the Roches Douvres—rocks situated about equi-distant from the islands of Brehat and Guernsey, and about twenty-seven nautical miles from the port of Portvieux. It will stand on the south side of the middle of the reef. The basement of the masonry on which it will be placed is on a level with high-water spring tides, and will be carried up 2·10 metres. The height to the summit of the lantern is 56·15 metres; its diameter at base is 11·10 metres, and 4 metres at the top beneath the lantern gallery. The focus of the light will be 53 metres above high-water. The tower is peculiar and elegant in form; the peculiarity of its construction is that its powerful framework is independent of the outer iron coating, so that any part of its plating may be removed or changed without in any way affecting its strength, enabling, moreover, easy inspection of its plates. It also has the advantage, during erection, of dispensing with all scaffolding, and combines strength with lightness and economy, the complete building (including the cost of erection, &c.) costing only £10,000. The tower contains, besides coal-bunker and oil-tanks, a kitchen and three keepers'-rooms, and a room for the inspecting engineer. It is surmounted by a first-order revolving light, giving a bright flash every four seconds, the eclipses being nearly double the duration of the flash, which is prolonged by a peculiar arrangement of the upper and lower prisms. The apparatus consists of a polyzonal cylinder of twenty-four sides; the dioptric lens and the two cata-dioptrics of each face have their axes in the same vertical plane; they have a horizontal divergence of 6°. and their maximum intensity is reckoned at 2,475 flames. The revolving machinery produces an entire revolution in 1min. 36sec. M. L. Renault, Chief Engineer of the Ponts and Chaussées, and Mr. E. Allard are the engineers, and M. Rigolet the constructor.

The following lenses are shown in the building, viz.:—

1. A first-order fixed lens, varied with sixty-second flashes from a second-order polyzonal lens, the whole revolving; the sections of the frame and lens and the fixed light being projected in advance of the revolving light in proportion as the diameter of a first-order frame is greater than that of a second order. The idea is to equalise the light from the revolving and fixed lenses by increasing the fixed as a first order and diminishing that of the revolving one as a second order.

2. A lens of alternate flashes and eclipses at intervals of sixty seconds. It is 0·70in. in diameter, a size between the third and fourth order. It consists of eight polyzontal lenses, with twelve prisms above and four below. The central zone, or polyzone, has six rings; the light is focussed in this lens by means of a long spiral screw from the base of the pedestal to admit of it being used for an electric light. Two of the eight sections open for trimming, &c.

3. A section of a third-order light fixed, with shutters outside the lens working from right to left simultaneously by clockwork machinery, creating eclipses in the direction of danger. The machinery and arrangement appear very simple. This apparatus is fitted with revolving machinery.

4. A first order revolving bolophotal lens, of twenty-four sections to the circle, similar to the one already described for the Roches Douvres. The glass, both in colour and finish, is very good. The supports or framework of the lower portion are of brass, which makes it costly without increasing its strength. Intended for America. Made by Barbier and Co.

The second lenticular electric apparatus exhibited produces different periods of light. Both are revolving. The first prolongs the flash, and thereby reduces the period of the eclipse, the lenses being placed so as to give a greater divergence than is generally the case, and to avoid as much as possible all vertical divergence, to effect which recourse has been had to the system of double lenses—such as are seen in the Calais and some other French lighthouses. Each of these lenses consists in the first place, of a sixth-order fixed light, very well made, with the prisms as small as possible to avoid thickness of the glass.

Around the lower fixed lens a six-sided apparatus revolves, each face consisting of a central section of a cylinder, about 30° wide, and the full depth or height of the fixed apparatus. On each side of this central piece are fixed, parallel with it, three refracting prisms, each of the three comprising about 15°, thus making each entire face about 60°. By focussing each panel about ½in. beyond the light, a greater degree of divergence is given than would be due to the size of the light—this divergence is about 6°, consequently each flash would be ten times as bright as a fixed light of the same power as the one employed. The outer apparatus revolves in seventy-two seconds, giving a flash every twelve seconds, and the light interval is to the dark as 1 to 10.

The upper lens has around it a revolving apparatus, consisting of eighteen very thin sections of a cylinder of 20° wide, each without any prisms. The side next the light in these, as well as those in the lower lens, are plane surfaces—the outer only is curved. The focus of these, as of the others, is behind the light, for the purpose of giving extra divergence. In these the divergence is 5°, with a flash four times as strong as the fixed light; and the proportion of time between the duration of the flash and the darkness is 1 to 3. The revolving part of this upper lens turns with the same velocity as the lower, which gives a flash every four seconds.

Drawings of the various lenticular apparatus are exhibited in the lighthouse.

The intensity of the flashes is considered to be as follows, viz.:—

| | | | Flames. | |
|---|---|---|---|---|
| The flash light ... ... | from | minimum | 13,500 to 20,000 | maximum. |
| The fixed light ... ... | „ | „ | 5,000 to 5,000 | „ |
| The fixed light, with flashes | „ | „ | 49,000 to 73,000 | „ |
| The 30 sec. eclipse light ... | „ | „ | 10,000 to 15,000 | „ |

It is thought these intensities may be doubled by putting both steam-engines in motion.

A type of the harbour lighthouse adopted by France is shown on the banks of the Seine. Its height is 8 metres from the base to the platform gallery; diameter at base, 1·71 metres; and at the summit, 1·49 metres.

It is octagonal in form, of T-shaped iron mountings, bent to the desired angle and covering the joints. Its cost is £360. The illuminating apparatus is composed of six annular lenses, partly dioptric and partly cata-dioptric, producing a flash every twenty seconds. Colza, petroleum, or schist oil may be used in these lenses. The flashes alternate red and white. M. L. Renault and E. Allard, engineers; and M. Rigolet, builder.

Among the models of this department are the following:—

3. The lighthouse of Triagoz is represented by a model in relief. It is a third-order light, situated on a rocky island to the east of the Sept Isles, in the Channel. It consists of a square tower; on the basement is a vestibule with store-rooms and three keepers'-rooms, the roofs being vaulted; and it has an external gallery. The building was commenced in 1861 and completed in 1864, at a cost of about £12,000.

4. Phare de la Bancbe, began in 1861, finished in 1865, is situated to the south-east of the entrance to the Loire, about 9,500 metres from the land. The height of the building is 26,525 metres, and the focus of the light 21·225 metres above high water spring tides. The cost of the work amounted to nearly £13,000. Built under the superintendence of M. Chatory and Messrs. Lalley and Britat.

5. This model represents a lighthouse erected, in 1865, in New Caledonia; it is of iron, and in nearly all respects analogous to that of the Roche Douvres, which renders a detailed description of it here needless. It was constructed under the same engineers as the former one.

The following are drawings of various lighthouses, either completed or in process of erection:—

Phare du Créach, established on a reef of rocks lying off the west point of the island of Ushant. The tower is 43 metres high, built of the stone of the island, pointed with Portland granite, and was completed in 1863, at a cost (lens inclusive) of upwards of £14,000. M. Matrot de Varennes is the chief engineer.

Phare de Conti, mid-distance from Arcachon to Biarritz, on a sand-hill surrounded by a sandy desert, rendering the construction of it a matter of great difficulty. It cost upwards of £7,000.

A drawing claiming attention is that of the lighthouse of Cape Spartel, at the entrance of the Strait of Gibraltar, on the shores of Morocco, at a spot where the Brazilian frigate *Dona Isabel* perished with her crew in 1860.

Many other interesting drawings of lighthouses are exhibited.

As for the floating-lights, there is a model of a lightship moored in the roadstead of Dunkerque, called the "Ruytingon" Light. It is built nearly on the lines of our English floating-lights, and has little deserving special notice. Its cost was about £5,000.

With regard to the models of buoys exhibited by France, the first four numbers represent beacon buoys, the fifth a mooring buoy. They are made of iron plates on an iron frame, divided into water-tight compartments, so that, should a plate be damaged or become leaky, the buoy would heel over, but the air-tight compartments prevent it sinking. These buoys, both in form and construction, resemble those in use in England, the report on which will serve equally for either. This applies also to the bell buoys.

Model of a beacon on the Antioche Rocks, Isle of Oberon, consists of four iron cylinders carrying a square iron cage, surmounted by a pyramid, intended as a refuge from shipwreck. Cost about £800. Executed by Mr Beaucé under M. Leclerc.

A tour balaisé for sea mark and saving life has a tide-gauge and beacon, also a bell, rung by the motion of the sea acting on floats. Erected April 20, 1865, in the Isle of Noirmontier; also in use off Rochelle. The bell and machinery by M. Foucalt Gallois, of the Ile de Ré; built by M. Forestiér.

### England.

In class 66 of the English section of the Paris Exhibition, in the very limited space afforded for exemplifying the lighthouse illumination of Great Britain, the Trinity House authorities contrast some beautiful modern lenses with a ponderous old bull's-eye lens, made by Cookson, of Newcastle, which, in spite of the green colour of the glass and the workmanship, which looks very coarse when compared with the high finish and sparkling appearance of those of the present day, still did service for many years, having in its turn succeeded the patched old metal reflector that had taken the place of the beacon fire about a century.

With whom the first idea of the built lenses, on which those of the present day are merely improvements originated, is, and probably ever will be, a disputed point. Sir David Brewster and Condorcet both lay claim to priority of invention; but there is little doubt that M. Fresnel was the first to produce a lense built of separate pieces of glass, at the suggestion of Condorcet, and this system of illumination is known as "Fresnel's system."

For many years the superiority of French glass left England entirely dependent on that country till Mr. James Chance, of Birmingham, took the matter in hand; and the Trinity House exhibition in Paris proves the success that has crowned the labours of this talented and indefatigable gentleman, both in respect of glass, workmanship, and optical science.

The following is a list of the various lenses, &c., exhibited by England:

1. A first-order fixed light for 360° of the horizon, consisting of eight panels of lower prisms, eight prisms in each panel; eight inclined panels of lenses, each panel having a central belt and eight rings above and below it; eight panels of upper prisms, eighteen prisms in each panel. The twenty-four panels are connected together by a gun-metal armature, and mounted on a cast-iron lens curb, which is supported on ornamental cantilevers secured to the lantern block ring. By Chance Brothers, of Birmingham.

2. An eight-sided revolving light of the first order, with gun-metal armature, and mounted with its rotatory carriage on a square pedestal, with glazed doors containing the clockwork. An improved pressure-lamp is placed inside this apparatus.

3. (In the Park.) A third-order fixed light, to illuminate 288° of the horizon, and on the land side an arc of 72°, having Mr. Thomas Stephenson's dioptric mirror with the improvements of Mr. James Chance. This apparatus is arranged for the electric light, and has ten upper prisms, and inclined lenticular panels, consisting of a central belt, with six rings above and below. The dioptric mirror is made in halves, so as to allow of its being opened to afford access to the electric lamp and for cleaning. The standards of the upper and lower frames are made to alternate with each other. The whole of the apparatus is mounted on an ornamental cast-iron circular pedestal. This light is erected inside a temporary lantern with its framing coinciding with that of the apparatus. The joints of the lenticular zones are inclined in the directions of the corresponding refracted rays from the focus.

4. (In the Building.) A small third-order fixed light, designed by Mr. Thomas Stephenson, to condense its light into 45°. This apparatus consists of 180° fixed light, the 45° in the centre giving direct light, and the 67½° on each side being condensed over the central 45° by means of a dioptric reflector, the same as that already referred to; whilst a fourth-order semi-holophote condenses the rays passing above the mirror, and throws them on a set of rectangular reflecting prisms, so curved as to transmit the light falling on them over the arc of 45° required to be illuminated. In use in the Tay.

5. A first-order dioptric mirror for 180°. The light, radiating from any point in the vertical axis, is returned upon a corresponding point in the same horizontal plane by two internal reflections. The idea was originated by Mr. Thomas Stephenson in 1850, but was first carried into effect by Mr. James Chance in 1862. Intended for Ushinish.

6. A fixed floating light, composed of eight small beehives, of 180° each, of the eighth order. Each apparatus is fitted with a reflector and lamp, the whole being mounted in a small lantern. By Messrs. Milne, of Edinburgh.

7. A sixth-order holophote, with dioptric mirror of flint glass, having the successive rings abutting together. This mirror is constructed on the principle of Mr. Thomas Stephenson (already referred to), and was the first one ever constructed, the work having been successfully carried out by Mr. James Chance.

8. A sixth-order holophote, with metallic reflector.

9. A 21-inch parabolic reflector, with a small holophote in front, 10¾in. diameter of periphery. A portion of the above reflector at its back is replaced by a spherical metallic mirror, of the same opening as the diameter of the holophote; the whole is fitted on a stand with a lamp.

10. A sixth-order fixed light, with a segment of holophote attached, throwing its light on a set of vertical prisms, intensifying a particular arc.

A first-class mechanical pump lamp, by Milne and Co., of Edinburgh.

The lantern exhibited by the Trinity House is a first-order one, designed by their engineer, Mr. J. Douglas, and is intended for the Wolf Rock Lighthouse. The chief difference between this lantern and all former ones is that the glass of it, being cylindrically curved, affords the greatest degree of optical accuracy, and the helical steel framing offers the least possible obstruction to the light.

The Wolf Rock lies midway between the Scilly Islands and the Lizard, about twenty-two miles and a half from either, and almost in the fair way of ships bound from the Channel either to the west coast of England, to Ireland, or Scotland. It is submerged at high tide, and, owing to there being deep water all round it, the lead gives no warning of its proximity. From time immemorial, therefore, it has been a terror to navigators bound to any of the above-named destinations, and still more so to inward-bound ships, which in the dark and stormy winter months have not been able to correct their reckoning by observation of sun or stars. In the earlier days of engineering science the impracticability of placing a lighthouse on it, owing to its exposed position, its great distance from land, and, above all, to the heavy sea which at all times breaks over it, appeared to be insurmountable. In 1840, however, the lighthouse authorities determined to try and place a beacon on it, which, after various failures, was accomplished at an outlay of £10,000 and after seven years of danger and disappointment to the builders. This beacon, however, could only be seen by day, and the terrors of the *Wolf* during dark and stormy nights remained undiminished. When the eminent engineers, Messrs. Walker and Burgess, had succeeded, in 1858, in crowning the Bishop Rocks, which lie to the S.W. of the Scilly Islands, and on which Sir Cloudesly Shovel and his fleet suffered shipwreck in 1707, with a lighthouse, the greatest triumph of engineering skill extant, the Trinity House authorities applied for the Government sanction to erect a lighthouse on the *Wolf*, which was unhesitatingly granted, and the first stone of the building was laid by their engineer, Mr. W. Douglas, on August 6, 1864; since which, through his indefatigable energy, after the frequent destruction in a few minutes of the work of days, the lighthouse has in the course of three summers attained a height so unexpected that the authorities hope to exhibit the light from it in the course of a couple more years. The light which will be a powerful first order dioptric one, showing entirely round horizon at a height of 110ft. above high water, will not merely warn ships off the rock, but will act as a point of departure and a landfall for both outward and inward bound ships; for, standing, as it does, out in the midst of the ocean, navigators will not hesitate approaching close, though at present they give so wide a berth to the Wolf Rock.

### The Electric Light.

Before entering on this subject it may not be irrelevant here to call attention to an axiom in the theory of light produced by chemical action—viz., that its production depends on two conditions; first, that there must be solid particles in a condition capable of taking up the velocity; and, secondly, chemical action to impart the velocity to them. For instance, in the lime light we have the combination of hydrogen and oxygen which produces of itself very little useful light, as it is purple; but when the combined flames are made to play on a piece of lime, the heat produced by the combining gases sublimes the lime, and then the particles or atoms floating in the flame produce an intense white light.

In the oil-lamp the hydrogen of the oil unites first with the oxygen of the air, and during this combination the particles of liberated carbon are floating in the combining gases as the particles of the lime were in the former instance; but, as the combination in this case is not nearly so violent, or rather as the velocity of the combining hydrogen and oxygen is not so great, the light produced is less intense. As, therefore, electricity exceeds all other means of giving velocity to such particles, so must the light it gives be of greater intensity than all other known lights.

As this light is now in use on both sides of the Channel, it may be well before describing those in operation at the Great Paris Exhibition, to remind our readers of its origin. In 1831 that great and modest man Faraday announced to the world his grand discovery—viz., that whenever the magnetic force in a soft piece of iron or steel is being increased or diminished a current of electricity will be induced in a coil of insulated wire wound round such piece of soft iron or steel; to this discovery was soon added the knowledge that the force of the electric current thus produced is proportional to the magnitude of the increase or diminution divided by the time in which the change takes place; and, further, that the current thus produced is modified by the length and size of the wires employed being changed from a current that will melt a large iron wire on passing through it, but which at the same time will pass through the human frame unfelt, to a current that will not warm a small wire, but which will or can cause instant death to any living creature. The object, therefore, of the arrangement of all the parts is, first, to arrive at a maximum of electricity from a given weight of magnets, and, secondly, to modify the current in the coils, so that the shock shall be trilling, but the intensity great enough to produce a permanent light.

The application of the immortal Faraday's discovery to the purposes of coast illumination is solely due to the scientific attainments and great mechanical skill of Professor Holmes, whose indefatigable perseverance for more than a quarter of a century resulted in the magnificent light which was first shown from the South Foreland in August, 1858, was permanently placed at Dungeness, and has since been brought into use at Cape La Hève, to light the entrance to the River Seine, and will, moreover, shortly be shown from a lighthouse in the course of erection on the coast of Yorkshire. The great Paris Exhibition has afforded world wide opportunities of witnessing its splendid effect.

In the electric light first experimentally used by the lighthouse authorities at the South Foreland and finally placed at Dungeness, the arrangement is as follows—viz., there are three concentric rings of magnets, and between the poles of those forming the first and second rings, and also those forming the second and third rings, the rims of two brass wheels revolve. The rims of these wheels are hollow, and contain the "helices" or "bobbins;" but the soft-iron cores round which the wire of the bobbins is wound are screwed into the sides of the hollow rims, and are turned off flush on the outside. The wires of all the helices or bobbins are connected together in series in the rim of each wheel, and the terminal wires are carried down behind the panel to four screws, two of which screws receive the wires for each wheel. These wires are carried through the hollow axle of the wheel to the outside of the bearing, and are there joined to their respective commutators. The commutators are contrivances by which the alternating currents of electricity induced in the helices are directed, and thus the entire current passes from the machine in one direction, instead of alternating, and forms a constant current.

The magneto-electric machine in the English portion of the Exhibition in Paris differs from that at Dungeness simply in this—that each machine consists of six brass wheels, every wheel having sixteen helices of insulated copper wire. Inside each helix is placed a hollow core of soft iron; the wheels are all firmly fixed on a shaft, which is driven by an Allen steam-engine. The horseshoe magnets are placed in rings of eight in each ring, with their sixteen poles in the same plane pointing inwards towards the axle, and so adjusted that the distance from centre to centre of the poles is exactly equal to the distance from centre to centre of the cores of the helices. The magnets are so arranged that, whether counting the poles around one ring, or counting longitudinally through the seven rings, the poles are alternately north and south poles. In each machine there are ninety-six helices and fifty-six magnets. The intensity of current depends on the length of the wire throughout the connected series of helices; the quantity of electricity depends on the quantity of magnetism induced in the soft-iron cores, and on the velocity with which this quantity is taken up at each reversal of the poles. Experience of this engine shows us that 6,400 changes of polarity per minute give the best result for light. No wood is employed in the English machine. The electric current is conducted through the wires to the lantern, where it passes alternately through the carbons, and at the points of these, when nearly in contact, the effect described at the opening of this subject occurs, and the most brilliant light known is the result.

The English and French electro-machines now in operation at the Paris Exhibition, though different in construction, are the same in principle; so is the motive power, only that the French use the driving strap, whereas our electro-engine is worked by the direct action of the steam-engine, experience alone can prove which will turn out the most efficient. The English light is shown in a fixed lens, because the position it is intended to occupy on the east coast of England is that of a fixed light; and, however glad the lighthouse authorities would have been to test the great increase of power a revolving lens would have imparted to it, they had no such lens ready to experiment with. The result obtained in the fixed lens has proved a great success. Viewed from the hills surrounding Paris, the long-wished-for opportunity of testing the effect of the electro-magnetic light against the ordinary dioptric system is afforded by the beautiful revolving first order dioptric light intended for the Roches Douvres and shown from the fine iron lighthouse built for those rocks and placed in the French section of the park. This induced the English authorities to put up a rough scaffolding, on which, at a height of 145ft., and nearly on a level with the French dioptric revolver, their electric light is exhibited. Had the French electric one been at a similar elevation, there can be no doubt that the powerful concentration into one beam of those rays which in a fixed light are scattered round the horizon would have been made amply manifest; nothing, however, could be more beautiful or dazzling than the effect of the French electric light already described, shown as it is at an elevation of only a few feet from the ground, through alternalting colouring lenses. I may take this opportunity, in the name of my colleagues and myself, of offering our tribute of thanks to M. Leonce Renault, Inspecteur-Général des Ponts et Chaussées, for his kind courtesy in affording information on every subject connected with his department of this beautiful exhibition. Whatever rivalry there is, here is an international and honourable rivalry of science and art, and one that only result in the good of our fellow-creatures.

The French electric light, or rather two lights, exhibited from the windows of a small building in the park, differs from the Dungeness one in that, whilst the latter consists of three rings of magnets, with their poles outwards, radiating from the centre, each ring consisting of twenty magnets or forty poles, the French machine has seven rings of eight magnets each, or sixteen poles (*i.e.*, 112 in all), the poles of the magnets turning inwards; between these turn six wheels, each containing in its periphery sixteen helices. The maximum intensity of light is attained by a speed of from 350 to 400 rotations per minute, whereby the electric current is inverted about 100 times in a second. Another difference between the French machine and the Dungeness one is due to an improvement of M. van Maldern, and consists in doing away altogether with the commuta ors. The magnets in the French machine are of a power of about 60 kilog. each. There are two engines and two electric lamps; the second engine is used in hazy weather to augment the intensity of the light, or in case of accident to the other engine. This light, like our own, is furnished with magneto-electric clockwork, which regulates the movements of the carbons; these, however, require constant watching. Although the electric current passes alternately through each of the carbon pencils, it is found that the lower one burns away more rapidly than the upper one in the ratio of 108 to 102, necessitating a very delicate and intricate arrangement of the clockwork and frequent manipulation.

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THE survey of the Thames sewer outfalls made in June showed near the northern outfall a space of more than forty acres, and near the southern outfall about 120 acres of the bed of the river covered by a deposit varying in depth down to 7ft.; the deposit has been traced for above a mile, and might be followed further down the river, though in decreasing amount.

## NEW RAILWAY BILLS.

The notices of intended application to Parliament for railway bills in the session of 1868 are 109, as compared with 171 for 1867, 450 for 1866, 415 for 1865, and 360 for 1864. Considering the protracted effects of the panic of May, 1866, and the continued want of confidence in railway enterprise and railway securities generally, it seems surprising that so many notices for the incorporation of new companies should have been given to carry out what might be considered very doubtful projects; and, as powers are sought to lease or sell some of them to other companies, the object appears speculative and intended for private advantage.

About 50 per cent. of the intended bills are for the extension of the time granted in 1864, 1865, and 1866, for the purchase of several lands and completion of works; including also the abandonment of several branch and extension lines, Acts for which were obtained two years ago by great exertions and at enormous expense. With the exception of notices of application for the extension of time to purchase lands and complete works, and to abandon useless and fighting lines, those for the actual requirements of established companies are very few. The Eastern Metropolitan Underground Railway Company seek to be incorporated for the purpose of making a railway from the Great Eastern line at Bow to the East London Railway at Whitechapel, and thence to the Metropolitan (extension to Tower-hill) line at Aldgate; also to form a junction line at Bow with the North London Railway, and to sell or lease the undertaking. The Islington Company propose to make a railway from Lower-street, Islington, to Little Moorfields, to the north of the Moorgate-street station of the Metropolitan Railway. The East London Railway Company seek for an extension of time for the purchase of lands and houses, to make up and down junction lines with the Brighton Railway, the New-cross station line, and to abandon portions of lines not required. The London and Blackwall Railway Company require further time to purchase lands and complete the works of the Millwall Extension line. The Metropolitan Railway Company propose to make a short railway from their line under the meat and poultry market in Smithfield to the London, Chatham, and Dover Railway at Snow-hill, and to extend the time for the purchase of lands and completion of works, and for making the deviation on the company's Western Extension line. The Metropolitan and St. John's Wood Company ask for an extension of time to purchase lands and complete the works of the extension to Hampstead, granted by Act 1865. The South-Eastern and London, Chatham, and Dover Companies jointly seek for power to abandon the London, Lewes, and Brighton "fighting line," sanctioned by Act 1866. The Metropolitan District Railway Company ask for an extension of time to purchase lands and houses, and to complete works. At the same time the Board of Works seek for power to prevent delay in the opening of the Thames Embankment, and the roadway and streets thereof, by any default on the part of the Metropolitan District Railway Company in proceeding with their railway in connection with the embankment. The Great Eastern have given notice for extension of time for the purchase of lands and completion of railways, especially in reference to their Metropolitan Station and Railway, and the Alexandra-park branch. The South-Eastern and the London, Brighton, and South Coast Railway Companies intend to apply for power to unite them for the purpose of joint management, working, and maintenance as one undertaking. It is proposed to incorporate a company to construct a subway under the River Thames from near the Tower to Vine-street, Southwark. The Waterloo and Whitehall Railway ask for an extension of time to purchase land and construct works. There are three distinct notices of intended application to Parliament for the construction of street tramways. The Metropolitan Tramway Company (limited) propose to lay down street tramways from the Archway-road, near Highgate, to Finsbury-place; from Seven Sisters-road, through Camden-town and Tottenham-court-road to Oxford-street; from Whitechapel to Stratford; from High-street, Clapham, to Kennington-park-road, Lambeth: from Brixton-hill to Kennington, and from Kennington to Westminster-bridge. It is proposed to incorporate the London Street Tramways Company to make tramways from Upper Holloway to Camden-town and Bishop's-road, Paddington; from Camden-road, Bayham-street, to New Oxford-street; from Holloway-road to Islington and Smithfield; from Westminster-bridge-road to High-street, Borough; also from Westminster-bridge to Clapham and to Brixton. Each tramway is to occupy 5ft. 3in. in width, and pass along the central portion of the street, or within 4½ft. of an imaginary central line. Liverpool is to be favoured with twelve street tramways. Notices for extension of time for purchase of land and completion of works have been given by fifty companies. Notices of abandonment of authorised lines have been given in respect of the Chichester and Midhurst, the Surrey and Sussex, the Newhaven Tramway, the Ouse Valley lines, the Tunbridge-wells and Eastbourne, the St. Leonard's and the St. Leonard's Deviation line, all belonging to the London, Brighton, and South Coast Railway Company. By the West Riding and Grimsby Company the abandonment of the Keadby and Lincoln Extension is sought. By the Worcester, Dean Forest, and Monmouth Company power is sought to abandon the Great

Malvern to Abinghall, and from Abinghall to Newland, also the extension from Newent to Glocester. By the North-Western and Charing-cross Company power to abandon the undertaking and dissolve the company is sought. By the Lymington Harbour and Docks Company is sought the abandonment of the Railway Act 1864. By the Sevenoaks and Tunbridge it is proposed to abandon part of the undertaking. By the Bristol and Exeter Company power is sought to abandon the Tiverton and North Devon Railway. By the Bristol and North Somerset to abandon one line not required. By the Caledonian it is proposed to abandon the Bangholm Junction, the Shielhill branch, the Crieff connecting Junction, and Barrhead and Paisley branch. By the Ilfracombe Railway Company it is intended to abandon the undertaking and dissolve the company. By the North British it is proposed to abandon No. 1 of the Lasswade branches, No. 1 of the Coatbridge lines, the Dundee Branch Railways, the St. Margaret's diversion line, the Camps, &c., branches, No. 1 and No. 3, authorised by the Devon Valley and North British branches; No. 2 railway, authorised by the General Powers Act, 1867, and also a portion of No. 2 railway, authorised by the Financial Act, 1867.

The intended new railway companies are the Isle of Wight (Newport Junction), for making junction railways to Sandown and Newport; the Monmouthshire and Great Western Junction, for making railways from the Western Valleys Railway to the South Wales Railway and to the Alexandra (Newport) Dock branch; the Somerset and Dorset propose to purchase the existing Somerset and Dorset Railway and to wind up the affairs of the company; the Ross and Monmouth and Forest of Dean seek for power to make a railway from Lydbrook to the Ross and Monmouth Railway at English Bicknor; the Eastern Metropolitan Underground, for making a railway from the Great Eastern Railway at Bow to the East London Railway at Whitechapel and to the Metropolitan Tower-hill Extension at Aldgate; the London, Thames Haven, and Kent Coast Company, for making a railway from Herne Bay Pier to the Herne Bay station of the Kent Coast Company; Islington Railway Company, for making a railway from Lower Islington to Little Moorfields; the Liverpool and Birkenhead Railways and Ferry Junction, to make a railway from the Birkenhead and Chester Railway to the river Mersey, and from the Dingle Tunnel of the Garston and Liverpool to the opposite bank of the Mersey; the interval on the Mersey was to be worked by a steam ferry; the Glastonbury and Street Company, for making a tramway between those places; the Great Marlow Railway Company, for the construction of a railway from the Wycombe branch of the Great Western to Great Marlow; the Isle of Wight Central, for making railways from Newport to Sandown; the Isle of Wight, Cowes, and Newport Junction, for making three railways to connect the Cowes and Newport and the Isle of Wight Railways; the Langdale and Windermere, for making tramways in Westmoreland; the Birkenhead and Liverpool Railway Company, for making a railway from the Birkenhead Railway, passing under the river Mersey to Liverpool, with extensions to other railways; the Weedon and Daventry Railway Company, for making a Railway from the Weedon station of the London and North-Western Railway to Daventry.

The proposed amalgamation or joint working of companies are those of the South-Eastern and London, Brighton, and South Coast, who are also, it appears, to work the London, Chatham, and Dover Railway; the London and North-Western and Knighton, Central Wales, and Central Wales Extension; and the Great Western and Bristol and South Wales Union Railway Company.

The Brecon and Merthyr Tydfil Junction Company seek power to define, consolidate, or readjust the several classes of mortgages, bonds, and other securities, guaranteed, preferential, and ordinary shares and stock. Power to suspend actions and suits for a certain period; to convert debentures and other debts into stock, and to provide for the conversion of Lloyd's bonds and other securities. The Cambrian Railway Company propose to provide for the separation of the undertakings of the company into two separate undertakings, and, in another notice, to confirm a scheme of arrangement filed in Chancery under the Railway Companies Act (1867), and to grant powers to carry the same into effect. The Crystal Palace and South Junction Railway Company propose to form junctions with the Chatham and Dover and the Brighton South London Junction lines, and to raise further capital. The Great Eastern, to alter and improve its management. The Lancashire and Yorkshire, to extend the time authorized for the completion of certain branch railways. The London and North-Western (branches and additional powers), authorizing the company to make a railway to Sheffield, the Crown-street, Liverpool, Extension, a railway at Derby, the Harpur-hill deviation, and the Llanberis Junction, and to enter into arrangements with the Midland and the Sheffield Railway Companies. The Midland (additional powers) propose to raise further capital for the general purposes of the railway, and to make the Coton-park branch, the Darfield Junction, a connecting line in the parish of St. Pancras, also the Codnor-park curve, and to extinguish right of way on a footpath at Hendon. The Midland and London and North-Western (Ashby and Nuneaton lines) propose to make the Nuneaton Junction line, the Abbey Junction line at Weddington, and deviations. The North British propose to make a railway over the Forth at Alloa, and to abandon part of the authorized line over the Forth. The Sirhowy Company propose to make nine extension lines. The Bishop's Stortford, Dunmow, and Braintree Company intend to make provision for payment or satisfaction to Messrs. Brassey, Ogilvie, and Harrison, and all other persons and companies, of all debts and sums of money due to them on account of the construction and maintenance of the railway station and works, and to authorize the Dunmow Company and the Great Eastern Railway Company to create preference or debenture stock, to satisfy the claims of Messrs. Brassey, Ogilvie, and Harrison. The Great Western Railway Company ask for power to enable them to make a siding or branch railway at Swansea, and an extension at Stourbridge. They also ask for extension of time to construct a branch line at Kidderminster, Ruabon, and Wrexham. The London and South-Western and South-Eastern Railway Companies ask for power to widen parts of the Charing-cross line and to construct platforms, &c., to connect the Waterloo station with the Charing-cross station. It is proposed by a notice to repeal the North British and Edinburgh and Glasgow Railway Company Amalgamation Act, 1865, and to incorporate the Edinburgh and Glasgow Company, with full powers to resume its former position.

## ENGINEERING, etc., IN SCOTLAND.

### Recent Ship-building Contracts.

Messrs. Scott and Co., Greenock, have, we understand, received an order from the Anchor Line Company to build and engine a steamer of about 660 tons register and 100-horse power.

### Launch at Port Glasgow.

Messrs. Henry Murray and Co. launched, on the 17th ult., a handsome iron screw steamer of 100 tons, intended for the canal and coasting trade.

### Launch of the "Margaret Mitchell" at Rothesay.

Mr. Robert Maclea launched, on the 17th ult., a fine sloop of 95 tons, named *Margaret Mitchell.*

### Launches of the "Janette" and the "Rona" at Kelvinhaugh.

Messrs. Alexander Stephen and Sons have just launched, from one of their building sheds at Kelvinhaugh, a fine iron schooner of 140 tons, named the *Janette*, for employment in the African trade; she is the property of Messrs. William Couper and Co., Glasgow.

Messrs. Alexander Stephen and Sons have also just launched a fine new composite ship of 650 tons, named the *Rona*, classed 15 A1 at Lloyd's. The *Rona* is owned by Messrs. Sandbach, Tinne, and Co., of Liverpool, and is to be employed in their West India trade.

### Scotch Lifeboats.

The Edinburgh branch of the National Lifeboat Institution, of which Admiral Sir W. J. Hope Johnstone, K.C.B., is the chairman, and George Mathieson, Esq., the hon. secretary, has just sent to the society £225 as its contribution for this year in aid of the support of its Scotch lifeboats. At this period of the year the pressure on the funds of the society is unusually heavy. During the storms of the past and present months the lifeboats of the institution have contributed to the saving of upwards of 200 lives, making a total of 1,035 human beings rescued through the instrumentality of the Lifeboat Institution during the current year alone.

### Recent Steamship Contracts and Purchases.

We understand that the Messrs. Caird and Company have received orders to build another screw steamship of 3,000 tons and 600 horse power, for the North German Lloyds' Steam Navigation Company, in place of the *Rhein*, just sold by that company to the Royal West Indian Mail Company, and with whom Messrs. Caird have closed a contract for a steamer similar to the *Rhein*, the keel of which has been laid, and they have thus orders for two steamers from this company besides the *Rhein*. The three steamers that are to be built are to cost about £280,000, while the two nearly ready for launching from this yard are said to cost other £200,000, including machinery and fittings.

The Royal West India Mail Company have purchased from the North German Lloyds' Company the large screw-steamship *Rhein*, 3,000 tons, at present building by Messrs. Caird and Co., Greenock, to supply the place of the *Rhone*, lost by the late hurricane in the West Indies. It is said she will be the largest screw-steamer in the West Indian fleet, being 250 tons larger than the *Rhone*, and 100 horse-power stronger. This company have had several steamers built by Messrs. Caird and Co. In 1855 the the *Arno*(paddle), 1,200 tons; in 1864 the *Eider* (paddle), 1,500 tons, and *Douro* (screw), 2,500 tons; and in in 1853 the *Atrato* (paddle), 3,200 tons, besides engines for steamers built elsewhere.

### SALE OF A TOWING FLEET.

The plant and goodwill of the business of the River Towing Company has been purchased by the Clyde Shipping Company. The fleet of steamers now owned by the Clyde Shipping Company is 14.

### LAUNCH OF THE "BERKSHIRE" AT WHITEREACH.

Messrs. Barclay, Curle and Co. launched, on the 12th December, a fine iron sailing ship of 1,450 tons register, named the *Berkshire*; she is owned by George Marsball, Esq., of London, and will be engaged in the East India trade.

### SHIPBUILDING AT PAISLEY.

Messrs. Donald and M'Farlane launched, from their yard at Paisley, on the 7th December, a screw steam tug, named the *Francisco*, of the following dimensions:—Length, 50ft.; breadth, 12ft.; depth, 6ft. She is intended for the South American trade.

### LAUNCHES ON THE CLYDE DURING NOVEMBER, 1867.

The following is the number and tonnage of vessels launched during the month of November and 11 months, as compared with corresponding periods of two previous years:—

| | 1867. | | 1866. | | 1865. | |
|---|---|---|---|---|---|---|
| | Ves. | Tons. | Ves. | Tons. | Ves. | Tons. |
| Month | 6 | 3,650 | 13 | 12,490 | 19 | 12,730 |
| 11 months | 161 | 102,250 | 195 | 110,230 | 237 | 142,920 |

## FORTY YEARS IN THE LIFE OF STEAMSHIPS.

It is now nearly fifty years (1818) since public attention was first given to steam navigation in the United States. Doubt and darkness then hung over the whole question, but some few had hopes of success, and among these was Mr. Scarborough, of Savannah, an old merchant, who came to New York, purchased a ship of 350 tons, then building and named her the *Savannah*. This done he engaged Captain Moses Rogers, of Connecticut, a person of great mechanical skill and ingenuity, who had been familiar and identified with the experiments of Fulton. Captain Rogers was placed in charge of the engine and machinery of the *Savannah*, and Captain Stevens Rogers, of New London, placed in command of the vessel. The *Savannah* having been equipped with engine and machinery, steamed out of New York harbour on the 27th day of March, 1819, bound to Savannah on her trial trip, which was most successfully made. May 26th 1819, she left Savannah for Liverpool, making the trip in twenty-two days, eighteen of which she was propelled by steam power. From Liverpool she sailed to Copenhagen, Stockholm, St. Petersburgh, Cronstadt, and Arundel, and from the latter port returned to Savannah, making the passage in twenty-five days. The log book of the *Savannah*, was sent to the Navy Department in 1848. Captain Stevens'Rogers is yet living in New London, Connecticut. For a number of years past he has been collector of city taxes, but at the election in June last he was suspended.

This "Log" is one of the most interesting curiosities of modern times and we are glad to learn that it is destined to find a resting place in the Historical Society at New Haven.

## PALESTINE EXPLORATION FUND.

We have received a very interesting account from Mr. George Grove the honorary secretary of the above fund, of the explorations effected under the superintendence of Lieutenant Warren, R.E. A vast amount of work has been performed, resulting in many most interesting discoveries, for an account of which we must refer our readers to a communication from Mr. Groves, which appeared in *The Times* of November 14th. It seems that just when they are upon the eve of still more important discoveries, their funds are all but exhausted; we trust, however, that such an interesting engineering work will not be allowed to be discontinued, but that the liberality of engineers, antiquarians, and others will continue to support Lieutenant Warren in his most valuable labours.

## REVIEWS AND NOTICES OF NEW BOOKS.

*Etudes sur l'Exposition de* 1867. Par MM. les Rédacteurs des Annales du Génie Civil, &c. Paris: Libraire Scientifique, Industrielle, et Agricole. EUGENE LACROIX, editeur, 15, Quai Malaquais.

THIS is a very complete account of the various exhibits of scientific interest in the Paris Exhibition. The engravings and data are got up with great care, while the description of the various subjects, and the remarks thereon, are exceedingly good, and in every case show a thorough acquaintance with the subject on the part of the writer. This, however, was to be expected, when we are told that upwards of seventy well-known scientific men are amongst the contributors.

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*On Puddling.* By a PRACTICAL PUDDLER. London: Taylor and Greening, Graystock-place, Fetter-lane.

THIS little work, as its title suggests, is thoroughly practical. The writer seems to have studied his subject deeply, and criticises the merits of the various process with great ability. His knowledge of metallurgy is extensive, and it is seldom that such an excellent treatise emanates from one whose opportunities for study must necessarily be but few.

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*Rain: How, when, where, why it is Measured.* By G. J. SYMONS, F.M.S. Stanford, Charing Cross; Simpkin, Marshall and Co., Ludgate-hill.

Scarce half a century has passed since Luke Howard wrote his now celebrated treatise on the "Climate of London."

The publication of that and other kindred works by the same author, created for Meteorology—then hardly recognized as a science, and studied chiefly by a few scattered observers—an interest that has increased from year to year, as new and more useful results have been developed from closer and more systematic investigation and research.

Howard devoted the leisure of a lifetime to the study of this science, and, considering the few facilities he had for comparison, and the paucity of observers at that time, left it in a creditably complete state.

What he did for English meteorology, Mr. Symons, the author of the book before us, is now doing for one of its principal branches.

The subject of rainfall in this and other countries is beginning to receive—principally through the untiring efforts of that gentleman—the amount of consideration it justly deserves, and when we state that in 1866 he received returns of rainfall in Great Britain from no less than 1,200 stations it will be seen that there are many persons who appreciate and willingly assist his endeavours.

It may give some idea of what Mr. Symons has accomplished, and of the magnitude of the task still before him, if we mention that his collection of British rain records extends from the year 1677 up to the present date, and he estimates it to contain no less than 15,000 yearly returns; these data having been, until very recently, scattered over the country, in the possession of isolated observers, and, of course, without the slightest order or arrangement.

The first four chapters of this little work give (as the title tersely expresses it) the "How, when, where and why" of rain measurement, Chapter I. treating of the shape, size, and position of rain gauges.

Of the numerous forms extant, several of which are illustrated in the book, Mr. Symons gives preference to the well-known "bottle-gauge" of Howard, with a few slight improvements, to protect it from accident and frost.

As to the proper receptive area for a gauge, the author finds, from a series of careful experiments, that "no difference exceeding 1 or 2 per cent. exists between the indications of gauges whose apertures have areas from 12 to 452 inches."

The fifth chapter is devoted to an interesting account of the progress of British rainfall observations from their earliest known commencement up to the present date.

The remaining chapters contain, besides much other instructive matter, a table of mean annual rainfall at 165 British stations, calculated from the 6 years' observations from 1860 to 1865, the total average rainfall of these years being estimated to approximate very closely to the true annual mean.

In another table, compiled from various works and collections of MSS., he gives us the mean annual fall, the number of years from which it has been deduced, &c., at places in all parts of the globe; from Calcutta to Quebec, and from Finland to the Society Islands; and, in addition to these, a lucid diagram of the fluctuations in the fall of rain in England from 1726 to 1865.

By meteorologists this little volume will undoubtedly be welcomed as an accession to their favourite science; but we can also recommend it to agriculturists and civil, hydraulic, and sanitary engineers, and to all others with whom the question of rainfall is important, as being well worthy of perusal, and exceedingly useful for reference.

From amongst other useful tables in the work we have extracted the following:—

### Approximate Mean Annual Depth of Rain at 165 Stations.

[The stations are arranged alphabetically against their respective mean annual fall, the countries being separated by colons. For example, against 40 will be found the English stations, Barnstaple, Chapel-en-le-Frith, and Plymouth, then *two* colons, indicating the absence of Wales, then Shetland in Scotland, then another colon, showing that Cork and Waterford are in Ireland. Or take 60; it is followed by two colons, indicating the absence of England and Wales, and that Aberfoyle is in Scotland; then a colon, to show that Valentia is in Ireland.]

| in. | |
|---|---|
| 20 | Lincoln, Southwell, Stamford |
| 21 | Aylesbury, Bedford, Grantham, Grimsby, Witham |
| 22 | Boston, Market Rasen, Monks Eleigh |
| 23 | Bury St. Edmunds, Coventry, Holkham, Oundle, Retford, York |
| 24 | Bushey, Cobham, London, Norwich, Thirsk : Hawarden : Edinburgh |
| 25 | Ackworth, Epping, Hertford, Horncastle, Oxford, Sunderland : : Elgin |
| 26 | Derby, Leominster : : Inverness |
| 27 | Canterbury, Chatsworth, Ross, Shields, Shrewsbury : : Dunrobin |
| 28 | Berkhampstead, Worcester : : Cromarty, Haddington |
| 29 | Bath, Bridgewater, Chichester, Hastings, Monmouth, Taunton : : Peebles : Banbridge |
| 30 | Carlisle, Gosport, Hereford, Salisbury, Ventnor : Llandudno : Arbroath, Perth : Dublin |
| 31 | Birmingham, Cirencester, Halifax, Sheffield : Aberdeen, Dundee : Belfast |
| 32 | Bridport, Chard, Cheltenham, Dawlish : : Lawrencekirk |
| 33 | Alderley, Clifton, Exeter, Uckfield, Staleybridge : : Braemar, Orkney |
| 34 | Selborne, Teignmouth : : Applegarth |
| 35 | Appleby, Arncliffe, Encombe, Liverpool, Ormskirk : : : Limerick |
| 36 | Hengoed, Manchester |
| 37 | : : Glencorse |
| 38 | : : Alford : Castle Connor |
| 39 | Falmouth, Helston, Preston : : Glasgow |
| 40 | Barnstaple, Chapel-en-le-Frith, Plymouth : : Shetland : Cork, Waterford |
| 41 | Bovey Tracey : : Dumfries : Londonderry |
| 42 | Truro : : Carbeth, Cumbrae, Sorn |
| 43 | Clithero, Penzance, Wigan : Cardiff |
| 44 | Lancaster : : Ayr |
| 45 | Ivybridge, Tavistock : Lampeter : Baillieston |
| 46 | : Rhayader : Stornoway |
| 47 | Bodmin, Rochdale, South Molton : : Stranraer |
| 48 | : Haverfordwest : : Killaloe |
| 49 | Carlisle : : Ardnamurchan |
| 50 | Bolton, Settle : : : Galway |
| 51 | Largs |
| 52 | Garsdale, Whitehaven |
| 53 | Kendal : : Brisbane |
| 54 | |
| 55 | : : Castle Toward |
| 56 | |
| 57 | Derwent Island |
| 58 | |
| 59 | Keswick |
| 60 | : : Aberfoyle : Valentia |
| 61 | |
| 62 | |
| 63 | : Ystalyfera : Bridge of Turk |
| 64 | : : Greenock, Inverary |
| 65 | : : Wanlockhead |
| 66 | : : Oban |
| 67 | |
| 68 | |
| 69 | : : Oronsay |
| 70 | |
| 71 | |
| 72 | |
| 73 | Selside |
| 74 | |
| 75 | : : Raasay |
| 76 | : : Arddarock |
| 77 | : : Dunoon |
| 78 | Ambleside |
| 79 | |
| 80 | The Howe : : Torosay |
| 81 | |
| 82 | |
| 83 | |
| 84 | |
| 85 | Coniston : : Tyree |
| 86 | Dartmoor |
| 87 | |
| 88 | |
| 89 | : : Ledard |
| 90 | |
| 91 | : : Ben Lomond |
| 95 | : : Glen Gyle |
| 109 | : : Portree |
| 117 | : : Glen Quoich |
| 140 | Seathwaite |
| 165 | The Stye |

*Guide Pratique de la Culture du Saule.* Par M. J. P. J. Koltz. Paris: Eugène Lacroix.

This is a very complete treatise upon the cultivation and management of osier beds, to which is attached a short treatise upon the reed. In this country the trade is not of much importance, but in France it gives employment to a large number of hands, both in growing and preparing the osiers, and in making baskets and all sorts of wickerwork.

*Les Droits des Inventeurs en France et à l'Etranger.* Par H. Dufrene. Paris: Eugène Lacroix.

This is a very useful work as a guide to inventors, and will be found of assistance in determining the best countries to protect their designs, as it gives the principal branches of industry which especially flourish in particular countries. There are also furnished a number of directions as to the manner of obtaining protection in various countries, with the different laws upon the subject pertaining to the principal countries in Europe and the United States.

*A Book of Inventions.* By Norman W. Wheeler, Brooklyn, New York.

In this "Book of Inventions" only such inventions are noticed as have been created by the fertile brain of the author. The object of the pamphlet is, therefore, as the author acknowledges, "to bring to the notice and knowledge of the profession a new method of condensation and distillation, as well as a general system of improved steam machinery." The book consists of various abstracts from specifications and some very good illustrations, explaining the author's various inventions. One thing we may especially commend to notice, viz., the frontispiece, which is original, striking, and decidedly Yankee.

*L'Art Naval à l'Exposition Universelle de Paris en 1867.* Par M. le Vice-Admiral Paris. Paris: Arthur Bertrand, 21, Rue Hautefeuille.

This work, of which the first part only has as yet been received, promises to be a very valuable treatise upon the various styles of naval architecture, including the modes of propulsion that have been exhibited at the late Paris Exhibition, and, consequently, up to a recent date. After devoting a small space to prove that with the French originated the idea of exhibitions in general, and have crowned that idea by having the grandest the world has ever seen, he begins at once with his subject as applied to vessels intended for warfare. The larger portion of this first number is composed of descriptions of various iron-cased men-of-war built in England, either at the various Government yards or in private establishments, such as Messrs. Napier, of Glasgow, Messrs. Samuda, and the Thames Iron Works, after which he discusses the merits of the various systems of armour plating. The book of plates accompanying the work is remarkably well got up, and this, together with the dimensions, &c., furnished in the letter press, forms a very valuable work of reference. The great eminence to which Vice-Admiral Pâris has attained in his profession will, no doubt, command that attention to his opinions which they so well merit.

## NOTICES TO CORRESPONDENTS.

D.C. (Calcutta).—An account of a very simple description of water barometer was given a short time ago by Mr. Alfred Bird, of Birmingham, which we think would be suited to your requirements. It is remarkably sensitive, and for countries such as India, where the usual mercurial barometer rarely shows any change, we think it might be of great assistance in forecasting cyclones. It would be impossible intelligibly to describe it without a sketch, which we will endeavour to supply in the next number of The Artizan.

H. A. I. (Port Louis).—You mistake. There is, of course, a back pressure on the piston of the small cylinder, as fluids press equally in every direction, and there is no theoretical advantage in having two cylinders. The reason why double cylinders have been adopted is to get a more equable force from the steam, and thereby equalizing the strain on the working parts of the machinery. It is also preferred in many cases (especially in marine engines), as being a more compact arrangement. The *Euphrates* is 360ft. between perpendiculars; breadth, 49ft. depth of hold, 34ft. 7in.; tonnage, O.M., 4,173; H.P. nominal, 700; speed, 14·72 knots. The dimensions of the *Russia* are:—Length over all, 370ft.; length of keel, 343ft.; breadth of beam, 42¼ft.; depth of hold, 29½ft.; tonnage, O.M., 3,100. The "distance between the lights" is 13·66 knots; ditto Liverpool to Greenock, 196 knots; Liverpool to Queenstown, 240 knots. The quickest she has made was in last July: the time from New York to Liverpool being 8 days 2¼ hrs., and the dis- run 3,225 miles.

Letters have been received from the commander of the ram *Stonewall*, at Montevideo. This vessel was sold by the United States to Japan, but the commander states that she is a failure as a sailing vessel, and he despairs of being able to get her to Japan.

## LATEST PRICES IN THE LONDON METAL MARKET.

| | From £ | s. | d. | To £ | s. | d. |
|---|---|---|---|---|---|---|
| **COPPER.** | | | | | | |
| Best selected, per ton | 77 | 0 | 0 | 78 | 0 | 0 |
| Tough cake and tile do. | 76 | 0 | 0 | 77 | 0 | 0 |
| Sheathing and sheets do. | 79 | 0 | 0 | 80 | " | " |
| Bolts do. | 83 | 0 | 0 | " | " | " |
| Bottoms do. | 85 | 0 | 0 | " | " | " |
| Old (exchange) do. | 70 | 0 | 0 | 71 | 0 | 0 |
| Burra Burra do. | 84 | 0 | 0 | 85 | 0 | 0 |
| Wire, per lb. | 0 | 1 | 0 | " | 1 | 0½ |
| Tubes do. | 0 | 0 | 11½ | 0 | 1 | 0 |
| **BRASS.** | | | | | | |
| Sheets, per lb. | 0 | 0 | 9 | 0 | 0 | 10 |
| Wire do. | 0 | 0 | 8½ | 0 | 0 | 9½ |
| Tubes do. | 0 | 0 | 10½ | " | " | 11 |
| Yellow metal sheath do. | 0 | 0 | 7¼ | 0 | 0 | " |
| Sheets do. | 0 | 0 | 7 | " | " | " |
| **SPELTER.** | | | | | | |
| Foreign on the spot, per ton | 20 | 7 | 6 | " | " | " |
| Do. to arrive | 20 | 7 | 6 | " | " | " |
| **ZINC.** | | | | | | |
| In sheets, per ton | 28 | 0 | 0 | " | " | " |
| **TIN.** | | | | | | |
| English blocks, per ton | 96 | 0 | 0 | " | " | " |
| Do. bars (in barrels) do. | 97 | 0 | 0 | " | " | " |
| Do. refined do. | 99 | 0 | 0 | " | " | " |
| Banca do. | 92 | 0 | 0 | 93 | 0 | 0 |
| Straits do. | 87 | 0 | 0 | 87 | 10 | 0 |
| **TIN PLATES.*** | | | | | | |
| IC. charcoal, 1st quality, per box | 1 | 6 | 0 | 1 | 8 | 0 |
| IX. do. 1st quality do. | 1 | 12 | 0 | 1 | 14 | 0 |
| IC. do. 2nd quality do. | 1 | 4 | 0 | 1 | 6 | 0 |
| IX. do. 2nd quality do. | 1 | 10 | 0 | 1 | 12 | 0 |
| IC. Coke do. | 1 | 2 | 3 | 1 | 3 | 6 |
| IX. do. do | 1 | 8 | 3 | 1 | 9 | 6 |
| Canada plates, per ton | 13 | 10 | 0 | " | " | " |
| Do. at works do. | 12 | 10 | 0 | " | " | " |
| **IRON.** | | | | | | |
| Bars, Welsh, in London, per ton | 6 | 10 | 0 | " | " | " |
| Do. to arrive do. | 6 | 10 | 0 | " | " | " |
| Nail rods do. | 7 | 0 | 0 | 7 | 10 | 0 |
| Stafford in London do. | 7 | 10 | 0 | 8 | 10 | 0 |
| Bars do. do. | 7 | 10 | 0 | 9 | 10 | 0 |
| Hoops do. do. | 8 | 10 | 0 | 9 | 12 | 6 |
| Sheets, single, do. | 9 | 5 | 0 | 10 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 5 | 15 | 0 | 6 | 0 | 0 |
| Do. mrch. Tyne or Tees do. | 6 | 10 | 0 | " | " | " |
| Do. railway, in Wales, do. | 5 | 0 | 0 | 5 | 10 | 0 |
| Do. Swedish in London do. | 10 | 5 | 0 | 10 | 10 | 0 |
| To arrive do. | 10 | 5 | 0 | 10 | 10 | 0 |
| Pig No. 1 in Clyde do. | 2 | 13 | 9 | 3 | 1 | 0 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | " | " | " |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 7 | 0 | 0 | 7 | 10 | 0 |
| **STEEL.** | | | | | | |
| Swedish in kegs (rolled), per ton | 14 | 5 | 0 | " | " | " |
| Do. (hammered) do. | 15 | 5 | 0 | 15 | 10 | 0 |
| Do. in faggots do. | 16 | 0 | 0 | " | " | " |
| English spring do. | 17 | 0 | 0 | 23 | 0 | 0 |
| Quicksilver, per bottle | 6 | 17 | 0 | " | " | " |
| **LEAD.** | | | | | | |
| English pig, common, per ton | 19 | 0 | 0 | 19 | 2 | 6 |
| Ditto. L.B. do. | 19 | 10 | 0 | " | " | " |
| Do. W.B. do. | 21 | 10 | 0 | " | " | " |
| Do., ordinary soft, do.† | 20 | 0 | 0 | " | " | " |
| Do. sheet, do. | 20 | 0 | 0 | 20 | 5 | 0 |
| Do. red lead do. | 20 | 15 | 0 | " | " | " |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 0 | 0 | 23 | 0 | 0 |
| Spanish do. | 18 | 10 | 0 | 18 | 15 | 0 |

* At the works 1s. to 1s. 6d. per box less.

† A Derbyshire quotation, not generally known in the London market.

## NOTES AND NOVELTIES.

### MISCELLANEOUS.

On the 9th Dec., Herr von Dreyse, the inventor of the needle-gun, died at his native place of Sommerda, near Erfurt. He was born in 1787, and, the son of a locksmith, worked in his father's shop until, as is the wont of artisans in this country, he left home to perfect himself in his trade. In the course of his wanderings he came to Paris, where he found employment under Colonel Pauly, a German officer, commissioned by Napoleon I. to invent a breech-loading rifle. There he staid from 1809 to 1814. It is well known how after his return to Prussia he established an iron factory, and, devoting all his energy to the pursuit of the object which had been vainly attempted by his Paris teacher, at length succeeded in constructing the *zündnadelgewehr*. This was in 1836. Four years later orders were given to arm the light regiments of the Prussian infantry with his gun. Working steadily on amid the honours and riches heaped upon him, he from time to time presented his country with new inventions, some of which promise to add still greater lustre to his name. Among these, the grenade rifle, to be shortly given to some fusileer regiments, is mentioned as the most important. Its physical and moral effect upon the enemy is anticipated to exceed everything hitherto achieved in this line. The ball weighing 88 grammes, is 53 millimetres long, hollow, and filled with a charge of powder 2½ grammes in weight. On striking, it explodes with the greatest certainty, and, dispersing its fragments 3ft. in every direction, is reputed to do as much damage as three or four ordinary balls, and to create as much dismay as would a dozen. The ingenuity displayed in making a simple yet effective projectile is repeated in a contrivance to weaken the rebound, The calibre of the new rifle is 21 millimetrss. Speaking of firearms, a few words may be bestowed upon the rifled mortars devised by the Prussian Artillery Commissioners. They are breech loaders 6½ft. long, and can be brought to an elevation of 75 degrees. It is asserted that, hitting their mark with as much precision as the rifled cannon, they are applicable in many cases where the latter would be of no use. If the hopes of professional people are fulfilled, their balls, flying over walls that would be impenetrable to rifled cannon, will prove incomparably more dangerous enemies to fortresses than the old mortar with its random shots, while when employed on coast defences they will fall perpendicularly on the deck of a vessel the cuirassed sides of which mock attack.

Borax Plenty.—The Napa (Cal.) *Reporter* says that the company engaged in taking aut borax in Lake county, will soon be in a condition to extract five tons of this article per day from the Borax lake, as they have received a new and powerful steam dredger, and an immense pump with which to exhaust the water from the coffer dams.

There are upwards of one thousand stationary engines employed within the corporate city of Philadelphia, aggregating from 25,000 to 30,000 horse power. About one-half of the number obtain their water supply from the city waterworks.

Machine-belting is now being manufactured from paper by J. B. Crane, of Dalton Mass. Most of the machinery in Mr. Crane's mill is run with paper belting, and the large driving-belt in Colt's mill at Pittsfield, Mass., is of the same material. Mr. Crane has made a paper belt 75ft. long, and 8in. wide. The paper belting is said to have all the merits of leather and some advantages. Time only will test the truth of this assertion.

Extensive works are under way in San Francisco for the manufacture of lead on a large scale. The supply of ores is very abundant, and generally sufficient silver is in combination to pay for transportation and extraction.

Petroleum Fuel for Locomotive.—A locomotive was recently run on one of the Pennsylvania roads for a considerable time, with oil instead of coal for fuel. The experiment was suspended only on account of the defectiveness of the mechanical appliances for the new fuel. A later trial was made on the Hudson River railroad; but in consequence of some blunder on the part of one of the operatives, the result was not as satisfactory as it might have been, although the indications were exceedingly favourable for a final success. An ordinary locomotive consumes, on an average, about one ton of coal in three hours, or its equivalent in wood. A vast saving in transportation of fuel will be made on the great continental road, in passing over those portions of the line destitute of wood or coal—a distance of about 800 miles—if oil is found an economical fuel for making steam. Experiments thus far tend to prove that a pound of oil will make as much steam as two pounds of coal.

The gross public income of the year ended the 30th of September, 1867, was £69,470,470—namely, Customs and Excise, £42,826,000; stamps and taxes, £18,829,000; Post Office, £4,590,000; Crown lands, £332,000; miscellaneous, £2,893,470, this last item including £1,095,250 received from the revenue of India on account of charges of British troops serving in that country. The expenditure of the year consisted of the following items:—£26,421,479 for interest of the debt, including £2,788,585, the year's payment of Terminable Annuities; £26,184,978 for the Army and Navy; £9,945,431 for civil services voted in supply and charges on the Consolidated Fund; £2,497,249 for charges of collection of Excise and Inland Revenue, and £3,155,506 for Post Office expenditure at home and abroad; making the whole of the ordinary expenditure £68,204,643, leaving a sum of £1,265,827 as excess of income over expenditure. A sum of £350,000 is to be added to the expenditure on account of expenses of fortifications, but this is not a charge upon the year's income, but was raised by the sale of Terminable Annuities, and the year's share of the payment of Terminable Annuities has been already included in the charge for the debt. The account of the balances of the public money shows that at the beginning of the year there was £3,790,533 in the exchequer, and £4,140,925 at the end of the year; but this latter sum includes £230,000 of money raised for fortifications, and the balance at the beginning of the year included no money raised for fortifications.

### SHIPBUILDING.

Iron Shipbuilding on the Humber.—An iron ship was launched at Hull on the 9th ult. from Messrs. Earle and Co.'s yard, the only one now in operation. The vessel was for Messrs. Wilson, Sons, and Co., of Hull, by whom she is intended during the season to ply in the Baltic trade. She is 217ft. long, 29ft. broad, and has a depth of hold of 17ft. Her gross tonnage is about 900 tons, and she will be fitted with engines with a power of 90 horses. The vessel was named the *Fido*. She will be schooner rigged, and has open decks, with the exception of a bridge amidships. For the same owners Messrs. Earle and Co are building another steamer of similar burden and power. They also have on the stocks a vessel of about 500 tons for another Hull firm, and a large one, about 2,000 tons, for Mr. J. Moss, of Liverpool, for whom several large vessels have already been built at the same yard.

### STEAM SHIPPING.

The ironclad ship *Penelope* has made her first trial trip at Pembroke Dock. She steamed out to the channel, a distance of twenty miles, and, although there was a heavy sea running, the vessel behaved admirably in every respect. The machinery worked so smoothly that not any of the bearings were heated in the slightest degree, and little or no oscillation or vibration was perceptible. The vessel was in charge of Mr. Ivemy, the Queen's pilot, and Capt. Hall, superintendent of the dockyard, and several other nava officers, were on board. The engines, which are of 600 horse power, were manufactured by Messrs. Maudslay, Son, and Field. Mr. Warrener, chief engineer of the firm, superintended the working of the machinery. The principal results of the trip were as follows:—Draught of water aft, 14ft.; forward, 11½ft.; speed, 11¾ knots; mean revolutions, 96; pressure of steam, 25lbs.; vacuum, 27.

The double screw launch recently constructed at Chatham dockyard having been fitted with her high pressure engines by Messrs. John Penn and Sons, has undergone her official trial at the measured mile, outside Chatham harbour, under the superintendence of Mr. W. Eames, assistant inspector of machinery, and the other officials connected with the engineer department. The launch is fitted with a pair of engines of 6 horse-power nominal, each driving an independent four-bladed screw, with a separate shafting, each screw working beneath the launch's counter. Each of the screws is 2ft. 6in. in diameter, with a length of 3½in., and an immersion of the upper edge of 1in.; during the trials they were set at a pitch of 3ft. 6in. The quantity of coals on board during the trial was 11cwt., and, with the necessary stores and the officials and engine men, the launch had a draught of water of 3ft. aft, and 1ft. 9in. forward. On reaching the measured mile at Saltpan Reach six runs were made at full steaming power, when with a force of wind of 3 to 4 a mean speed of 8·239 knots per hour was obtained, which is considerably higher than that attained by any of the double-screw launches hitherto tried. The load on the safety-valve, by Salters' balance, was 70lbs.; mean pressure of steam in boilers, 7·95lbs; maximum number of revolutions of screws per minute 308, and minimum 306. The complete circle was made in 1min. 1sec., with the rudder put over to an angle of 46 degrees, the diameter of the circle being 40 yards, or about three times the launch's length. The engines during the trial worked with the utmost regularity, and there was an entire absence of priming.

The recent outward passage of the *Weser* was the finest ever made by any steamer from Southampton, and has seldom been surpassed on any Atlantic voyage. She passed the Needles on the 19th of November at 5.30 p.m., and arrived off Sandy Hook at 9 p.m. on the 28th, having run the distance of 3,150 miles in nine days three hours, or at the rate of more than 14 knots per hour. The company have ordered two new steamers of Messrs. Caird and Co., of Greenock, and have sold their steamer *Rhine*, now in course of construction, to the Royal West India Mail Company, who were anxious to replace the *Rhone* as soon as possible, and certainly the acquisition of such a magnificent steamer for the West India mail service is particularly fortunate at the present time.

## RAILWAYS.

The Mont Cenis tunnel has advanced 109 metres during the month of November.

The Porte has granted a provisional concession for a railway from Constantinople to Bussorah, with a 5 per cent. guarantee upon an estimated cost of thirty-seven millions sterling. The surveys and the plans are to be completed in two years, when the concession will become definitive.

An interesting extract from a new edition of his "Journey from Belgrade to Salonica" has been printed apart by M. von Hahn, the Austrian consul at Syra. It examines the practicability and the advantages of continuing a railway from Salonica to the Piræus. M. von Hahn is well known in the learned world by his comprehensive work on Albania, which is the best authority on that strange country, its strange inhabitants, and strange language. Consul von Hahn was the first who proved that all our maps are wrong in making the Balkan mountains join the great dorsal range that in Turkey corresponds to the Apennines. He found a level country between these two chains of mountains, and he demonstrated that the construction of a railway would encounter no great difficulties by purchasing a carriage and horses at Belgrade and driving them over the existing roads all the way to Salonica, without breaking his own neck or laming his horses. The distance from Salonica to Alexandria is 670 nautical miles, from Brindisi to Alexandria 835, and from Marseilles to Alexandria 1,425. A line of railway from the Danube to Salonica would pass through the most industrious population in European Turkey, and would be the most immediately useful to Northern Europe, perhaps even including England, of any of the lines lately proposed in the Sultan's dominions.

With reference to the extension of the Bombay, Baroda, and Central India line to Delhi and Agra, it has been agreed with the Government that Wassud shall be the point of departure instead of Baroda, and surveys are being actively carried out along the whole line.

Railways in Russia.—The second section of railway from Moscow to the south has been opened for traffic. The first section, from Moscow to Serpoukhoff, 59⅓ miles, was opened for traffic last year; and the section now opened extends from Serpoukhoff and Toula, 58⅔ miles more. Traffic is thus now conducted over a distance of 112⅓ miles. The third section, between Toula and Orel, and the fourth, from Orel to Koursk, will be opened to the public next summer. The heavy works are finished over the whole distance; the construction of the station buildings alone delays the commencement of traffic. It is also considered prudent, in order to assure the solidity of the way, to allow the embankments to stand before commencing traffic upon them.

The directors of the Grand Trunk of Canada Railway have issued the report of Captain Tyler on his return from his recent mission of inquiry. It is an elaborate document, and points out, in conclusion, that the greater works on the line are of a substantial character, one of them in particular being far too magnificent for its commercial resources; that it has suffered from defects of original construction as regards its permanent way and minor works; that a considerable portion of its mileage is actually worked at a loss and that the receipts on the greater part of it are earned only by a constant struggle against numerous competitors. After the various creditors and the bond and shareholders had submitted inevitably, but at so much sacrifice, to the compromises of 1862, it appeared to be in a fair way towards yielding some return to them. But the calculations which were then made have been upset, partly by the immediate effects and the after effects of the American war, and by the supply of unsuitable iron for the permanent way, partly also by the abrogation of the Reciprocity Treaty and other causes. In the existing condition of the property, two courses present themselves for adoption. It must be allowed to go on either without or with a fresh expenditure of capital. If no further capital be expended its improvement will, to say the least, be a gradual process; a large proportion, if not the whole, of its revenue will for a series of years be swallowed up in the cost of maintenance, the payment of fixed charges, and the supply of necessary means and appliances; and the prospects of cash dividends to the preference bond and stockholders will be very remote. If capital can be raised, and if it be expended on the various objects considered necessary, a more speedy return to the proprietors may, in Captain Taylor's opinion, with good reason be anticipated. The amount which will require to be raised and expended on capital account is £900,000.

Panama Railroad.—In the year 1866 this railroad carried across from sea to sea 31,709 passengers, 63,114,113 dollars of treasure, 67,262,679lbs. of freight by weight, 2,309,201ft. of freight by measurement, and mails weighing 888,997lbs. In mail matter there is very little variation, averaging about 380 tons annually. Merchandise has steadily increased from 10,658 tons in 1856 to 93,414 tons in 1866; and coal from 8,934 tons in 1856 to 13,418 tons in 1866. Jewelry has varied from 192,718 dollars to 844,490 dollars, but has been gradually declining in amount. The gold transported was 48,047,692 dollars in 1856, and in 1866 48,234,463 dollars, and in no intervening year equalled either of those amounts. Silver shows a gradual increase from 9,439,648 dollars in 1856 to 18,653,239 in 1863, since which it has declined to 14,331,751 dollars in 1866. The passenger traffic does not show any steady or important increase in the ten years. The income of the railroad in 1866 was 2,424,977 dollars, and the expenses 1,208,364 dollars, leaving 1,216,613 net proceeds. The total tonnage transported along the road in the year was 107,598 tons; it has almost doubled in every three years.

## DOCKS, HARBOURS, BRIDGES.

Sewage in the Thames.—Some correspondence has been published as a Parliamentary paper relating to the large shoals forming in the Thames in the neighbourhood of the main drainage outfalls, near Barking-creek and Crossness. The engineer of the conservators of the river reports that the character of the mud shows clearly enough whence it has come. Dr. Letheby, who analised a sample of it in the summer, found it fœtid, and in a state of active putrefactive decomposition. He describes it as consisting of broken-up sewage matter, with the remains of myriads of animalcules, and a large quantity of carbonate of lime in a partly crystalline state, together with the usual ferruginous clay of the lower water of the Thames. He found the very large proportion of 14·49 to 15·5 per cent. of organic matter in the well-dried mud; and he states that "by undergoing putrefactive decomposition this mud, which is accumulating in such large quantities at the sewer outfalls, may be a cause for serious alarm, especially as it there meets with sea water, the sulphates of which may, by their chymical decomposition by the putrefying mud, occasion the escape of much sulphuretted hydrogen, and set up that remarkably offensive change which is characteristic of the action of sewage upon sea water." It is not to be overlooked that near the northern outfall the greatest accumulation is 2,000ft. above the point of delivery, showing that the discharge of the sewage is not so managed as to carry it all down the stream.

## MINES, METALLURGY, &c.

A New Seam of Coal in Notts.—For some time boring operations have been carried on near Wilford-bridge, the property of Sir R. Clifton, about a mile from Nottingham. The workmen, after having penetrated several strata, have at length succeeded in finding coal. It is said that the seam is from 7ft. to 8ft. in thickness. Coal was found two miles from this place, on the Clifton estate, in August last.

Extensive deposits of coal have been found on the line of the Kansas Pacific railroad on the Albuquerque route. The veins are reported to be from ten to fifteen feet thick, and the discovery is said to settle the question of there being a sufficiency of fuel on this road.

The gold yield of America for 1867 is about as follows:—Montana, £2,400,000; Idaho, £1,200,000; Oregon, £400,000; Colorado, £1,000,000; Nevada, £3,800,000; California, £5,000,000, and miscellaneous £1,000,000. Total, £14,800,000.

Coal exists at various localities along the Pacific coast, from Russian America to Patagonia, and is now mined to a limited extent in Vancouver's Island, Washington Territory, Oregon, California, at Panama, in New Granada, and at the towns of Lota, Lotilla, and Coronel, in Chili. But all these coals are of later date than the carboniferous, and appear to be the production of periods from the Jurassic to the Tertiary. They are of all grades of the bituminous class, from the mineral pitch, or asphaltum, to the natural coke. The veins or seams are generally thin and unreliable, and subject to the imperfections natural to all coals of recent formations. But, under present circumstances, these deposits of coal are invaluable to the commerce of the Pacific. The coal mines of Panama are worked by several English and American companies, almost exclusively for the use of the ocean steamers of the Pacific. The coal is of a soft, bituminous character, and is much inferior to the English steam coals. Though coal exists at intervals along the entire Pacific coast, it is only worked at two prominent points south of California, viz., Panama and at the Chilian mines in the northern portion of Araucania. The mines in Chili are located at the towns or bays of Lota, Lotilla, and Coronel, which lie about 200 miles north of Valdivia. The coal area is comparatively extensive, but the seams are generally thin and frequently terminate abruptly. Their dip is irregular or undulating, and mining operations are conducted by both shaft and drift. A considerable coal trade is done here, and sailing vessels are constantly being laden for various ports on the Pacific, and passing steamers generally supply themselves here. The coal is soft, and burns rapidly with great flame and smoke, but leaves only a moderate residium, and makes no clinker.

## GAS SUPPLY.

Metropolitan Gas Companies in Parliament.—The Imperial Gas Company have a bill, the chief objects of which are the increase of capital, the purchase of lands at St. Leonard, Bromley, and West Ham; the construction of gasworks there, together with bridges over the Lea and Bow Creek; and to obtain powers to work colliers, collieries, mines, &c. The Corporation of London have also a bill for powers to purchase lands, to erect gasworks at West Ham and East Ham; to purchase by agreement or compulsorily all or part of the works and property of the Great Central Gas Consumers' Company, the City of London Gas Company, and the Gas Light and Coke Company, and by agreement the works and property of the West London Junction Gas Company (Limited); and powers to supply gas within the city of London and liberties, the Metropolitan Meat and Poultry Market, and the Metropolitan Cattle Market. The Metropolitan Gas Companies Amalgamation Bill is for an amalgamation of all or some of the metropolitan gas companies, with regulations as to capital and districts, and other purposes. The Metropolis Gas Bill is for the amendment of the Metropolis Gas Act, 1860, and of the local and personal Acts relating to the supply of gas in the metropolis and adjacent districts; the amalgamation of all or some of the metropolitan gas companies; adjustment of capital; reduction of charges and dividends of gas companies; to compel gas companies to sell gas in bulk; and for other general purposes. The Metropolitan Subways Bill is for the purpose of compelling gas, water, and other companies and persons to lay down pipes, &c., in subways under the streets provided with access thereto, accompanied by restrictions with reference to the breaking up of streets, &c.

## APPLIED CHEMISTRY.

Boettger has constructed a galvanic battery of such great constancy that it retains its activity for several years, and is admirably adapted to the working of electric clocks, ringing electric bells, and the requirements of electro-metallurgy. Each cell consists of a cylinder of thick plate zinc enclosed in a glass jar. In the centre of the cylinder is placed a bar of compact coke, and the intervening space is packed with a powder composed of a mixture of equal volume of pounded sulphate of magnesia and common salt, moistened with a saturated solution of these two substances. The salt mixture is moistened from time to time, and the zinc of one cell carefully combined with the coke of the next, according to the usual method.

The last new metal which has been discovered by means of spectrum analysis—indium—has been found in the wolfram of the Zinnwald. This mineral contains [illegible] per cent of oxide of indium, and forms a convenient source whence to obtain a quantity of this new metal.

## 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 15th, 1867.

3235 G. R. Solomon and M. Bebro—Ticket register
3236 J. Crossley—Looms for weaving
3237 W. E. Gedge—Gas engine
3238 A. Airiau—An hydraulic clock
3239 R. Morson—Keys for locks
3240 L. B. Bertram—Tobacco pipe
3241 E. Farrington—Tubular cannon
3242 R. C. Addy—Spinning and twisting frames
3243 A. M. Clark—Refining copper
3244 J. Templeman—Fire lighters
3245 R. Howson—Gas furnace
3246 R. Heathfield—Cut nail machinery

### DATED NOVEMBER 16th, 1867.

3247 H. A. Bonneville—Propelling vessels
3248 I. Swindells—Treating and separating substances when ground
3249 R. Holliday—Cleansing animal fibres
3250 C. E. Brooman—Ornamenting articles of glass or crystal
3251 R. Garhett—Indoor games
3252 A. V. Newton—Manufacturing and securing envelopes
3253 F. W. Russell—Cask stands
3254 C. Ritchie—Brushing, combing, cleansing, drying, and perfuming hair
3255 R. W. Pearce—Extending the power of keyed instruments
3256 J. E. Richter—Breech loading firearms
3257 J. M. Napier—Machines for printing calico and other fabrics
3258 W. R. Lake—Covering metallic trimmings for carriages and harness with a coating of gum
3259 W. Bailey—Ornamenting paper hangings
3260 J. G. Tongue—Ageing and refining liquors

### DATED NOVEMBER 18th, 1867.

3261 L. Brierley, W. Brierley, and J. Bonnell—Construction of carriages employed on railways or tramways
3262 R. Husband—Manufacture of hats
3263 E. Lord—Opening and cleaning fibrous substances
3264 C. E. Brooman—Manufacture of metal direct from the ore
3265 E. T. Hughes—Knitting machines
3266 W. Busfield, J. Busfield, and J. Busfield—Preparing slivers of wool for spinning and dyeing
3267 W. J. Hanson and J. C. Ellison—Dyeing fibrous substances
3268 J. V. Thornton and C. Abercrombie—Twisting yarns
3269 J. Colebrook—Butter basket
3270 G. Fitt—Artificial manure
3271 K. J. Winslow—Conveying rotary motion to axles
3272 F. Wood—Construction of lamps for burning mineral oils

### DATED NOVEMBER 19th, 1867.

3273 R. Ward and Travis—Woven fabrics
3274 E. Reynolds—Wheels for rolling stock
3275 W. J. Coleman and A. Coleman—Treating and employing certain preparations for various articles of food
3276 H. English and J. Farudon—Operating the shuttles of looms for weaving narrow fabrics
3277 W. Anderson—Evaporating apparatus
3278 R. A. E. Scott—Mounting and working ordnance
3279 A. Barclay—Motive power engines
3280 E. T. Trenery—Traction engines

### DATED NOVEMBER 20th, 1867.

3281 C. Mole—Manufacture of soles and heels for boots and shoes
3282 W. H. Richardson—Manufacture of iron and steel
3283 S. Coulson—Manufacture of coffins
3284 H. H. Lloyd—Communication applied to railway carriages
3285 T. H. Tilley—Couplings for boring tools
3286 J. Oppenheimer—Telegraph posts, and fixing the same
3287 H. Greene—Safety lamp
3288 Baroness C. de Lavenant—Coating metals and metallic articles
3289 J. Staincliffe—Smoke consuming apparatus
3290 W. Brewster—Cleansing and dyeing clothes and fabrics, &c.
3291 L. B. Joseph—Tramways for common roads, and wheels for carriages

### DATED NOVEMBER 21st, 1867.

3292 J. Owens—Manufacture of pile and other fabrics
3293 W. R. Lake—Packing for the piston heads of steam cylinders
3294 G. F. Redfern—Improvements in paving
3295 J. Townsend—Manufacture of soda and potash
3296 C. Butler—Lamps for burning liquid volatile hydrocarbons
3297 S. Barczinsky and B. Barczinsky—Producing illusory exhibitions
3298 J. F. Watson—The improvement of timepieces known as the escapement
3299 W. R. Green and J. G. Freeman—Motive power engines and valves for engines
3300 W. Blundell—Guards for chimneys
3301 W. J. Murphy—Breech loading firearms and cartridges
3302 W. G. McIvor—Apparatus for rendering innocuous the momentum of heavy bodies
3303 E. Thorold—Burning volatile oils
3304 E. W. Hughes—Improvements in rotary engines and pumps
3305 H. James and E. Drewett—Improvements in waterclosets

### DATED NOVEMBER 22nd, 1867.

3306 R. Leighton and T. Kirkham—Sewing sheets of paper, &c.
3307 V. Burchell—Aerated liquids
3308 J. Wormald and W. B. Dalton—Converting breech loading firearms into muzzle loaders
3309 J. G. Tongue—Gibs applicable to the cross heads and other parts of machinery, &c.
3310 T. G. F. Dolby—Hot water food warmer
3311 A. Munro—Boring rocks, &c.
3312 G. Welch—Killing whales
3313 J. H. Brown—A new game called "The queen and her court"

### DATED NOVEMBER 23rd, 1867.

3314 G. D. Hughes—Consuming smoke and economising fuel in furnaces
3315 W. Needham and J. Kite—Changing the condition of fluids in process of decantation
3316 G. H. Bolton, W. Whitthread, E. Bolton, and T. Robinson—Obtaining motive power, &c.
3317 E. T. Hughes—Telegraphic apparatus
3318 P. Salmon—Manufacture of gas, &c.
3319 W. Boulton—Transmitting motive power
3320 W. Macnab—Marine steam engines
3321 C. E. Brooman—Steam generators
3322 S. Amphlet and J. B. Fenby—Ruling ornamental patterns
3323 W. Mort—Preserving meat
3324 J. H. Johnson—Breech loading firearms, and cartridges for the same

### DATED NOVEMBER 25th, 1867.

3325 M. A. Hamilton—Railway rails
3326 T. Barton—Cribbage board
3327 F. Brown—Kitchen ranges
3328 G. Turner—Packing cases, and locking the same
3329 T. L. Greenwood—Dyeing piece goods indigo blue
3330 T. J. Mayall—Accumulating and delivering fabrics
3331 G. B. Galloway—Vessels and appliances connected therewith
3332 R. Ward—Twisting tobacco
3333 T. Chalmers—Producing seamless tubes
3334 A. V. Newton—Rotary steam engine
3335 W. F. Stanley—A meteorometer

### DATED NOVEMBER 26th, 1867.

3336 R. M. Letchford—Cigar and other lights
3337 W. Sim—Watering and cleansing streets and roads, &c.
3338 H. Greenhalgh—Mechanism for preparing cotton
3339 J. P. Smith—Cutting tools and tool holders
3340 J. P. Smith—Coating and uniting metals with metals
3341 E. Townshend—Tobacco pouches
3342 C. E. Penny—Envelopes
3343 J. A. Hopkinson and J. Hopkinson—Steam boilers
3344 J. Hinks and J. Hinks—Safety cans
3345 W. E. Lake—Breech loading firearms and cartridges
3346 W. R. Lake—Electric telegraph apparatus
3347 J. Hudson—Manufacture of paper
3348 C. T. Higginbotham—Construction of furnaces
3349 J. H. Johnson—Treatment of skins
3350 A. V. Newton—Steam injector
3351 A. V. Newton—Preparing paper pulp
3352 E. H. Bentall—Conversion of iron into blooms
3353 M. A. Hamilton—Lamp burners

### DATED NOVEMBER 27th, 1867.

3354 C. Coates—Cutting stone, &c.
3355 J. H. Johnson—Manufacture of girders
3356 W. Fowler and J. Griffiths—Tyres of wheels
3357 A. M. Clarke—Ornamenting fabrics
3358 A. V. Newton—Making extracts
3359 E. Belknap—Treatment of the solution of malt for brewing
3360 H. F. Gardner—Treating metals and minerals
3361 J. S. Smith—Ventilating buildings, &c.
3362 J. McFarlane and G. Barker—Permanent way of railways
3363 S. A. Chase—Running mechanism of car and carriage trucks of any nature
3364 W. R. Lake—Spring hinge
3365 M. A. Hamilton—Cutting implement

### DATED NOVEMBER 28th, 1867.

3366 A. Mackie—Composing and distributing type
3367 R. H. Bentham—Facilitating the flow of liquids from closed vessels
3368 W. Palmer—Horses' shoes
3369 M. H. Larmuth and L. H. Larmuth—Water meters and water power engines
3370 E. T. Hughes—Tea and coffee pots
3371 T. Carter, B. Carter, and J. Liste—Apparatus employed in the preparation of fibrous substances known as condensers
3372 W. Cotton—Cutting fabrics
3373 T. Rose and R. E. Gibson—Separating and cleaning seeds
3374 E. T. Hughes—Sprinkler for powdered substances
3375 E. T. Hughes—Folding and pressing the edges of elastics used in boots and shoes
3376 T. S. Horn—Miners' safety lamps
3377 J. H. Johnson—Improved hollow brick
3378 J. M. Napier—Vessels and apparatus for the preserving and more convenient use of unguents
3379 E. Wood—Steam engines
3380 J. R. Pratt—Articles of earthenware
3381 E. H. Bentall—Nuts and bolts
3382 J. Scholefield—Cases for umbrellas, &c.
3383 J. R. Towers—Bedsteads
3384 J. Baylis—Pauoline dye

### DATED NOVEMBER 29th, 1867.

3385 W. R. Lake—Boiling and washing textile fabrics and fibres
3386 T. B. Jordan and J. Darlington—Machinery for boring rocks, &c.
3387 J. Fraser and G. Duncan—Combined machinery for printing
3388 T. Rose and R. E. Gibson—Treating cotton seed, &c.
3389 C. Albisser—Preparation of sulphate of magnesia
3390 M. F. Maury—Protecting submarine cables
3391 H. S. Cowan—Signalling at sea
3392 W. C. Houghton—Apparatus to be employed in connection with packing presses
3393 J. H. Johnson—Grinding bones, &c.
3394 A. Turner and W. E. Newton—Manufacture of carpets, &c.
3395 A. V. Newton—Cleansing clothes
3396 A. M. Clark—Chronometers
3397 J. J. Parkes—Ventilating rooms and buildings and apparatus for the same

### DATED NOVEMBER 30th, 1867.

3398 W. E. Gedge—Connecting and disconnecting vehicles
3399 W. E. Gedge—Brake washer
3400 R. McClure—Moulds for casting metals
3401 T. Briggs—Drying and stretching woven fabrics, &c.
3402 W. Starkey—Obtaining motive power
3403 W. R. Lake—Lubricating apparatus
3404 S. E. T. Steane—Globes and glasses for the transmission of light
3405 W. R. Lake—Clarifying saccharine solutions
3406 S. Sharrock—Posts for electric telegraphs
3407 R. F. Compton—Couplings for railway wagons
3408 T. Holmes, W. W. Holmes, J. F. Holmes, J. B. Lancaster, and D. Lancaster—Applications to spinning machinery
3409 R. Clay—Breech loading firearms
3410 J. Fitter—Mechanism for expanding tables and other expanding furniture.
3411 W. Priestley and W. Bower—Spinning machinery

### DATED DECEMBER 2nd, 1867.

3412 T. F. Widenbom and J. Reynolds—Construction of easy chairs, &c.
3413 J. C. Woolfield—Boilers for supplying hot water to apparatus for heating buildings
3414 G. Heiroo—Castor for condiments
3415 E. Price—Regulating the supply of gas to burners
3416 C. Hargrove and S. Hargrove—Manufacture of bells
3417 W. R. Lake—Filtering syrup in the manufacture of sugar
3418 J. H. Dean—Handles for hails, &c.
3419 W. Schofield—Preparing cloth and yarn to be dyed Turkey red
3420 D. Barker—Construction of chambers for drying substances
3321 W. Black and T. Hawthorn—Valves for steam engines
3422 G. Philcox—Shoeing horses
3423 R. W. Page—Hand garden engines and hydropults
3424 J. Hadley—Decorticating and drying grain
3425 G. Breen—Steam winches
3426 J. H. W. Biggs—Joining warp ends
3427 F. Foster—Miners' safety lamps
3428 R. Porter—Construction of metallic buildings
3429 W. B. Leachman and J. Holroyd—Leather shaving and dressing

### DATED DECEMBER 3rd, 1867.

3430 J. H. Wilson—Waterclosets and pumps connected therewith
3431 S. Vaile—Tables
3432 J. Collingham and T. E. Smith—Steps of spindles
3433 J. Eckersley and D. Martin—Permanent way of railways
3434 J. G. Hope—Utilising mineral oils for generating steam
3435 W. Shave—Rabbit and vermin traps
3436 W. Pidding—Fixing fibrous materials on to reels
3437 J. Thorpe—Glazed paper
3438 H. F. Gardner—Horses' bits and stirrups
3439 W. Brown and C. N. May—Steam engines and boilers
3440 J. Gjers—Cast steel and homogeneous iron
3441 R. Hornsby and J. E. Phillips—Reaping and mowing machines
3442 W. Sangster—Umbrellas
3443 N. Grew—Cleaning seeds
3444 F. R. Ensor—Manufacture of lace in twist lace machines

### DATED DECEMBER 4th, 1867.

3445 C. Paley—Elastic material
3446 J. Sanders—Braces for supporting articles of dress
3447 T. Stephenson, G. B. Stephenson, and B. Stephenson—Waxing warps in the process of warping
3448 J. Newton—Self acting radial doffing knife or comb motion
3449 R. M. Letchford—Circular boxes
3450 R. R. Gray—Metallic casks
3451 E. T. Hughes—Lighting, heating, and cooking apparatus
3452 F. B. Baker and L. Lindley—Ornamenting textile fabrics
3453 E. Walker—Breech loading ordnance
3454 F. Jolly—Clamping and stretching woven fabrics
3455 J. T. Webster and W. Oxley—Spinning and doubling fibrous materials
3456 J. F. Clarke—Melting snow and ice
3457 W. A. Herring—Warming buildings

### DATED DECEMBER 5th, 1867.

3458 J. H. Johnson—Materials suitable for blasting and other purposes
3459 D. Smith—Steam boiler furnaces
3460 S. L. Worth—Step chairs, &c.
3461 J. Green—Breaking sugar
3462 J. Mahson—Bags for coffee and other pots
3463 S. Perkins and W. Smellie—Manufacture of malleable metal
3464 J. G. Scott—Safe transmission of money or money orders
3465 J. Adams—Dating tickets
3466 A. C. Sterry—Engines worked by heated air or gas
3467 M. Tiddesley and J. Bird—Annealing furnaces
3468 T. J. Leigh—Furnaces, &c.
3469 P. G. L. G. Designolle and J. Casthelas—Explosive and fulminating powders
3470 E. A. Pontifex—Condensers

### DATED DECEMBER 6th, 1867.

3471 S. Goldstein—Wearing apparel
3472 J. W. Kenyon and R. A. Armistead—Safety apparatus for steam boilers
3473 J. Durrans—Improved composition
3474 C. Kerby—Filtering liquids
3475 W. N. Nicholson—Spreading grasses
3476 H. J. F. H. Foveaux—Cell for galvanic batteries
3477 F. Roper—Driving straw elevators
3478 J. Evans—Couplings for railway trucks
3479 R. Jones and J. Abrahall—Hollow metallic seamless spheres and ornaments
3480 R. W. Lindsay—Brass and copper tubes

### DATED DECEMBER 7th, 1867.

3481 C. Brazil—Sizing yarns
3482 P. R. Hodge—Heating and forming metals
3483 R. B. Jones and W. Powell—Prevention of incrustation in steam boilers
3484 J. B. Morrison—Operating chairs, &c.
3485 O. Barrett and H. Leggott—Knife cleaner
3486 J. Blakey—Collars, cuffs, &c.
3487 J. Partington—Heating buildings, &c.
3488 J. Rae and G. Miller—Railway wheels
3489 W. Clissold—Preparing fibrous substances for spinning
3490 J. Beatty—Candle dipping machine
3491 C. M. Barker—Socket and flange spigot pipes
3492 R. Warry—Breech loading firearms
3493 A. M. Clarke—Orthopedic apparatus
3494 J. A. Munn—Weighing apparatus

### DATED DECEMBER 9th, 1867.

3495 E. Keirby—Elastic packings
3496 W. H. Croke—Door springs
3497 W. Clapperton—Shaping casks headings, &c.
3498 W. Clark—Shearing animals
3499 L. Rose—Preserving vegetable juices
3500 W. R. Lake—Excavating machines
3501 H. Bessemer—Fire bricks, &c.
3502 C. Martin, W. Barrett, and T. S. Webb—Titaniferous iron ores

### DATED DECEMBER 10th, 1867.

3503 C. Kerby—Filtering liquids
3504 R. G. Lowndes—Finishing fabrics
3505 C. Comer—Umbrellas and parasols
3506 W. H. Barlow—Measuring approximately the quantities of earthwork in continuous banks
3507 W. Palliser—Ordnance, &c.
3508 W. B. Leachmen—Rotary engine
3509 J. Grout and E. Mathews—Training plants
3510 J. W. Burton—Fibrous materials, &c.

### DATED DECEMBER 11th, 1867.

3511 J. Woolfield—Corrugating sheets of metal
3512 G. Holcroft and W. N. Dack—Steam engines
3513 H. Giles—Hats and bonnets, &c.
3514 W. J. Fraser—Steam boilers
3515 A. Camme and F. Delpech—Manufacturing iron and steel chains without welding
3516 A. M. Clark—Presses for endorsing
3517 A. M. Clark—Reduction of tin
3518 A. T. Carr—Improved manure
3519 J. M. Napier—Applying condiments
3520 F. Vits—A new industrial product giving a textile material, &c.
3521 G. H. Nick—An improved pulley
3522 T. A. Weston—Saws

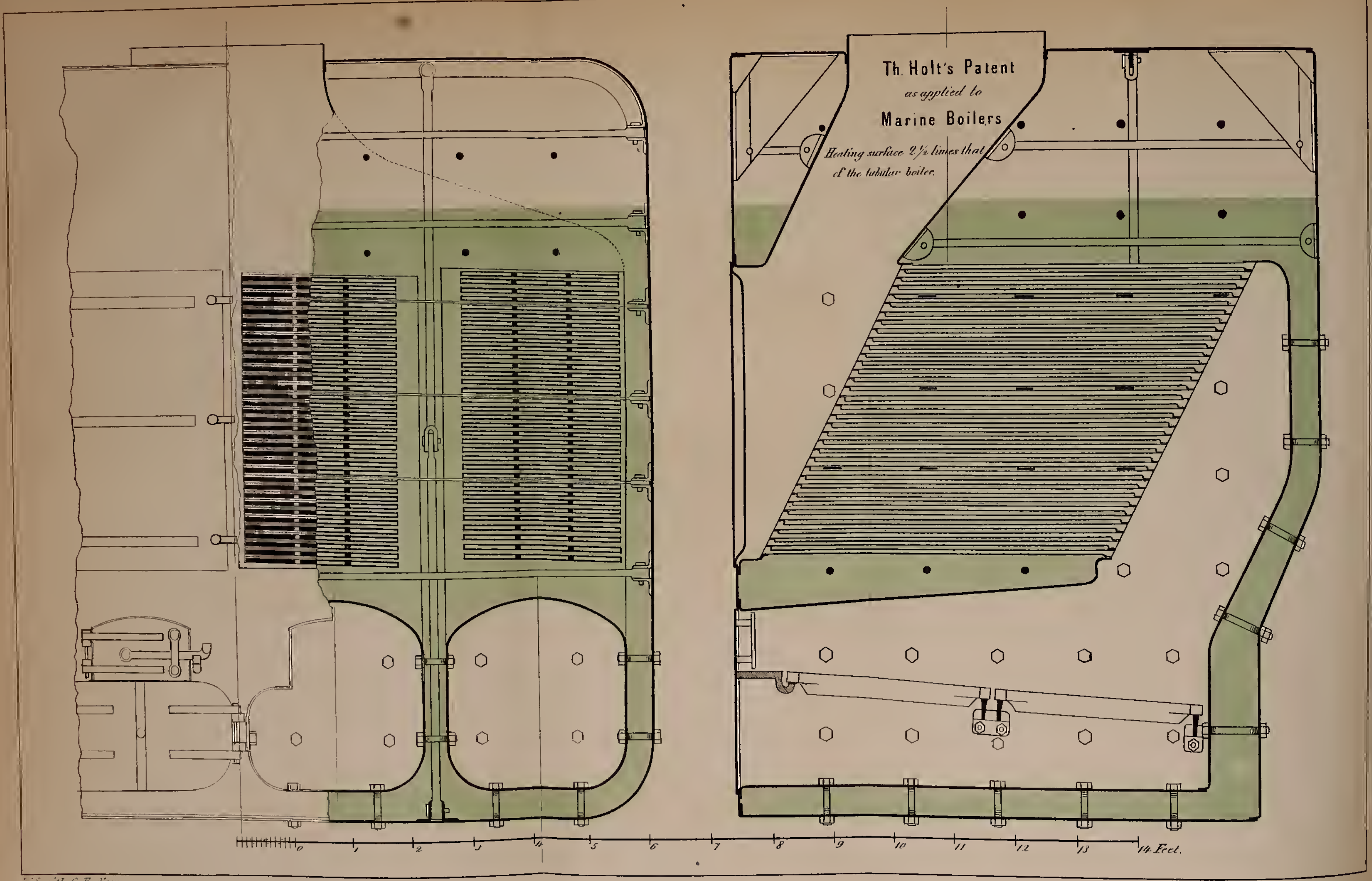
### DATED DECEMBER 12th, 1867.

3523 G. A. Young—An improved theatrical curtain
3524 J. Goodman—Production of wheels
3525 J. O. Butler—Securing the tyres of wheels
3526 J. R. Baillie—Caissons
3527 J. Ward—Lamps to be used under water
3828 R. Roberts and P. Williams—Equilibrium slide valve for steam engines
3529 R. W. Brownhill—Water tuyeres
3530 N. Paxman—Obtaining power in cylinders of steam engines
3531 E. Death—Steam pumps
3532 W. G. Hanning, G. B. Knott, and L. C. F. Clerc—Lamps
3533 J. Collingham and T. E. Smith—Spinning and twisting frames
3534 P. Bawden—Bricks and tiles
3535 E. R. Sintzenich—Treatment of paper, &c.
3536 H. Field—Candles and moulds employed
3537 A. V. Newton—Manufacturing cast steel and malleable iron
3538 R. Boby—Haymaking machines
3539 W. Richards—Firearms and cartridges
3540 J. Robinson—Mohair, etc.
3541 J. H. Pepper and T. W. Tobin—Producing scenic illusions

### DATED DECEMBER 13th, 1867.

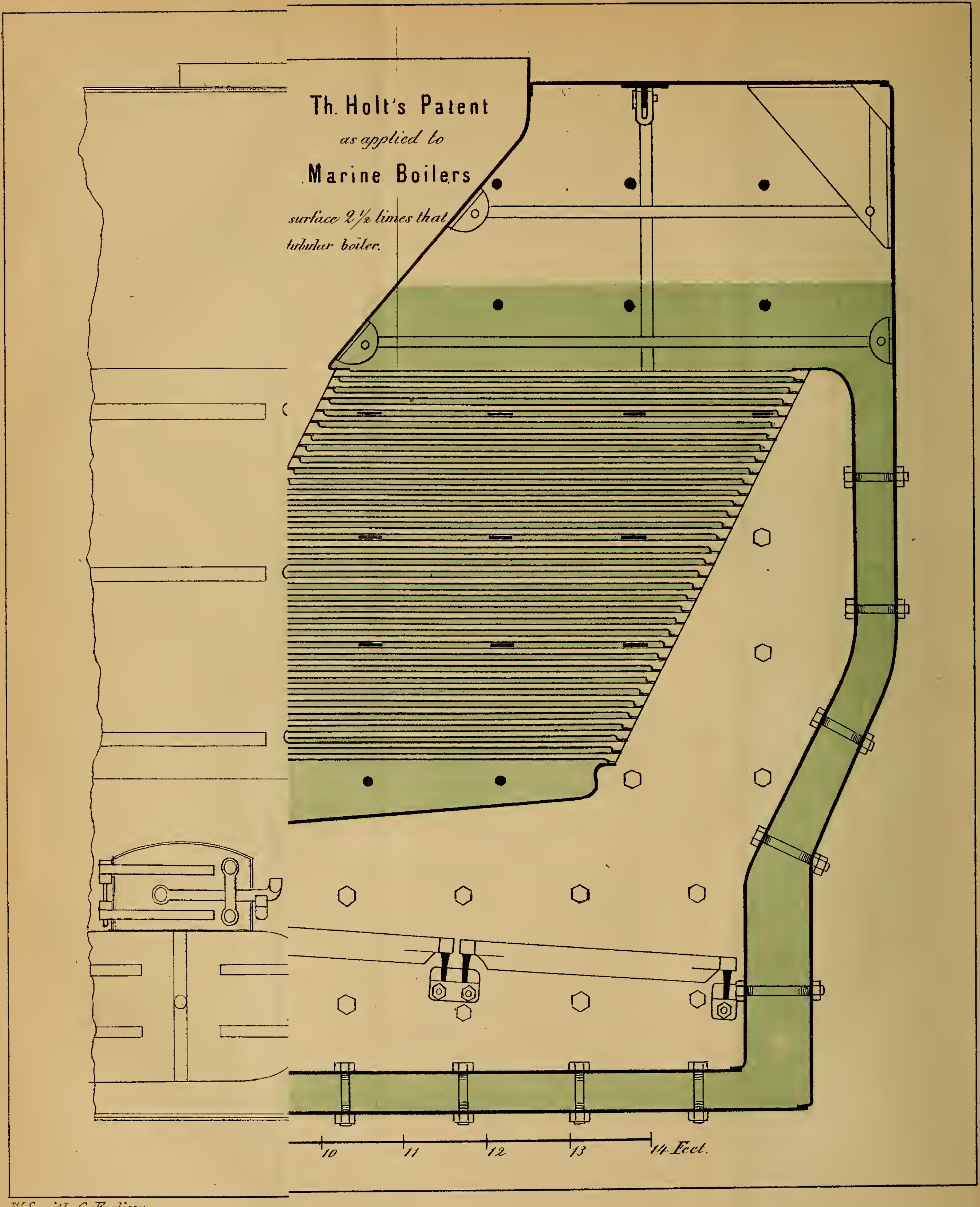
3542 E. R. Sintzenich—Treatment of gutta percha
3543 G. Whitehead—Coverings for bottles, etc.
3544 J. H. Johnson—Artificial fuel
3545 G. Marson—Retaining the outer ends of tapes
3546 J. Williams—An abacus
3547 W. McIlwraith and J. Bunner—Looms for weaving
3548 L. A. Damm—Conveying salt water fish
3546 A. Bullough—Looms for weaving

Smith C.E. Direx

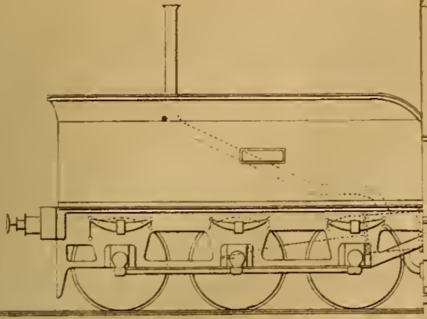


Th. Holt's Patent
*as applied to*
Marine Boilers
*Heating surface 2½ times that of the tubular boiler.*

Smith C E direx.



W. Smith C.E. direx.



2 M^{ce} URBAN.

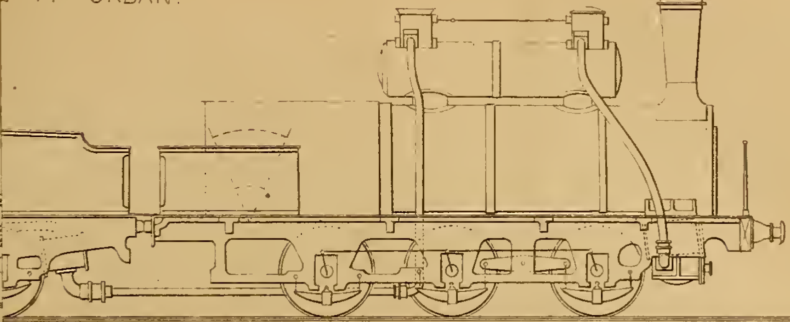


FIG:3. FOR

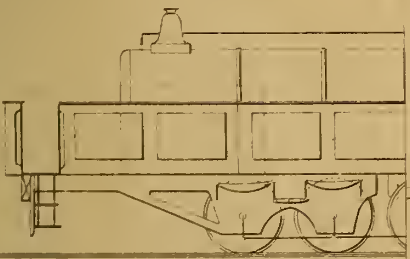


FIG: 5. WAËSSEN

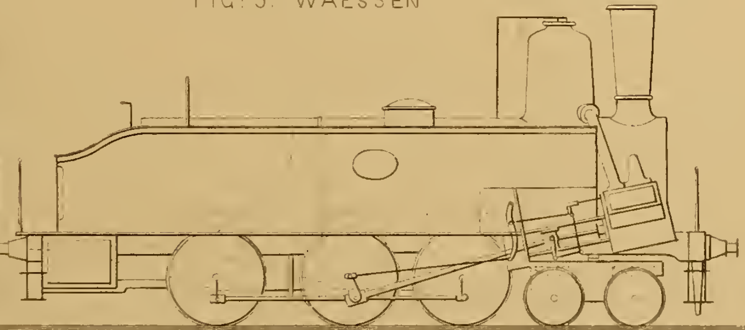


FIG 6 FIVES - LI

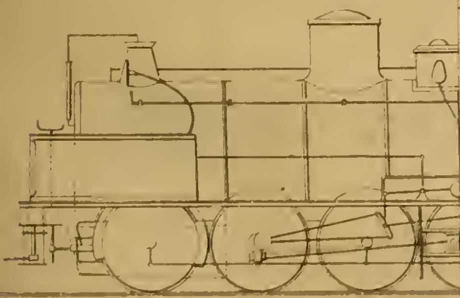


FIG 10 CARLSRUHE

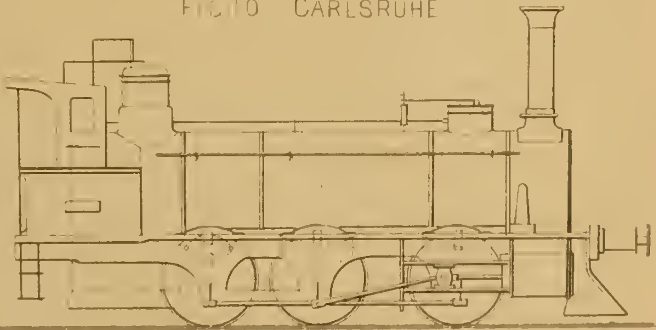
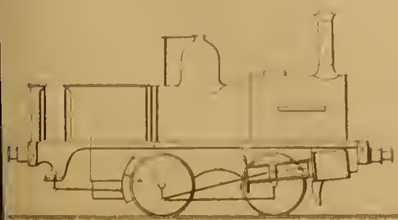


FIG 11 [illegible]



G.14 TRAINS

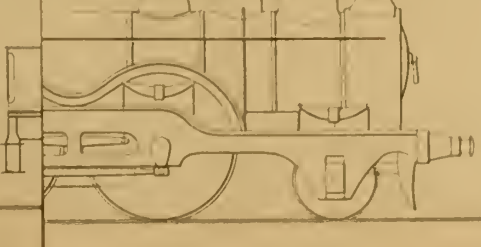
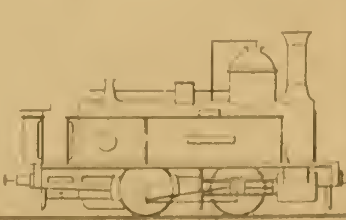


FIG 15 CREUSOT



# LOCOMOTIVE ENGINEERING.

*DIAGRAMS OF LOCOMOTIVES EXHIBITED*

AT THE PARIS EXHIBITION

1867.

FIG 1 GRAFFENSTADEN

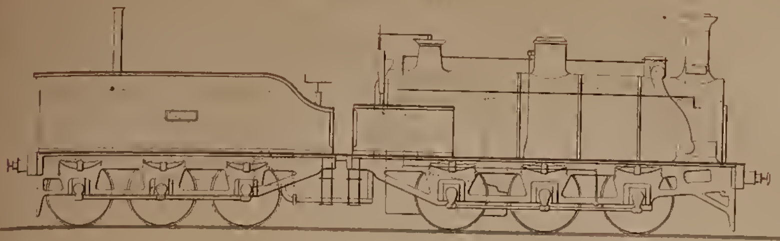


FIG 2 Mr URBAN

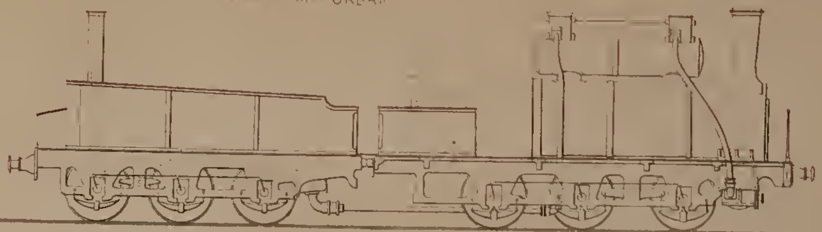


FIG 3 TORQUENOT

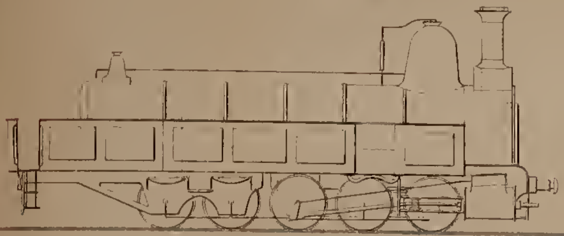


FIG 4 HASWELL

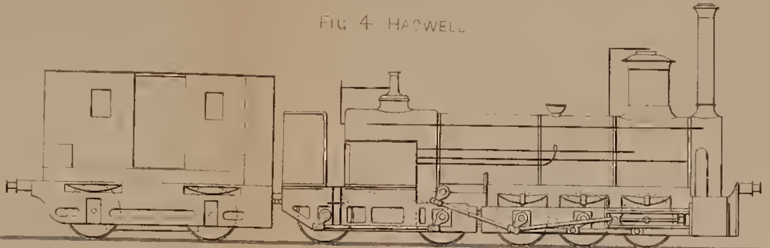


FIG 5 WA

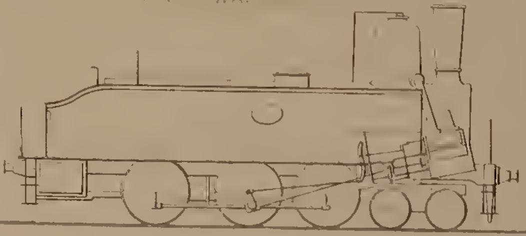


FIG 6 FIVES - LILLES

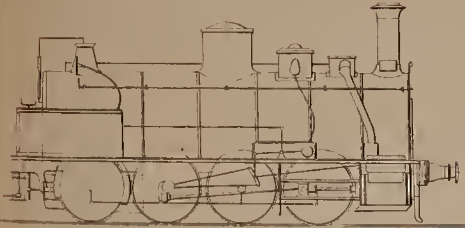


FIG 7 SCHNEIDER

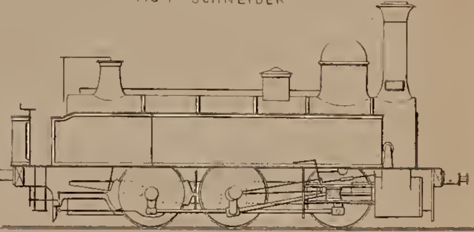


FIG 8 HUGHES

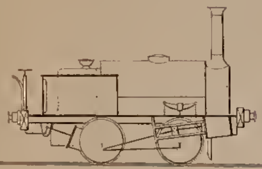


FIG 9 SIGL

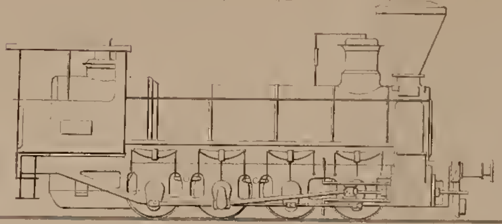
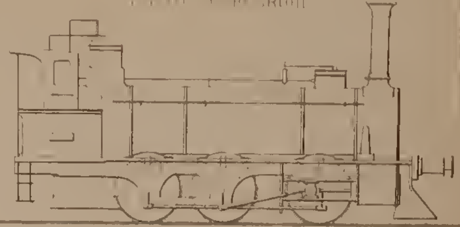


FIG 10 [illegible]



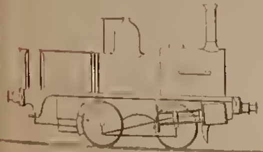


FIG 12 CREUSOT RUSSE

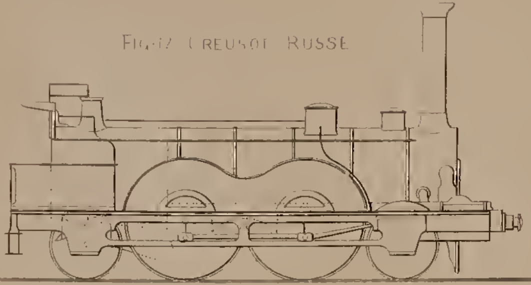


FIG 13 GOUIN

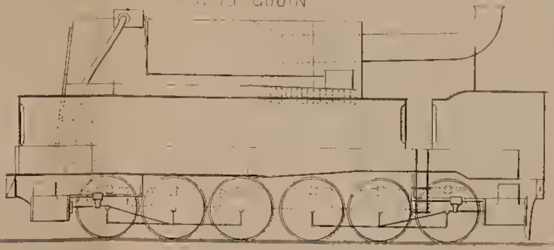


FIG 14 FRANC

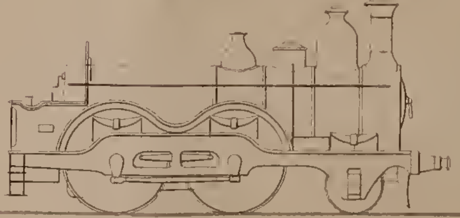
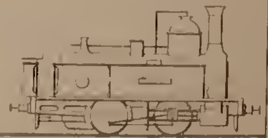


FIG 15 CREUSOT



W. Smith C.E. Direx

# THE ARTIZAN.

No. 2.—Vol. II.—Fourth Series.—Vol. XXVI. From the Commencement.

1st. FEBRUARY, 1868.

## LOCOMOTIVE ENGINES AT THE PARIS EXHIBITION.

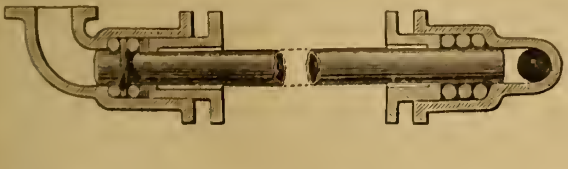
*(Illustrated by Plate 326.)*

In this plate, which is a continuation of the diagrams in The Artizan of December last (Plate 323), most of the peculiarities of the locomotives exhibited at the Paris Exhibition not already given, are here illustrated.

The locomotive shown by Fig. 1 (Plate 326), was constructed at Graffenstaden for the Eastern Railway Company, and is chiefly remarkable for having a steam tender, making, in fact, two locomotives with one boiler and tender between them. Both the engine proper and the tender have six coupled wheels, the axles having outside bearings and overhung cranks. The exhaust steam from the cylinders of the tender is not utilised, as in Mr. Sturrock's steam tenders.

There are two steam pipes: one to supply the cylinders of the locomotives and the other, which has no special coupling arrangement, to supply the cylinder of the tender. The wheels of the engine are 4ft. 3in. in diameter, and the wheel base 12ft. 2in.; the diameter of the wheels of the tender is 3ft. 11in., and the wheel base 10ft. 6in. The cylinders of the engine are 16½in. in diameter and 2ft. stroke, and of the tender 15in. diameter by 16½in. stroke. The tubes are 2in. diameter, 276 in number, and 9ft. 10in. long. The fire-grate is 3ft. 3½in. wide by 7ft. 4in. long, and the total heating surface 1,424 square feet, of which 159 square feet are fire-box surface. The weight of the engine is 30 tons 10cwt. empty, and 35 tons when working; the weight of the tender being 15 tons 18cwt. empty, and 28 tons when full.

Fig. 2 is another locomotive with a steam tender, designed by M. Maurice Urban for the Belgian Railways. It is by no means an elegant looking engine. the steam-chest being laid along the top of the boiler, and connected therewith by means of two short pipes—a plan not unfrequently adopted for land boilers, but looking very awkward upon a locomotive.



The steam-pipe which supplies the cylinders in the tender has a stuffing box joint, as shown in the annexed woodcut, the packing consisting of three rings of vulcanised indiarubber. The exhaust steam from the cylinders in the tender is used to heat the feed water. There are 368 tubes in the boiler, 1¾in. outside diameter, and 9ft. 10in. long. The furnace is 7ft. 2¼in. long by 3ft. 6in. wide; the total heating surface 1,929 square feet, of which 107 square feet is fire grate surface. The cylinders of the engine are 18in. diameter and 2ft. stroke; those of the tender are 13¾in. diameter and 15¾in. stroke. The engine and tender have each of them six wheels, 4ft. diameter, the wheel base of the engine being 12ft., and that of the tender 10ft. 6in. The weight of the engine when empty is 31 tons, and in working order 36 tons; that of the tender is 14 tons 16 cwt. empty and 27 tons full; the total weight when running being 63 tons.

Fig. 3, a ten-wheeled tender engine for the Paris and Orleans Railway Company, was built at their works at Ivry, from the designs of M. Forquenot, and is intended to work a branch line upon which there is an incline of 1 in 29. The axles of the two hind pairs of wheels are placed below the firebox, and have outside journals, so as to allow the width of the firebox to be increased, while the axle boxes are kept away from the heat of the furnace. To accommodate this arrangement the engine is provided with outside frames for a short length at the trailing end, which carry the horn plates for the two hind axles. The three remaining axles have inside bearings.

The principal dimensions are as follows:—Length of grate, 6ft.; width of ditto, 3ft. 8½in.; grate surface, 22¼ square feet; height of fire-box, 4ft. 10in. at front, and 3ft. 7in. at back; cubic capacity of ditto, 93½ cubic feet; number of tubes, 280; length of tubes, 16ft. 5in.; exterior diameter of ditto, 1¾in.; thickness of tubes, ·08in.; tube heating surface, 2,152 square feet; fire-box, ditto, ditto, 107½ square feet; total, ditto, ditto, 2,259½ square feet; diameter of body of boiler, 5ft. 3in.; thickness of plate, ·39in. (steel); working pressure allowed, 9 atmospheres; volume of water in boiler, 193 cubic feet; length of smoke-box, 3ft. 3in.; diameter of chimney, 17¾in.; diameter of cylinder, 19½in.; length of stroke, 23½in.; number of wheels, 10 (coupled); length of wheel base, 14ft. 10in.; diameter of wheels, 3ft. 6in.; load on wheels forward, 11 tons 14 cwt.; ditto second, 11 tons 14 cwt; ditto third, 12 tons 6½ cwt.; ditto fourth, 12 tons 9 cwt.; ditto fifth, 12 tons 9 cwt.; weight of locomotive working, 63 tons 12½ cwt.; ditto, ditto, light, 47 tons 10 cwt.; adhesion, at one-sixth, 10 tons 2 cwt; tractive force, 7 tons 10½ cwt.

In order to couple the two hind axles with the other wheels, the crank pins of the driving wheels are made very long, and are each furnished with three journals. The connecting rods are coupled to the central journal of each crank pin, whilst to the inner journal is connected the coupling rod for the front wheels, the outer journal taking the coupling rod for the hind wheels. The valve gear, which is of the stationary link class, is entirely outside, and is worked from overhung cranks on the outer ends of the driving crank pin.

Fig. 4 is an Austrian locomotive, constructed under the direction of M. Haswell from the designs of Chevalier de Engerth. It is the same engine as that exhibited at the London Exhibition of 1862, but since that time several alterations have been found necessary for its practical working. It was originally constructed as a tank engine, but in consequence of the excessive load upon the hind wheels, the tank has been removed and a tender attached to it. The ten wheels of the engine are arranged in two groups, the front truck having six coupled wheels, and the following truck, which is connected by a pivot joint, having four coupled wheels. The tender is coupled to this truck in a similar manner, and the engineers of the Austrian State Railway, who exhibit the engine, contend that this method of coupling facilitates the passing of curves. The engine has been constructed for running upon rails weighing only 48lbs. per yard, which are laid upon an incline of 1 in 50, and in curves of 360ft. radius. Under such circumstances the engine draws up a load of 120 tons in fair weather. The following are some of the principal dimensions:—Length of grate, 4ft. ¼in.; width of ditto, 2ft. 11in.; total grate surface, 12½ square feet; height of crown of fire-box over fire-bars, 4ft. 6in.; size of fire-box, 62 cubic feet; number of tubes, 158; length of tubes between tube-plates, 14¼ft.; external diameter of tubes, 2in.; thickness of tubes, ·079in.; heating surface of tubes, 1,240 square feet; ditto, ditto, fire-box, 78 square feet; ditto, ditto, total, 1,318 square feet; mean diameter of body of boiler, 4ft.; thickness of plate, ½in.: working pressure permitted, 7 atmospheres; cubic feet of water contained in boiler (3in. over crown of fire-box), 115·8 cubic feet; amount of steam space in boiler (ditto, ditto), 60 cubic feet; length of smoke-box, 2ft. 7¼in.; width of ditto, 5ft. 8¼in.; internal diameter of funnel, 16½in.; diameter of cylinders, 18⅛in.; stroke, 24⅞in.; number of wheels, 10; ditto, ditto, coupled, 10; distance between leading and trailing wheels, 19ft. 3¼in.; diameter of driving and coupled wheels, 3ft. 6in.; weight on leading axle, 9 tons 4cwt.; ditto on driving ditto, 9 tons 2cwt.; ditto, ditto, 8 tons 15cwt.; ditto, ditto, 6 tons 5 cwt.; ditto on trailing wheels, 9 tons 2 cwt.; total weight of locomotive working, 42 tons 8 cwt.; ditto, ditto, empty, 38 tons 13 cwt.; tractive force (counting 65 per cent. of effective), 6 tons 8 cwt.; adhesion, at one-sixth, 7 tons; weight of tender, 10 tons 4 cwt.

Fig. 5 shows a tank locomotive exhibited by M. Waëssen, constructed at St. Leonard, Liege, and is of a somewhat similar class of locomotive to that used on the North Spanish railways (Alar del Rey and Santander). This engine has six coupled wheels 4ft. 3⅛in. in diameter, and a four-wheeled Bissel truck under the leading end; the wheels being 2ft. 7½in. in diameter. The water is carried in wing tanks, the boxes for fuel being also placed on each side. The boiler is fed by injectors placed upon the top of the fire-box. The engine is fitted with M. Walschaërt's valve gear, a system which has been largely applied in Belgium, and which has also found favour in many other parts of the continent; but as it would be difficult to apply to any engines but those having outside valve gear, it is scarcely suited to locomotives in this country. In Walschaërt's gear the valve derives its motion partly from the piston rod cross-head, and partly from a small overhung crank; the valve spindle cross-head being coupled to the shorter arm of a lever, the longer arm of which is connected by a link to an arm on the piston rod cross-head. The fulcrum of this lever is not fixed, but consists of a pin carried by the end of a radius rod, which derives its motion from a quadrant link, having an oscillating motion imparted to it by being connected to the small overhung crank already mentioned. The extent and direction of the motion of the radius rod depends upon the position which the blocks carried by it occupy in the vibrating quadrant link, and this position is adjustable by a weigh shaft and lifting arms in the usual manner. The motion imparted to the fulcrum of the lever by the action of the crank and vibrating link gives the lead to the valve, and also enables the motion to be reversed. The distribution of steam effected by this description of valve gear is very good, but, as before mentioned, it is difficult to apply. The bogie frame is connected to the main frame of the engine in such a manner that it can not only rotate upon its central pivot, but can also move laterally, so as to adapt itself to any curve on which the engine may run. For this purpose the pin, which works in the socket in the bogie frame, is not fixed to the main frame of the engine, but is secured in the end of a radius bar 3ft. 4⅜in. long, the front end of which takes hold of another pin fixed to a strong transverse stay extending across the engine under the smoke-box. The other end of the radius bar is widened out, and the upper side of this widened part is fitted with two pairs of double inclines, which bear against corresponding inclines fixed to the under side of another transverse stay; by which means the pin in the socket of the bogie frame can move laterally its movement being governed by the radius bar and the inclines. The trailing axle of the engine has a lateral movement, the side play being permitted by making the axle-box guides 1¼in. narrower than the recesses in their axle-boxes, and their movement is restrained by double inclines fitted to the top of each axle-box. The trailing crank pins have spherical bearings. The front and hind pair of coupled wheels have their springs arranged over the axle-boxes in the usual way, but the middle pair of wheels are without springs, the spring pins resting on the tops of their axle-boxes, each bearing against the under side of a short beam, the ends of which are connected by links to the ends of compensating beams, the other ends of which are coupled by links to the springs of the front and hind pair of coupled wheels respectively. The draw-hook of the engine, instead of being attached to the trailing buffer beam, as usual, is coupled to a long draw-bar, which is cranked downwards, and connected at the other end to a pin which passes through a transverse stay carried across the engine between the front and middle pair of coupled wheels; the pull being thus taken from a point near the middle of the length of the engine.

The fire-box casing is flat topped, and the crown of the fire-box is stayed to the top of the casing in a similar manner to the sides. The back plate of the fire-box casing and the smoke box tube plate are strengthened by gusset stays. The following are some of the principal dimensions:—Length of grate. 7ft. 2·616in.: width of ditto, 2ft. 10·725in.; total grate surface, 20·7 square feet; height of crown of fire-box over fire-bars, 4ft. 1·21in.; size of fire-box, 84·5 cubic feet; number of tubes, 193; length of tubes between tube plates, 12ft. 1.67in.; external diameter of tubes, 2in.; thickness of tubes, ·079in.; heating surface of tubes, 1,197 square feet; ditto, fire-box, 96 square feet; ditto, total, 1,293 square feet; mean diameter of body of boiler, 4ft. 1·21in.; thickness of plate, ·472in.; working pressure permitted, 9 atmospheres; cubic feet of water contained in boiler (3in. over crown of fire-box), 148·5; amount of steam space in boiler (3in. over crown of fire-box), 67·5 cubic feet; length of smoke-box, 2ft. 11½in.; width of ditto, 4ft. 1.21in.; internal diameter of funnel, 17·71in.; diameter of cylinders, 18·11in.; stroke, 23·62in.; number of wheels, 10; ditto, coupled, 6; distance between leading and trailing wheels, 17ft. 8·59in.; diameter of driving or coupled wheels, 4ft. 3·18in.; ditto of leading ditto, 2ft. 7½in.; weight on leading axle, 10 tons 14 cwt.; ditto on driving ditto, 12 tons 9 cwt.; ditto, 12 tons 10 cwt.; ditto, 12 tons 14 cwt.; total weight of locomotive working, 48 tons 6 cwt.; ditto, empty, 35 tons 6 cwt.

Fig. 6 is an eight-wheeled goods engine constructed at Fives Lilles. Many similar engines have been already turned out at this shop, and are intended to work the heavy goods traffic of the Northern Railway. The trailing axle is arranged to pass under the fire-box so as to obtain a better distribution of the weight. The bottom of the fire-box is horizontal, but the fire-grate is slightly inclined downwards towards the front end. The grate bars, which are of cast iron, are made on the Belpaire system, being about ⅜in. thick at their upper edges, and arranged with spaces of about $\frac{7}{16}$in. between them. The grate is furnished in front with a rocking plate for clearing the fire, and worked by means of a screw. The fire-hole is of large dimensions and the door has two leaves. The top of the fire-box casing is flush with the barrel, and the latter is furnished on its under side with two cleaning holes. On the top of the barrel is a large steam dome, and the regulator is situated in a cast-iron casing fixed on the top of the barrel near the front end. From this casing two steam pipes, which are well lagged and protected by a sheet-iron covering, lead outside the boilers to the cylinders.

The frames are each cut out of a single plate without weld; they are well connected between the cylinders. The boiler is fixed to the frames at the front end, and the other connections between it and the frame are such that it is free to expand towards the rear end of the engine. The wheels are of wrought-iron, and were made by MM. Arbel et C , of Rive-de-Gier, by their patented process. The tyres are of Krupp's steel, those of the second pair of wheels from the front end being without flanges. The valve gear is of the shifting box-link kind, and is external. The boiler is fed by a pair of Giffard's injectors, No. 10, placed vertically, one on each side of the fire-box, and the water is delivered into the barrel at about the middle of its length. The hind pair of wheels is fitted with brake blocks, and there is a large sand-box placed on the top of the barrel of the boiler. The trailing springs are placed below the axles, and the springs of the two centre pairs of wheels are connected by compensating beams with equal arms.

The following are some of the principal dimensions:—Length of grate, 7ft. 1¼in.; width of ditto, 3ft. 3½in.; grate surface, 23½ square feet; height of fire-box, 4ft. 4in. in front, and 3ft. 5in. at back; cubic capacity of fire-box, 90½ cubic feet; number of tubes, 249; length of tubes, 13ft. 5in.; external diameter of tubes, 2in.; thicknes of tubes, ·08in.; tube heating surface, 1,656 square feet; ditto, ditto, fire-box, 103 square feet; ditto, ditto, total, 1,759 square feet; diameter of body of boiler, 4ft. 11in.; thickness of plate, ·63in.; working pressure allowed, 9 atmospheres; volume of water in boiler, 110 cubic feet; ditto steam in ditto, 86 cubic feet; length of smoke-box, 3ft.; width of ditto, 4ft. 10in.; diameter of chimney, 19¼in.; diameter of cylinder, 19⅝in.; length of stroke, 25½in.; number of wheels, 8 (coupled); length of wheel base, 14ft.; diameter of wheels, 4ft. 3in.; load on wheels forward, 12 tons; ditto second, 11 tons;

ditto third, 11 tons 12 cwt.; ditto fourth, 8 tons 16 cwt.; weight of locomotive working, 43 tons 8 cwt.; ditto, ditto, light, 38 tons 17 cwt.

Fig. 7 is a tank engine, constructed by Messrs. Schneider and Co., of Creusot. This is an outside cylinder engine, and has six coupled wheels, all the axles being placed under the barrel of the boiler, the fire-box being overhung. The tanks hold 990 gallons of water, and the principal dimensions are as follows:—Length of grate, 4ft. 2in.; width of ditto, 3ft. 2½in.; total grate surface, 12¾ square feet; height of crown of fire-box over fire-bars, 5ft. 1in.; size of fire-box, 69 cubic feet; number of tubes, 181; length of tubes between tube plates, 13ft. 11½in.; external diameter of tubes, 2in.; thickness of tubes, ·079; heating surface of tubes, 1,195 square feet; ditto, ditto, fire-box, 86 square feet; ditto, ditto, total, 1,281 square feet; mean diameter of body of boiler, 4ft. 2½in.; thickness of plate, ·47in.; working pressure permitted, 9 atmospheres; cubic feet of water contained in boiler (3in. over crown of fire-box), 113 cubic feet; amount of steam space in boiler (ditto, ditto), 45 cubic feet; length of smoke-box, 2ft. 11in.; width of ditto, 4ft. 3·4in.; internal diameter of funnel, 17·1in.; diameter of cylinders, 17·32in.; stroke, 23·6in.; number of wheels, 6 (coupled); distance between leading and trailing wheels, 11ft. 7½in.; diameter of wheels, 3ft. 11in.; weight on leading axle, 12 tons 13 cwt.; ditto on driving ditto, 12 tons 14 cwt.; ditto trailing ditto, 12 tons 17 cwt.; total weight of locomotive working, 38 tons 4 cwt.; ditto, ditto, empty, 29 tons; tractive force (counting 65 per cent. as effective), 10 tons 4 cwt.

Fig. 8 is a neat little contractor's engine, by Hughes and Co., of Loughborough. It is a four coupled wheel engine, furnished with a saddle tank of the usual description. The leading dimensions are:—Length of grate, 3ft. 1in.; width of ditto, 2ft. 4¾in; total grate surface, 7½ square feet; height of crown of fire-box over fire-bars, 3ft. 4in.; number of tubes, 100; external diameter of tubes, 2in.; diameter of body of boiler, 3ft. 2½in.; thickness of plate, ·39in.; diameter of cylinders, 12in.; stroke, 20in.; number of wheels, 4 (coupled); distance between leading and trailing wheels, 5ft. 2in.; diameter of wheels, 3ft.; total weight of locomotive, empty, 11 tons 10 cwt.

Fig. 9 is an eight coupled wheel engine, constructed by M. Sigl, of Vienna, and is intended to run on one of the Russian lines, the guage being 5ft. It is an outside cylinder engine. The axles have outside bearings, and are coupled by means of clumsy-looking outside cranks, to one pair of which the connecting rods are also coupled, according to the system patented by Mr. Hall. The engine is intended for burning wood, and the chimney is provided with an American sparkcatcher, the smoke-box being also furnished with a special arrangement for facilitating the removal of the wood ashes. The springs of the three hind pairs of wheels are connected by compensating levers. The boiler is supplied with a Giffard injector. The weight on the wheels is distributed as follows:—Upon the leading wheels, 11 tons 10 cwt.; upon the second, 12 tons 10 cwt.; upon the third or driving wheels, 13 tons; and upon the trailing wheels, 12 tons. Diameter of boiler, 4ft. 11⅞in.; number of tubes, 220; exterior diameter of ditto, 2in.; length of ditto, 15ft. 5¾in.; length of fire-grate, 5ft. 4⅛in.; width of ditto, 3ft. 7¼in.; height of ditto, 5ft. 1¼in.; heating surface of fire-box, 104 square feet; ditto of tubes, 1,787 square feet; diameter of cylinders, 20·47in.; length of stroke of ditto, 24·8in. diameter of wheels, 4ft.; wheel base, 12ft. 7½in.; weight, empty, 43 tons 10 cwt.; ditto, when in working order, 49 tons.

Fig. 10 is a goods locomotive for the Grand Duchy of Baden Railway, constructed at Carlsruhe, and destined for working the heavy traffic between Heidelberg and Wurzburg. This line has gradients of 1 in 80, and curves of 328ft. radius. The price of each engine, without tender, was about £2,184. The axles, tyres, piston rods, connecting and coupling rods, are made of steel, principally from Krupp's works; and the boiler is of iron plates made at Albruck, in Baden. The boiler tubes are of iron, and the fire-box of copper, ⅝in. thick, and the tube plate 1 inch thick. An engine of the same construction at its first trial took a load of 220 tons up an incline of 1 in 80, and through curves of 328 feet radius, at a speed of 16 miles per hour.

The following are the principal dimensions:—Length of grate 4ft. 4in.; width of ditto, 3ft. 4in.; total grate surface, 14·20 square feet; height of crown of fire-box over fire-bars, 4ft. 6½in.; size of fire-box, 70 cubic feet; number of tubes, 203; length of tubes between tube plates, 14ft. 3¼in.; external diameter of tubes, 2in.; thickness of tubes, ·084in.; heating surface of tubes, 1,290 square feet; ditto, fire-box, 80 square feet; ditto, total, 1,370 square feet; mean diameter of body of boiler, 4ft. 6⅝in.; thickness of plate, ·59in.; working pressure permitted, 10 atmospheres; cubic feet of water contained in boiler (3in. over crown of fire-box), 124 cubic feet; amount of steam space in boiler (ditto), 54 cubic feet; length of smoke-box, 3ft. 1½in.; width of ditto, 4ft. 6in.; internal diameter of funnel, 17¾in.; diameter of cylinders, 18in.; stroke, 25in.; number of wheels, coupled, 6; distance between leading and trailing wheels, 11ft. 4in.; diameter of driving and coupled wheels, 4ft.; weight on leading axle, 12 tons 3 cwt.; ditto on driving ditto, 11 tons 14 cwt.; ditto on trailing, 11 tons 15 cwt.; total weight of locomotive working, 35 tons 12 cwt.; ditto, empty, 30 tons 11 cwt.

Fig. 11 is a small contractor's engine by Messrs. Ruston and Proctor, the well-known agricultural engineers, of Lincoln. The chief peculiarity in the appearance of this engine is the forward position occupied by the saddle tank. The principal dimensions are:—Length of grate, 2ft. 4¾in.; width of ditto, 2ft. 3¾in.; total grate surface, 5½ square feet; height of crown of fire-box over fire-bars, 3ft.; size of fire-box, 17 cubic feet; number of tubes, 64; length of tubes between tube plates, 7ft. 3in. external diameter of tubes, 2in.; heating surface of tubes, 240 square feet; ditto, fire-box, 33 square feet; ditto, total, 273 square feet; mean diameter of body of boiler, 2ft. 10in.; thickness of plate, ⅜in.; working pressure permitted, 9 atmospheres; cubic feet of water contained in boiler (3in. over crown of fire-box), 33½ cubic feet; amount of steam space in boiler (ditto), 15 cubic feet; length of smoke-box. 1ft. 10in.; width of ditto, 2ft. 10in.; internal diameter of funnel, 8¼in.; diameter of cylinders, 8·66in.; stroke, 16in.; number of wheels, coupled, 4; distance between leading and trailing wheels, 5ft.; diameter of wheels, 2ft. 8in.; weight on leading axle, 5½ tons; ditto on trailing axle, 5½ tons; total weight of locomotive working, 11 tons; ditto, empty, 9 tons.

Fig. 12 is an express locomotive constructed for the Russian railways by Messrs. Schneider and Co., of Creusot, and, like Fig. 9, is intended for running upon a 5ft. guage. The cylinders are secured to inside and outside frames with which the engine is provided, the steam-chests being passed through openings formed in the inside frames; the flanges, which are bolted to the frames, are provided with lips, clipping the latter both above and below. The piston rods are enlarged at both ends, so that they are not weakened by the cotters which secure them to the crossheads, nor by their attachment to the pistons; the glands and packing rings being made in halves to admit of this arrangement. The connecting rods have solid ends. The slide bars are 4¾in. wide, and the slide blocks are 13¾in. long, so that they have a large wearing surface. The crank pin and cross-head bearings are also of a good size, the former being 4in. in diameter by 4¾in. long, and the latter 3⅝in. by 3⅞in.

The engine has eight wheels, the two pair of centre wheels being coupled, and a smaller pair of carrying wheels at each end; the leading and trailing wheels are provided with outside bearings, 6in. in diameter, and 10⅝in. long. One spring on each side is made to serve for the two coupled axles, there being on each side a compensating beam, which bears, through the intervention of pins, on the top of the axle boxes, and is connected by links with an inverted spring fitted between the axles. The valve motion is of the shifting link description, with back connections for the excentric rods, the throw of the excentrics being 2$\frac{1}{16}$in., and the maximum travel of the valve 5¼in. The boiler is fed by two injectors, the steam for working them being taken from the safety valve pillar on the fire-box casing. The following are some of the leading dimensions:—Diameter of cylinders, 17·32 in.; length of stroke, 23¼in.

distance apart, 6ft. 4in. from centre to centre; diameter of coupled wheels, 6ft. $10\frac{11}{16}$in.; distance apart, 7ft. $2\frac{5}{8}$in. from centre to centre; diameter of leading and trailing wheels. 4ft. $3\frac{1}{8}$in. diameter; distance apart, 19ft. $\frac{3}{8}$in. from centre to centre; barrel of the boiler, 4ft. $4\frac{3}{8}$in. in diameter; number of tubes, 180; outside diameter of ditto, 2in.; length of ditto, 14ft. $3\frac{1}{4}$in.; heating surface of ditto, 1,217·4 square feet; ditto of fire-box, 109·1 square feet; total heating surface, $1{,}326\frac{1}{2}$ square feet; steam space (the water level being 4in. above the crown of the fire-box), 70 cubic feet; water space, $128\frac{1}{4}$ cubic feet; area of fire grate, $23\frac{3}{4}$ square feet; weight on leading wheels, 9 tons $18\frac{1}{4}$ cwt.; ditto on driving wheels, 10 tons $8\frac{1}{4}$ cwt.; ditto on coupled wheels, 10 tons $6\frac{1}{4}$ cwt.; ditto on trailing wheels, 7 tons $13\frac{1}{4}$ cwt.; total weight of engine in working order, 38 tons 6 cwt.

Fig. 13 represents a peculiar-looking locomotive, constructed by M. M. E. Gouin and Co. for the Northern Railway of France. It is a four-cylinder engine, and is provided with a superheater and feed water heater. The plan of the engine is founded upon that of the four-cylinder engines constructed in 1863, from M. Petiet's designs and drawings of which were shown in the International Exhibition of 1862. The general arrangement of the axles and cylinders have been preserved in the new engines; but an important change has been made in the construction of the boiler. The superheater with which the first engines were fitted has been replaced by two cylindrical casings fitted with tubes, which are placed above the barrel of the boiler, and are traversed by the waste gases on their way to the chimney. The first of these two cases is a superheater, and it is traversed by the whole of the steam on its way from the boiler to the cylinders, the regulators being fixed directly to it. The second casing is a feed-water heater. It receives the water direct from the water apparatus, and delivers it, heated, into the boiler by a pipe which leads from the upper part of the casing to below the level of the water in the barrel. The feed is supplied by two pumps, the plungers of which are worked from the cross-heads; and a small injector (No. 2) is also provided for use when the engine is standing. The delivery pipe from the injector is led into that by one of the pumps.

The first of the two cylindrical casings above mentioned—or that which acts as a superheater—is 2ft. 8in. long by 3ft. 5in. in diameter, and it contains 86 iron tubes, $3\frac{1}{8}$in. diameter outside and 2ft. 8in. long. The second casing—or feed-water heater—is made of the same diameter, and contains the same number of $3\frac{1}{8}$in. tubes as the first; but its length is 3ft. 8in. The dimensions are as follows;—Length of grate, 6ft. 2in.; width of ditto, 5ft. 3in.; grate surface, $32\frac{1}{2}$ square feet; height of fire-box, 4ft. 3in. forward and 3ft. $5\frac{1}{2}$in. aft; cubic capacity of ditto, $124\frac{1}{2}$ cubic feet; number of tubes, 275; length of tubes, 8ft. 2in.; exterior diameter of ditto, $2\frac{3}{16}$in.; thickness of ditto, ·08in.; tube heating surface, 1,168 square feet; fire-box ditto, 102 square feet; superheater surface, 377 square feet; total ditto, 1,647 square feet; diameter of body of boiler, 4ft. 5in.; thickness of plate, ·55in.; working pressure allowed, 9 atmospheres; volume of water in boiler, 124 cubic feet; ditto steam in ditto, 63 cubic feet; length of smoke-box, 2ft. $11\frac{1}{2}$in.; width of ditto, 4ft. 10in.; diameter of chimney, 20in.; diameter of cylinder, 17·3in. (4 cylinders); length of stroke, 17·3in.; number of wheels, 12 (coupled); length of wheel base, 19ft. 8in.; diameter of wheels, 3ft. 6in.; load on wheels forward, 10 tons 2 cwt.; ditto, second, 10 tons 14 cwt.; ditto, third, 8 tons 18 cwt.; ditto, fourth, 9 tons 6 cwt.; ditto, fifth, 10 tons 16 cwt.; ditto. sixth, 10 tons 12 cwt.; weight of locomotive working, 60 tons 8 cwt.; ditto, light, 46 tons 8 cwt.

Fig. 14 is a locomotive built by Messrs. Cockrill, at Seraing, for the Belgian State Railway, and is one of a class adopted on that line since 1865. It is an inside cylinder engine with the driving and trailing wheels coupled. They are used for various kinds of traffic, and are said to perform exceedingly well. The cylinders are horizontal, with the slide valves placed between and above them, the valve spindles being slightly inclined. The driving axle has both inside and outside bearings, and the other axles outside bearings only. The reversing gear is of the combined lever and screw kind as employed by M. Belpaire, it being so arranged that either screw or lever may be used independently.

The following are the leading dimensions:—Length of grate, 8ft. 9in.; width of ditto, 3ft. 8in.; height of crown of fire-box over fire-bars, 3ft. $7\frac{3}{4}$in.; number of tubes, 208; length of tubes between tube plates, 11ft. 3in.; external diameter of tubes, $1\frac{3}{4}$in.; thickness of tubes, ·098in.; heating surface of tubes, 861 square feet; ditto, fire-box, $107\frac{3}{4}$ square feet; ditto, total, $968\frac{3}{4}$ square feet; mean diameter of body of boiler 3ft. 2·5in.; thickness of plate, ·433in.; working pressure permitted, 9 atmospheres; cubic feet of water contained in boiler (3in. over crown of fire-box), 109·45 cubic feet; amount of steam space in boiler (ditto), 70·983 cubic feet; length of smoke-box, 2ft. 6in.; width of ditto, 4ft. 1in.; internal diameter of funnel, 1ft. $9\frac{1}{4}$in.; diameter of cylinders, 16·929in.; stroke, 22in.; number of wheels, 6; ditto, coupled, 4; distance between leading and trailing wheels, 15ft. 2·287in.; diameter of coupled wheels, 6ft. 6·743in.; ditto of leading ditto, 3ft. 11·191in.; weight on leading axle, 11 tons 2 cwt.; ditto on driving axle, 11 tons $3\frac{1}{2}$ cwt.; ditto on trailing axle, 11 tons $3\frac{1}{2}$ cwt.; total weight of locomotive working, 33 tons 9 cwt.; ditto, empty, 33 tons 4 cwt.

Fig. 15 is a small tank locomotive, constructed by Messrs. Schneider and Co., of Creusot, for mineral traffic, the guage upon which it is intended to run being only 2ft. $9\frac{1}{2}$in. It has outside cylinders and four coupled wheels, the weight of the engine being equally divided between the axles.

The leading dimensions are:—Length of grate, 2ft. $\frac{1}{4}$in.; width of ditto, 1ft. $5\frac{1}{8}$in.; total grate surface, $3\frac{1}{4}$ square feet; height of crown of fire-box over fire-bars, 3ft.; size of fire-box, $9\frac{3}{4}$ cubic feet; number of tubes, 73; length of tubes between tube plates, 5ft. $10\frac{1}{2}$in.; external diameter of tubes, $1\frac{1}{2}$in.; thickness of tubes, ·06in.; heating surface of tubes, 155 square feet; ditto fire-box, 23 square feet; ditto total, 178 square feet; mean diameter of body of boiler, 2ft. 6in.; thickness of plate, ·364in.; working pressure permitted, 9 atmospheres; cubic feet of water contained in boiler (3in. over crown of fire-box), 25·38; amount of steam space in boiler (ditto, ditto), 9·5 cubic feet; length of smoke-box 1ft. $9\frac{1}{4}$in.; width of ditto, 3ft. 4in.; internal diameter of funnel, 8in.; diameter of cylinders, 8in.; stroke, $14\frac{3}{16}$in.; number of wheels, 4 (coupled); distance between leading and trailing wheels, 4ft. 8in.; diameter of wheels, 2ft. 4in.; weight on leading axles, 3 tons $3\frac{1}{2}$ cwt.; ditto on driving ditto, 3 tons $3\frac{1}{2}$ cwt.; total weight of locomotive working, 6 tons 7 cwt.; ditto, ditto, empty, 5 tons 4 cwt.

## AN ACCOUNT OF THE WATER BAROMETER, CONSTRUCTED AND ERECTED BY MR. ALFRED BIRD, OF BIRMINGHAM.

In the construction of a water-barometer four things have to be attended to:—

1st. The water must be deprived of air.

2nd. The air must not again enter the water.

3rd. The water must go into the barometer, to the exclusion of the air; and—

4th. The instrument must be so constructed that, while the atmospheric pressure within the instrument shall be uninterrupted, no air shall penetrate into the vacuum-chamber.

I begin by describing the material. The tube is composed of metal and glass, and the three taps are those which go by the name of "Lambert taps." The size of the metal part is half an inch internal diameter, and is that sort of white-metal tube which is in universal use by gas-fitters, called "compo." I believe it is an alloy of lead and zinc.

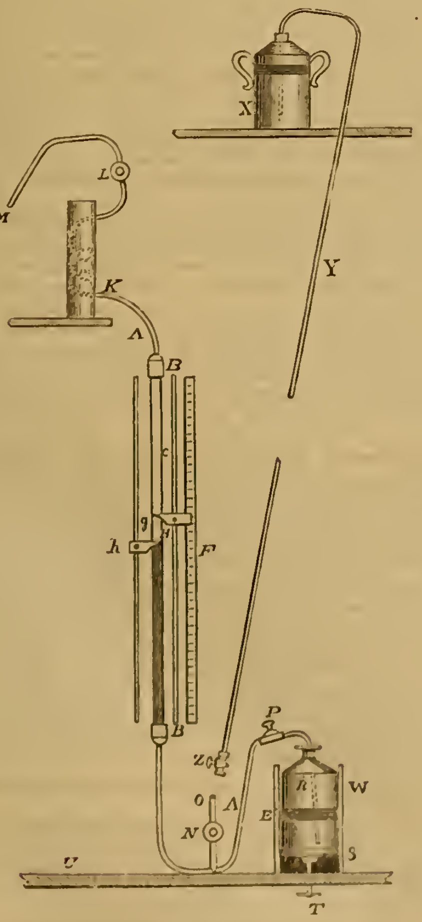
The glass tube to show the "readings" is 1 inch internal diameter and 6 feet long. The brass Lambert taps are half an inch internal diameter. These taps are constructed internally with a cushion of india-rubber, pressed down by means of a brass plate acted upon by a screw, which makes them absolutely secure.

I now proceed to describe the upper and lower parts of the barometer in reference to the drawing. AA is the compo tube, having two enlarged sockets B, B, $1\frac{1}{2}$ inch in diameter and 3 inches deep. These sockets were made of brass, and their office is to receive the ends of the glass tube. To fix the glass tube C, about six inches of the compo tube was soldered to the bottom of the socket, and being inverted and fixed very steady, enough dry sand was poured into the compo tube to fill it up to the *bottom* of the socket B. The using of the sand was to prevent the cement from running into and stopping up the compo tube. The glass tube C, perfectly clean inside, was now placed in the socket; and being most carefully steadied to keep it upright, six inches of dry sand were poured down to keep the cement from rising up the glass tube C.

The cement was composed of two parts of gutta percha and one part of common black pitch. These two substances were heated in an iron ladle with a lip, till they became perfectly fluid and quite free from froth. A "copper bit" used by plumbers having been heated to low soldering-heat, a small quantity of cement was poured into the socket. The copper bit was then applied to the outside, the effect being to perfectly liquefy the cement *in situ*. A little more of the hot cement was then poured in, and again the heated copper bit was applied till the socket was quite full of very liquid cement without any air-cavities therein. As the cement cooled, it clung to the glass and metal, and became absolutely solid and air-tight. If the cement is poured in *all at once*, it is impossible to prevent crevices, which will let in air when the barometer is filled, causing the water gradually to descend till it falls out of the instrument.

A place being chosen on the staircase of my house, a flat board, 7 feet long and 1 foot wide, was fastened to the wall, upon which board was fixed the socketed glass tube C, and graduated scale F, from the top of which 422 inches were most carefully measured down to the "zero"-point E beside the cistern.

The scale F is to the right of the glass tube. It is made of well-seasoned boxwood, and is graduated to inches and tenths. The sliding-tube, with the vernier H, is between the glass tube and the boxwood scale F. On the left side of the glass tube C is another sliding-tube *g*, with a vernier *h*, to record position of top of tidal column of water at 9 A.M. the morning previously.



The glass tube, scale, and verniers having been securely placed on the board and perfectly upright, the gas-fitter proceeded to connect, by soldering, the remainder of the compo tube *above* the glass tube C, which was continued upwards till it entered nearly at the bottom into a round vessel K, made of zinc, 4 inches in diameter and 18 inches high. Inside the vessel the tube coils round in a spiral, like the worm of a still. This vessel and spiral are not necessary to the action of the barometer; but as the spiral is in that part of the tube in which is the vacuum-chamber, it gives the opportunity of artificially cooling with ice or snow the included aqueous vapour, and thus determining by actual expeiiment the amount of correction required.

If the experiment of cooling the included vapour to 32° be tried in summer, when the external temperature is 70° or 80°, the sudden cooling causes so great an evaporation from the surface of the water, and condensation in the upper part of the barometer, that a real rain-shower is produced, the condensed water running down the glass tube in innumerable pellucid drops in the most beautiful manner, thus perfectly imitating the condensation of invisible watery vapour in the higher regions of the atmosphere. When the compo tube leaves the zinc vessel, it is led up perpendicular to the Lambert tap L. Above the tap L the tube still rises perpendicular, when it suddenly bends down, leaving the end open at M.

I now describe the part of the barometer *below* the glass tube.

The compo tube being soldered on, was carried down to the cistern, not necessarily perpendicular; for instance, the tube may descend at an angle of 30° or 40°, and may be led in any convenient direction. The entire instrument erected by me is in the house, to escape a freezing temperature. At the lowest end of the compo tube is a short upright tube, having at the end a Lambert tap N, to which is soldered a male screw of a ⅜th-inch gas union-joint O, the use of which will be understood further on. The compo tube now begins to ascend; and at the top of the bend is another Lambert tap P. Beyond this the compo tube bends down, and reaches nearly to the bottom of the cistern, which is a one-gallon white-glass narrow-mouth upright bottle R. The bottle rests upon a stand S, which moves up and down by means of a set screw T, acting through a stout shelf U; and the bottle is kept steady by means of two uprights W, upon one of which is fixed the zero-point E.

I shall now describe the method of filling the barometer, which was as follows.

Four gallons of water were carefully distilled, and being put into a *perfectly clean and new* tin oil-can with a narrow mouth, the water was boiled for one hour over a bright fire, the object being to drive out the air. While still boiling, two quarts of olive oil were poured in. This slightly increased the pressure in the water underneath, causing the last remains of the air to rise with the steam in jets or spirts through the stratum of oil. The instant ebullition was stopped, the oil closed over the boiled water, and it became hermetically sealed from the atmosphere. The contents of the tin-can were now cooled, and the can X was placed above the top of the water-barometer. A piece of ⅜th-inch gutta-percha tube Y, sufficiently long to reach from the can X above to below the very bottom of the barometer, was procured, and one end of the tube was put into the mouth of the can X, the end passing through the supernatant stratum of oil down to the bottom of the water underneath. At the other end of the gutta-percha pipe Y is a ⅜th-inch tap, terminating with a ⅜th-inch female screw union-joint Z. The gutta-percha pipe being in position, and hanging down as seen in the drawing, became a siphon; and the air being sucked out, the water at once came over, and was stopped from running away by turning the small tap Z. The female union screw at Z being tightly screwed on to the male screw-joint O, the water was ready to enter the barometer.

The first thing to be done was to displace the air in the bend of the tube, reaching from the tap N at the bottom, to the extreme end of the compo tube in the cistern R. This was done in the following manner:—The cistern or bottle was taken clean away and filled quite full to the very brim with best olive oil; the three Lambert taps being all open, and the bottom end of the "compo" tube hanging down, the small gas-tap Z was opened; the water then began to ascend both legs of the barometer, and when it reached the tap P, it passed over and ran out of the end of the tube which was hanging down. At that instant the stream was stopped with the thumb, and, the tap Z being turned off, the bottle full of oil was brought to the thumb which stopped the end of the compo tube and kept in the water. The thumb supporting the tube was now put into the oil, and the end of the tube slipped down to the bottom of the oil. The bottle was then put into its place on the stand S, and the surplus oil being siphoned out, there remained in the cistern R about 3 inches in depth of olive oil, the compo pipe dipping into it *nearly* to the bottom.

The next thing was to fill the longer part of the barometer, which was accomplished as follows:—The tap P being closed and the small tap Z opened, the water rapidly rose in the barometer; when the water had reached the opening M at the top, it was allowed to run a minute or two to carry any traces of air away which might have lingered in the tube. The tap L at the top and tap N at the bottom being then securely closed, tap P was opened, and the column of water began to descend and to accumulate in the cistern R *under* the stratum of olive oil. As the column fell it was narrowly watched in the glass tube, but not a bubble of gaseous matter was observed. On examining the cistern R, it was found that the oil did not quite reach the zero-point E, more oil therefore was poured in till the zero-point E and the *level* of the oil were coincident. The graduated scale was now looked at, and it showed that the column of water was 400in. high, the mercurial barometer being 30·4 inches, and the temperature 67°.

In order to test if gaseous matter would accumulate in the vacuum-chamber, the gutta-percha siphon was allowed to remain in its place for some weeks, and four different times tap P was closed, tap N opened, with tap Z, thus filling the barometer up to tap L at top, which being opened allowed the water and gaseous matter, if there had been any, to flow out at M. On closing tap L and tap N and opening tap P, the column of water again fell; and after siphoning out the surplus water from *under the oil* in the cistern till the oil was level with the zero-point E, the column of water was found on the different trials to be exactly the same height on the scale after each trial as before. It was therefore plain that no gaseous matter had accumulated above the water, and that, with the exception of the vapour of water, it was a perfect vacuum.

I will now mention one or two precautions which are required in order to ensure success. In the first place the water must be distilled—for this reason, amongst others, that if the water contains "earthy salines" or colouring matter, it is certain, by the constant evaporation and precipitation in the working part of the glass tube, to crust it over so completely, that in a few months the water becomes invisible; pure distilled water is therefore indispensable. Then, if the slightest leak in the barometer exists, it will infallibly bring the instrument to grief. In order, therefore, to be sure that the barometer was sound (before the water deprived of air was put in), I closed tap L at top and tap P; then, connecting the gutta-percha tube with the "street waterworks" pressure, I allowed it to enter the barometer till the included air was contracted to one-fourth of its length, having a pressure of water under it of between 40 and 50 lbs. to the inch.

The barometer stood this internal pressure for ten hours without the air being forced out. I therefore concluded that if the barometer would stand this great pressure *inside*, it would stand 14 lbs. to the inch pressure on the outside, and without hesitation I filled it with the prepared water.

As the instrument is made by a gas-fitter, it would be easy to put the whole of it together, Lambert taps included, and to *prove* it with some powerful water-pressure *before* the instrument is taken to the place where it is to be erected. Also the water deprived of air and covered with the stratum of olive oil in the tin can could be sent, if necessary, 100 miles away without the possibility of any air getting into it. If a gutta-percha pipe is not to be had to fill the barometer, a piece of compo tube will answer every purpose, which, when done with, is none the worse for gas-fitting purposes.

I shall conclude with some account of the action of the water-barometer. In the Philosohpical Transactions for 1832 is a description by Mr. Daniell of a water-barometer which he erected at the "Royal Society's Rooms," at Somerset House, which was in action for two years, but afterwards got out of order. In describing the action, Mr. Daniell states that "the water appears to be in perpetual motion, resembling the slow action of respiration."

I can fully corroborate Mr. Daniell in this particular, and from careful and continued observation am able to state that the times of the oscillations are about every four minutes and twenty seconds. It is requisite to watch the oscillations with a magnifier, as they vary from the twentieth to the thirtieth part of an inch, which distance can be well observed when it is slightly magnified. But the most surprising oscillations in the water-barometer are during a thunder-storm accompanied with great falls of hail and heavy rain-drops.

## TRIAL TRIP OF H.M.S. "DANAE."

The *Danae*, 6 guns, 350-horse power screw engines, 1,287 tons, Captain Sir Malcolm M'Gregor, commissioned for a term of foreign service, commencing on the West Coast of Africa, made her official trial of speed over the measured mile in Stokes Bay, near Portsmouth, on the 19th Dec. The ship weighed from Spithead about 9 A.M., and soon afterwards was placed on the mile-ground in Stokes Bay, the wind being quite moderate from the N.W., at a force between two and three, and the sea quite smooth. 247 tons of coals were in the ship's bunkers, all other stores were on board complete for 12 months' use, and the ship in all respects was ready to proceed at once to sea for a three years' tour of foreign service. The general results of the trial were as follows:—With six runs, with full-boiler power, the ship's speed in knots was 12·245, 13·846, 12·500, 13·906, 12·457, 14·018; the steam pressure being 27lbs., the vacuum 27in. and the (mean) engines' revolution 96. The mean speed of the ship over the measured mile under full steam 13·172 knots. In the four runs with half-boiler power the the speed was in knots 10·256, 13·091, 10·198, and 12·950. The mean speed of the ship over the measured mile under half-boiler power being 11·634 knots. According to the foregoing figures the *Danae* has gone through her trials at her seagoing draught of water with even a greater amount of credit to her designer than she attained (in point of speed) on her trial on the 15th of October last at her light draught. On this latter occasion her mean draught was 14ft. but at this trial her mean draught was 15ft. 1½in. In the half-boiler speed, however, the difference between the full and the half power is very remarkable, and must be considered as remarkable as affecting the true steaming power of the ship, inasmuch as, while the rate of speed made over the measured mile at full-boiler power can only be sustained there, the speed attained with half-boiler power over the measured mile can be easily and economically maintained at sea. Thus in the light draught trial of the ship's speed over the mile on the 15th of October last the mean speed of the ship with half-boiler power was 11·262 knots, while with an increased immersion of the ship's hull of close upon 13in. the mean speed obtained over the same number of runs made was 11·634 knots—a decided increase of speed by the ship with half-boiler power on her deep over her light draught trial. The machinery of the ship, by Messrs. Napier and Sons, of Glasgow, worked most satisfactorily throughout the trials. After the trials had been concluded the *Danae* anchored at Spithead, where she awaits sailing orders.

## NITRO GLYCERINE.

The following opinion respecting the properties of this peculiar compound was delivered by Professor Doremus at an inquest held on the bodies of nine persons killed by an explosion at South Bergen, New Jersey:—

"On Dec. 2, I received from the coroner two bottles of nitro-glycerine, with a request to report upon its properties; I have subjected it to ultimate chemical analysis, and find it to correspond to the formula $C_6H_3O_3$ and $(NO)^5$; it is well made nitro-glycerine; the substance freezes at about 46°; it is made to decompose in a very peculiar way; on moistening paper with it, it burns with rapidity; it does not explode when red-hot copper is placed in it; we tried it with the most intense heat we can produce with a galvanic battery, with two hundred cells holding a gallon and a half each; some nitro-glycerine was placed in a cup and connected with one of the poles of the battery; through a pencil of gas-carbon the other poles of the battery were connected with the glycerine; no explosion ensued; but when the point touched the britannia metal vessel the nitro-glycerine took fire, a portion burning and the rest scattering about; this is as severe a test as we can submit it to in the way of heat under the pressure of air; we therefore would conclude that nitro-glycerine carried about exposed cannot explode, even if you drop a coal of fire into it; if the liquid is confined, or is under pressure, then an explosion will ensue; if paper be moistened with it and put on an anvil and a smart blow given with a hammer, a sharp detonation ensues; if gunpowder or the fulminates of mercury, silver, or gun-cotton be ignited in a vacuum by a galvanic battery, none of them will explode; if any gas be introduced so as to produce a gentle pressure during the decomposition, then a rapid evolution of gases will result; the results of decomposition in a vacuum differ from those under atmospheric pressure, or when they are burnt in a pistol, musket, or cannon, or in a mine; where we have little or no pressure it is difficult to get these substances to burn rapidly; nitro-glycerine is more difficult to explode than powder; in many respects it resembles gun-cotton, which is made in a similar way; if gun-cotton be immersed in the proto-chloride of iron it turns into common cotton; the same experiment was tried with nitro-glycerine by mixing it with proto-chloride of iron, and it reverted into common glycerine; there are four well known varieties of gun-cotton made by employing acids of different strengths; they differ in chemical composition and properties, as well as in their explosive qualities; the late Minister of War in Austria, in 1862, stated to me that he had ordered 400 cannon for gun-cotton, and six months after he stated that he had ordered all the cannon to be changed and adapted to powder in consequence of spontaneous combustion; much less is known of nitro-glycerine than of gun-cotton, and probably several varieties of this article may be formed, as of gun-cotton; this would explain cases of spontaneous explosion; if the nitro-glycerine is not carefully washed to get rid of the acid, a gradual decomposition will ensue, producing gases which, if the vessel be closed, will explode; my opinion is that nitro-glycerine should be used in the most careful hands; do not think I would put it in the hands of a common labourer for blasting purposes; it is less dangerous in a frozen than a liquid state; I think concussion would explode frozen nitro-glycerine."

## AMERICAN ENGINEERING.

### REPORT OF COMMITTEE ON SAFETY-VALVES AND STEAM-GAUGES.

*(From the Journal of the Franklin Institute.)*

The committee, to which was referred the consideration of the legal requirements which should be made for safety-valves and pressure-guages upon steam-boilers, ask leave to report—

Considering, first, the subject of safety-valves:

We do not find there has been acknowledged in American or English practice of engineers or boiler-makers, any general rule of dimensions of safety-valves, relating to other dimensions of boilers, or to the pressures of steam or the rates of combustion of fuel, although such relationship is admitted by the assumption and use of different constructors without any definite rule.

Neither have those writers in our language, whose works are regarded as authoritative upon the subject of steam and the steam-engine, nor has American or English legislation established or stated suitable proportions and requirements for the various conditions. On the other hand, the laws of France and of other continental nations have been framed with an evident appreciation of the essential demands; and established areas of valve-openings for all sizes of, and pressures of steam in, boilers, so that it has only remained for the committee to translate into English measures, to modify the ratios by using as the surface of comparison with the safety-valve area, the grate surface in place of that adopted by the French—the boiler surface—and to make a further correction by embracing in the rule the differing rates of combustion upon the grate surface.

The committee have not found, nor have they sought very carefully, the reasoning upon which the French rule or formula has been based, and will say that they reached the same conclusion independently, and were not a little surprised by the coincidence after their own investigation. We proceed to give, as briefly as possible, those considerations which control or influence this question of area of safety-valves. A safety-valve is a loaded valve covering an orifice opening outwards from a boiler, which valve is intended to lift whenever the pressure of steam within the boiler rises above that to which the valve has been loaded, and the opening thus produced ought to discharge the steam of the boiler in such quantities that the pressure within shall not exceed, to any considerable degree, or beyond some fixed limit, the defined pressure at which the valve opened.

Upon this proposition it is evident that a safety-valve may sometimes be required to discharge all the steam, which, under the most favourable conditions, may be formed by evaporation in any given time. As the rapidity of evaporation is evidently the result of rapidity of combustion of fuel, which itself refers to extent of grate-surface and strength of draft or blast (supply of air), we take the grate-surface or area as that element of a steam-boiler presenting the most readily measured surface for comparison with the required area of the opening or least section of the aperture or channel of discharge of an opened safety-valve. We can assume that the draft or supply of air to the fuel being burned under any given steam-boiler, is, on the average, that existing in ordinary stationary steam-boilers with chimney draft, and afterwards correct our proportions for forced draft or blast and more active combustion. In like manner, we can modify the results based on this assumption to suit the conditions of boilers which are heated by the waste heat or by the burning of gases unconsumed in manufacturing processes. As it is the object of this investigation to determine that area of safety-valve needed to ensure safety, it is proper to give so great an excess above the absolute demand for the sectional area of the vein of steam escaping from a boiler under any given pressure as will be sure to cover the emergency of extraordinary rapidity of combustion during any short period of time, and also to include the co-efficient of resistance to discharge through a passage offering as much resistance as the one formed by lifting a disk-valve of the ordinary construction from a flat seat.

We here notice that there may be so large an excess of area that the opening of the valve may, by its sudden relief of pressure and discharge of steam, especially in boilers with limited water surface for the elimination of the steam from the water, dangerously disturb the equilibrium of circulation of water within the boiler, and also that the safety-valve may be so badly formed, in regard to shape of disk and seat, that, after lifting a little without any change of load upon the valve, the pressure within the boiler may dangerously increase, while a small quantity of steam only is discharged. In both of these points of difficulty we will refer to the practice of engineers, only saying here that the ratio of excess which we assume, when applied to the case of the gradual rising of temperature and pressure which occurs in a boiler containing a mass of water, and only admitting the gradual opening of the valve, is much below any dangerous condition, and our assumed excess is really additional safety. The assumption of considerable excess also allows us, when in our theoretical examination we find considerations of obviously very small value, to reach, in a practical form, a perfectly satisfactory general result. Proceeding on these grounds, therefore, let us take the average combustion of a well set or arranged boiler at eight pounds of coal (or fuel equivalent) per square foot of grate per hour, and that the maximum combustion, when the fire is in the best condition, and is evolving heat most rapidly, can be taken at three times that of the average. That is, for a portion of time we must assume the rate of burning will be twenty-four pounds of coal per square foot of grate per hour. We can estimate with the slow rate of average combustion assumed, and with adequate heating surface to the boiler, which surface shall be in good working order, both within and without, that there will be evaporated about nine pounds of water to each pound of coal consumed.

This gives a maximum rate of evaporation of two hundred and sixteen pounds of water per square foot of grate per hour, or 0·06lbs. of water per square foot of grate per second.

On the grounds stated in a preceding paragraph, we may neglect the increase of heat demanded for the evaporation of water at higher temperatures than 212°, and assume within our limits of twenty to one hundred and twenty pounds above the atmosphere, the weight of water evaporated or quantity of steam produced by the combustion of a given quantity of fuel to be constant.

Whatever error there is, from taking a larger quantity of steam at the higher pressures than is actually produced in the result, only adds to the dimensions of the safety valve of such higher pressures, and is an error in a safe direction as well as a very small one.

When we come to the discussion of how great an allowance of excess of size over absolute requirement is to be made, we take, first, the co-efficient of friction, as found by experiments on the flow of liquids through apertures and passages of a character similar to the passages of safety valves: $A_0 = 1{\cdot}5\, a$ where $A_0$ is the area of absolute requirement sought, and $a$ the sectional area of vein of fluid, supposing no resistance from the mouth of discharge to exist. And, secondly, the practical co-efficient employed to give adequate excess of area of valve for all contingencies.

This last has been taken at eight times the area of absolute requirement, or $A = 8\, A_0 = 12a$, where $A$ is the area of the valve sought, and $a$ as before, the values of $A_0$, $A$ and $a$ being taken in square inches.

The most simple equation expressing the relation of volumes of steam to water applicable to our purpose, is that given as the result of experiment by Fairbairn and Tate.

$$U_p = \frac{389}{P + 15{\cdot}052} + 0{\cdot}41,$$

where $U_p$ = the volume of one pound steam in cubic feet, under any nominal pressure = $P$ per square inch above the atmosphere. Whence we have

$$U = 0{\cdot}06\left(\frac{389}{P + 15{\cdot}052} + 0{\cdot}41\right) = \text{cubic feet of steam formed,}$$

under our supposition, per second.

The height of column to effect the discharge of steam under any pressure $P$ (per square inch), is evidently equal to the volume of $P$ pounds of steam multiplied by 144.

$$h = 144\, P\left(\frac{389}{P + 15{\cdot}052} + 0{\cdot}41\right),$$

and the theoretical velocity of discharge in feet per second = $V$ = $8{\cdot}025\sqrt{h}$.

$$\therefore V = 8{\cdot}025\sqrt{144\, P\left(\frac{389}{P \times 15{\cdot}052} + 0{\cdot}41\right)}.$$

The size of the vein $a$ (in square feet), which will convey the volume $U$ at the velocity $V$ per second, is

$$a_1 = \frac{U}{v} = \frac{0{\cdot}06}{12 \times 8{\cdot}025}\;\frac{\dfrac{389}{P + 15{\cdot}052} + 0{\cdot}41}{\sqrt{P\left(\dfrac{389}{P + 15{\cdot}052} + 0{\cdot}41\right)}}$$

but $144\, a_1 = a$, and $12\, a = A$. $\therefore A = 1728\, a_1$.

$$\therefore A = \frac{1728}{12} \times \frac{0{\cdot}06}{8{\cdot}025}\sqrt{\frac{\left(\dfrac{389}{P + 15{\cdot}052} + 0{\cdot}41\right)^2}{P\left(\dfrac{389}{P + 15{\cdot}052} + 0{\cdot}41\right)}}$$

$$\therefore A = 21{\cdot}23\sqrt{\frac{1}{P}\left(\frac{1}{P + 15{\cdot}052} + 0{\cdot}00105\right)}.$$

We will now compare this with the legal formula of France, which reads

$$A\ (\text{in centimetres}) = 0{\cdot}00053\,\frac{S\ (\text{in metres})}{n - 0{\cdot}412},$$

where $A$ = area of safety-valve, $S$ = heating surface of boiler in square metres, and $n$ = absolute pressure of steam in atmospheres. We can safely take the French practice in construction of their boilers at twenty units of boiler surface to each unit of grate surface, as the boilers in general use in France assimilate in these ratios to those of our long cylinder or two-flued forms, when the proportions generally correspond. Substituting this value and taking 14·7lbs. for the atmospheric pressure, deducting one atmosphere of constant pressure, and reducing the whole to American weights and measures, we have—

$A = \frac{22{\cdot}5}{P + 8{\cdot}62}$, where $A$ = area in square inches of safety-valve per square foot of grate surface.

The results of the two formulas are given below—

$$\text{Formula as calculated—}A = 21{\cdot}23\sqrt{\frac{1}{P}\left(\frac{1}{P + 15{\cdot}052} + 0{\cdot}00105\right)}.$$

| Pressure in pounds per square inch. | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 100 | 120 |
|---|---|---|---|---|---|---|---|---|---|---|
| Area of safety-valve per square foot of grate—square inches. | 1·33 | 0·815 | 0·589 | 0·465 | 0·334 | 0·328 | 0·287 | 0·257 | 0·209 | 0·178 |

$$\text{Formula as given in French law—}A = \frac{22{\cdot}5}{P + 8{\cdot}62}.$$

| Pressure in pounds per square inch. | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 100 | 120 |
|---|---|---|---|---|---|---|---|---|---|---|
| Area of safety valve per square foot of grate—square inches. | 1·21 | 0.786 | 0·583 | 0·461 | 0·384 | 0·328 | 0·286 | 0·254 | 0·207 | 0·175 |

This coincidence of result could only have existed from having the same basis, and the difference of form of the two second terms can only have arisen from the using some other and more tractable empirical formula for the volume of steam by those who originated the French rule.

The divergence below 20lbs. we do not consider essential, whether the calculated formula gives too large values, or the French one too small, and we would recommend for adoption the more simple formula

$$A = \frac{22{\cdot}5}{P + 8{\cdot}26}.$$

It next remains to show the results of this formula when applied to practical cases, so as so see how nearly it is corroborated by the use of our American stationary boiler makers.

We give tables of two pressures, 50lbs. and 80lbs. per square inch, and for areas of grates from 4 to 25 square feet of grate as below:—

Areas of safety-valves for boilers with 80lbs. pressure ($A = 0{\cdot}254$), and with grates of different dimensiona.

| Surface of grate in square feet. | 4 | 6 | 9 | 12 | 16 | 20 | 25 |
|---|---|---|---|---|---|---|---|
| Estimated area of safety-valve. | 1 | 1·5 | 2·25 | 3 | 4 | 5 | 6·25 |
| Estimated diameter of safety-valve in nearest whole numbers or quarters of inches. | $1\frac{1}{4}$ | $1\frac{1}{2}$ | $1\frac{3}{4}$ | 2 | $2\frac{1}{4}$ | $2\frac{1}{2}$ | 3 |

Areas of safety-valves for boilers with 50lbs. pressure ($A - 0{\cdot}384$), and with grates of different dimensions.

| Surface of grate in square feet. | 4 | 6 | 9 | 12 | 16 | 20 | 25 |
|---|---|---|---|---|---|---|---|
| Estimated area of safety-valve. | 1·52 | 2·28 | 3·42 | 4·56 | 6·08 | 7·60 | 8·50 |
| Estimated diameter of safety-valve in nearest whole numbers or quarters of inches. | $1\frac{1}{2}$ | $1\frac{3}{4}$ | $2\frac{1}{4}$ | $2\frac{1}{2}$ | $2\frac{3}{4}$ | $3\frac{1}{4}$ | $3\frac{1}{2}$ |

We think these dimensions correspond very nearly to the practice of all experienced constructors, and exhibit at once the usual size of safety-valve, and that of the main steam-pipe generally employed.

If we adopt the formula as expressing the proper areas of safety-valves for stationary boilers, which are not prepared to burn upon their grates more than 8lbs. of coal per hour on the average, we have next to show how it can be applied to other conditions. With natural draft, the rapidity of combustion depends, in a great measure, upon the intensity of the fire, and a maximum rate of 24lbs. may, and probably does, accompany an average rate of 8lbs. of coal per square foot of grate per hour, while with artificial draft or blast this rapidity of combustion is nearly independent of the condition of the fuel, and a maximum rate of 24lbs. will hardly be exceeded with an average one of 16. We think it safe to take this quantity of 16lbs. average combustion per hour, with or by the aid of induced, or produced supply of air to the fuel (as with jets or by fans) as an equivalent to the one square foot of grate surface, which we had taken as the unit of comparison with the area of the safety-valve.

That is, the area of one square foot of grate, *without* artificially accelerated draft, may be assumed to require the same area of safety-valve, as the burning of 16lbs. of coal per hour, *with* such draft, properly demands.

As regards those boilers which are heated by the waste heat of furnaces, or by the combustion of waste gases from some processes of manufacture, the circumstances are too variable to admit of statement in any law, and only the judgment of competent mechanics upon the performance of such boilers or steam-generators, can determine the proper area of safety-valves for them.

If the area given by the formula be applied to the opening of the seat of the safety-valve, it is obvious that the lift of the valve must be at least one-fourth the diameter, to have the same sectional area when open.

Hence, should any valves be so constructed that the range of motion will not admit, when fully raised, a lift equal to one-fourth the diameter of the opening of the seat of the valve, the sectional area actually given between the raised valve and the edge of the valve seat should be taken as that to which the rule applies.

And while the formula gives areas abundantly large to meet the general resistance to discharge, which proceeds from the necessary form of a disc resting upon, or placed in proximity to, a seat, we think we ought here to state, that it is always advisable that the undersides of safety-valve discs should have a globular or pointed form (whether with or without guide wings), and not be made flat as they sometimes are, and that the discs be beveled-edged, resting upon a very narrow beveled seat and do not have a flat bearing. It may be well to state, also, that, as ordinarily constructed, a safety-valve, after lifting and allowing a flow of steam all round the disc, does not continue to raise and allow all the steam, as formed, to escape at the constant pressure, but admits some elevation of pressure before opening wide. With the areas given by the formula, and where the discs have been shaped as we have before described, this increase of pressure will not exceed 10 per cent. of the initial load on the valve, and the additional resistance to opening is a safeguard against the too sudden relief of steam, to the derangement of the water circulation of the boiler.

The committee will only add, as regards further consideration of the form or description of safety-valves, and as to legal requirements beyond the adequacy of the openings, that the subject becomes too extensive for them to consider.

As originally made in the days of Watt, almost as planned by Papin, the essential parts of the safety-valve have substantially remained until this time. No patent covers its simplicity or improves its certainty, although there have been made and used a thousand kinds, and there are a hundred existing patents.

It can only be imperfect by palpable misconstruction, or unsafe by vicious intent, and we can only recommend the defects to competent inspection with power to remedy, and the misuse to the punishment of the law. There is very little likelihood that a safety-valve, properly constructed and in proper hands, would get out of order or fail to act at the needed moment. But, on the supposition that such catastrophe might occur, it has been thought by the committee, after much deliberation, that, in order to divide the small chance for failure, it may be as well to make it a legal requirement, that in place of one safety-valve, each and every boiler shall have at least two, the aggregate area of which should be that established by the formula.

These valves ought to be loaded with the same load, and blow off indiscriminately, so that either or both may be in action at once.

This plan would call for, and ensure, more care in graduating the loads on safety-valves than is at present employed. The committee feel justified in observing that there are now in use more safety-valves improperly graduated or marked, then there are those improperly or unsuitably constructed. Lock-up safety-valves are but little protection from fraud or over-pressure, and less security, unless frequently tested, and their use is decidedly discountenanced by the committee.

We conclude our discussion of this branch of the subject committed to us, by recommending for the approval of the Institute, the following

SCHEDULE,

Giving the least aggregate area of safety-valves (being the least sectional area for the discharge of steam) to be placed upon all stationary boilers with natural or chimney draft.*

This area may be expressed by the formula—

$$A = \frac{22{\cdot}49}{P + 8{\cdot}62}$$

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* Where boilers have a forced or artificial draft, the combustion of 16lbs. of coal per hour should be taken as equivalent to the 1 square foot of grate surface = G in the above formula and table.

in which A = area of combined safety-valves in square inches.
G = surface of grate in square feet.*
P = { pressure of steam in pounds per square inch to be carried in the boiler above the atmosphere.

The following table gives the result of the formula for one square foot of grate as applied to boilers used at different pressures.

Pressure in pounds per square inch.

| 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 | 120 |
|---|---|---|---|---|---|---|---|---|---|---|

Areas in square inches corresponding to each square foot of grate.

| 1·21 | 0·79 | 0·58 | 0·46 | 0·38 | 0·33 | 0·29 | 0·25 | 0·23 | 0·21 | 0·17 |
|---|---|---|---|---|---|---|---|---|---|---|

We give one example of the application of the figures given by the table:—

Suppose the boiler to work under 60 pounds pressure, then each square foot of grate surface should have an area of safety-valve by the table of } = 0·33 square inches.
Suppose the boiler to have 25 square feet of grate-surface, } = 25

giving a calculated area for the safety-valves = 8·33 square inches.

This would call for two safety-valves, each having an area of 4·16 square inches, or a diameter of $2\frac{3}{10}$ths inches.

And the committee would report on the second branch of the subject referred to them—the legal requirements which ought to be made as to pressure-gauges—that the time allotted to them has not permitted a complete investigation. The great advantage which any of these instruments possess, is found in their indicating the pressure of steam within a boiler, so as to allow a fireman to regulate his supply of fuel with economy. There are many kinds and forms of guages, almost every one of which has some characteristic superiority over all, or most other kinds and forms, but we do not wish to say that any of them are perfectly or permanently reliable.

And your committee would ask to be relieved from further consideration of the subjects referred to them.

Robert Briggs,
Coleman Sellers,
J. Vaughan Merrick,
Wm. Barnet Le Van.

# ON THE COMPOSITION AND DURABILITY OF LOCOMOTIVE BOILER TUBES IN REFERENCE TO COAL-BURNING.

By Mr. George A. Everitt, of Birmingham.

The question of coal-burning in locomotive engines and its consequent action on the copper fireboxes and brass tubes has drawn attention to the importance of ascertaining the best alloy of brass for the tubes, and also to the necessity of overcoming the difficulties often experienced from the copper plates of the fireboxes being of hard or brittle quality; and the opinion has been extensively held that the duration of the brass tubes and copper plates has been lessened since the general adoption of coal-burning in locomotives.

Previous to the year 1852, three qualities of metal were recognised in copper smelting—namely, tile copper, tough cake, and best selected copper. Of these the tile copper was the lowest quality, and there was a difference in cost of £2 per ton between each quality. The best selected copper is produced by stripping or skimming off the upper surface of the melted metal in the smelting process, this portion being the purest quality of metal; the upper portion of the remaining metal formed the second quality or tough cake copper; while the tile copper was the residue at the bottom of the melting pot, containing the largest proportion of impurities. In 1852 the description called tile copper was discontinued, and the other two sorts only were made—namely, tough cake and best selected copper, with a difference in cost of £3 per ton. This change, however, did not prove beneficial in respect of the durability of copper plates and sheathing made from the new description of tough cake copper, which was not of such good quality as previously; for owing to the very great demand for best selected copper for the manufacture of Muntz's metal for sheathing and of brass tubes for locomotives, &c., the stripping or skimming process in the smelting was now carried too far, the cake copper being seriously robbed by the greatly increased proportion of metal skimmed off to form the best selected copper, whereby the remainder was left inferior in quality to what it should be, and little if at all better than the tile copper of former years, while the best selected copper itself was also injured in quality by containing too great an admixture of impurities.

As early as 1858, it was found at Chatham dockyard that the copper sheathing of ships' bottoms, which is made from cake copper, did not last so long as before the above change; and copper sheathing which had been in use only two years was found to have lost as much as 14 per cent. of its weight; whereas only $\frac{1}{4}$ per cent. of the weight had been lost after eighteen years wear of copper made in 1825, at which time but little best selected copper was made, the stripping or skimming process not having then been introduced to any considerable extent. At the present time the average duration of the copper sheathing on ships' bottoms is reduced to only three or four years, instead of from twenty to twenty-five years as formerly, owing solely, it is believed, to the extent to which the stripping process is now carried. The same explanation probably accounts also for the complaints which are frequently made that the copper firebox plates for locomotives are found inferior in quality to those obtained in former years.

The great and increasing demand for best selected copper undoubtedly caused a large quantity to be supplied under that designation which was not even so good as the tough cake of former years. Attention was again drawn to the subject at Chatham dockyard on the occasion of a ship which had lain some time in the harbour, being suddenly ordered to sea; the brass tubes in the boilers, which were new, were then found to be leaky, and had to be taken out and the boilers re-tubed before the ship could proceed to sea. The cause of this and other similar failures was considered to be, that the copper used in the manufacture of the tubes must have been of inferior quality, and not best selected as it ought to have been.

The following method of testing was consequently adopted by the Admiralty in 1865 for ensuring the use of the proper quality of copper in brass boiler tubes for marine purposes. Portions of several of the tubes are melted in a crucible, and zinc is added until the compound contains as nearly as possible 62 per cent. of copper and 38 per cent. of zinc, which is a composition that can be rolled hot and appears to give the maximum of tensile strength. The metal is then cast into an ingot, and after being brought to a low red heat in an annealing furnace is rolled out into a plate $\frac{1}{4}$in. thick, from which strips are cut 1in. wide. If the proper quality of copper has been used, these strips then stand a tensile strain of at 6 tons each, equal to 24 tons per square inch; and the fracture when broken across presents a silky appearance in texture, which cannot be obtained if common tough cake copper has been used, or even ordinary selected copper, as none but the best selected copper gives this appearance to the fracture. As the quantity of copper contained in brass tubes is much in excess of the composition here fixed for the purpose of testing, it may appear strange to add zinc for reducing the proportion of copper; but the reason is that the richer alloys are so ductile that they elongate considerably under a tensile strain, and will not stand anything like the breaking strain of 24 tons per square inch, nor will the test composition containing the 38 per cent. of zinc stand the test, if annealed previous to testing. Another advantage in adopting the lower percentage of 62 per cent. of copper is that the appearance of the fracture of the low alloy gives a better test of the quality of the copper than a richer composition would afford.

From a number of experiments upon the tensile strength of alloys containing the above proportions of 62 per cent. of copper and 38 per cent. of zinc, it was found by the writer that only a few of the makes of best selected copper taken indiscriminately came up to the required strength; and a quality that would stand the test could only be ensured by an extra price for the copper. At the present time, however, some of the copper smelters have accepted this test, and produce a quality of best selected copper which is quite up to the mark. Great benefit has certainly been derived from the government researches in this matter, which have undoubtedly caused an improvement in the quality of best selected copper; and the standard test above described is now invariably adopted by the writer for all best selected copper used in the manufacture of brass tubes for boilers.

The brass tubes in most general use at the present time for locomotive and marine boilers are known as solid-drawn tubes, consisting of two parts of copper to one part of zinc, which proportion becomes a little changed in the process of manufacture, owing to the volatility of the zinc when melted: and on analysis the writer has found the composition of the metal to be copper 69 to 68 per cent., and zinc 31 or 32 per cent. The question arises, however, whether this is the best alloy for the purpose, and whether the addition of more copper would not increase the durability of the tubes, especially in resisting the action of sulphur in coal-burning engines with bad coal; and the writer was first led to consider this question by finding, some years ago, that the practice on all the French railways was to adopt a standard composition containing at least 70 per cent. of copper, which was adhered to for all locomotive tubes. In this country the same con-

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* Where boilers are heated by the waste heat of furnaces, or otherwise than by fire upon grates, the value to be taken for G must be estimated by some competent person, based upon the comparative performance of boilers with others heated in the usual way.

clusion has been arrived at on the North Eastern Railway, where it has been found by Mr. Fletcher after more than twenty years' experience with tubes of this composition, that they are more durable than those containing a smaller proportion of copper; and consequently all the tubes for that railway are now required to contain 70 per cent. of best selected copper, and 30 per cent. of best Silesian spelter. The actual results of working on that line, where the water is unusually bad, have been that 15 sets of tubes containing 70 per cent. of copper or upwards, lasted an average of 87,808 miles each; while the average of 54 sets containing a lower proportion of copper was 81,665 miles. It is difficult, however, to arrive at any reliable statistical information respecting the duration of tubes, as it is materially affected by the quality of the water used in the boilers, and also by the quality of the coal as regards its freedom from sulphur; their average duration throughout the railways of this country may be taken at from 100,000 to 150,000 miles.

The proportion of 70 per cent. of copper is considered by the writer so great an improvement that it has been adopted as the composition of the locomotive tubes of his own manufacture; and this opinion is confirmed by the circumstance that the alloys of brass used for other purposes, such as to resist the action of sulphur and acids, are always made with this or even a higher percentage of copper. Hitherto the composition of locomotive tubes has been very various, the percentage of copper extending down to the proportion in the composition known as Muntz's metal, which is ductile when worked hot and contains 60 per cent. of copper and 40 per cent. of zinc; and one advantage which will attend the adoption of a standard percentage of copper in boiler tubes will be that old tubes when taken out of the boilers will have a certain definite value exactly in proportion to their weight.

The question of the best thickness of metal for the tubes is one of much importance, and one on which great diversity of practice at present exists upon the different railways; but with the increased percentage of copper in the composition it may safely be assumed that greater ductility will be obtained, and that some reduction in the thickness of tubes may be made without diminishing their durability. The thicknesses of tubes range from as much as 9 and 13 wire-guage (·150 and ·095in.) at the thick and thin ends respectively, down to as little as 13 and 15 wire-guage (·095 and ·070in.); the most general practice of the leading English lines being about 10 and 13 wire-guage (·135 and ·095in.) The thickest tubes, of 9 and 13 wire-guage (·150 and ·095in.), have only been used regularly on one or two railways; and a serious difficulty having been experienced in keeping these thick tubes tight with very long fireboxes, a trial has been made at the writer's suggestion of the thin tubes of 13 and 15 wire-guage for that purpose, whereby the previous difficulty of keeping the tubes tight has been obviated. The relative durability of the thinner tubes has not yet been proved, but an important saving in first cost is effected, the thick tubes having weighed 26lbs. each for 11ft. length, while the thin tubes weigh only 21lbs. each, effecting a saving on a set of 150 tubes of 750lbs. weight, amounting to £29 in cost. Very good results have been obtained on one large railway with these thin tubes of 13 and 15 wire-guage and $1\frac{9}{16}$in. external diameter, in locomotives burning coal exclusively.

The greater rigidity of the thick tubes may have caused the difficulty previously mentioned of keeping them tight, the thick tubes not yielding so readily as the thinner ones to the inevitable difference in expansion of the brass tubes and iron boiler-shell. That this difference in expansion is a point of importance is seen from the circumstance that in a length of 11ft. the expansion of iron at 350° Fahr., the temperature of 120lbs. steam, is $\frac{1}{4}$in., but that of brass is $\frac{3}{8}$in., giving a difference of $\frac{1}{8}$in., which has unavoidably to be allowed for either by compression of the metal or by lateral springing of the tubes. On many railways the tubes are now annealed throughout, and the same practice has also been adopted to some extent by the Admiralty for marine boiler tubes; which tends to show that softness combined with great ductility is the desideratum needed.

On foreign railways it may be remarked that a different construction of tubes has been extensively tried, namely, wrought-iron tubes with copper ends brazed on at the firebox end. The copper ends are bevilled to a feather edge on the inside, and the tube ends in a similar manner on the outside, and the two are then brazed together. The object of this construction is to give the ductility of copper at the end where the tubes are flanged over the firebox tube-plate, and thus to overcome the difficulty of leakage, which has always been the great objection to iron tubes in locomotives. Although by this means an economy is effected in first cost by the use of iron tubes, in practice the saving is not so apparent; and on many foreign railways where such tubes have been tried, brass tubes are now being substituted for them. On one railway in Russia, tubes of copper alone are used, but the fuel employed in that case is wood; and in the peat-burning locomotives on the Grand Trunk Railway of Canada brass tubes are now being substituted for the iron tubes previously tried.

Brass tubes are found to suffer serious damage from long exposure to damp, and to become hard or brittle, losing their ductility. This arises possibly from the circumstance that the injurious action known to be produced upon brass by the sulphuric acid gas present in the atmosphere of towns is greatly dependent upon the presence of moisture in the atmosphere; and at the writer's suggestion, the stores for brass locomotive tubes have in some cases been heated and enclosed, with advantageous results in preserving the tubes from damage.

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## ON THE OCCLUSION OF GASES BY METALS.

By William Odling, M.B. F.R.S.

The remarkable property first observed by M. Deville, in the case of homogenous platinum and iron, when at a red heat, of being permeable to hydrogen gas, is not by any means confined to these two metals; and has been shown by Mr. Graham to be manifested in a much greater degree by palladium, even at temperatures falling considerably short of redness.

An exhausted tube of wrought palladium, surrounded by atmospheric air, remains perfectly vacuous at a red heat; surrounded by an atmosphere of hydrogen, it remains vacuous at 100°, but allows of some transmission at 240°; while at 265°, and up to a temperature just short of redness, there is a steady and considerable passage of hydrogen to its interior, maintained vacuous by the Sprengel pump. Surrounded, under the same conditions, by coal gas, the free hydrogen of the coal gas alone finds its way into the interior of the tube, the remaining constituents of the gas being excluded by the heated palladium as effectively as, in other experiments, they are excluded by ignited platinum.

This transmission of hydrogen through the substance of various metals, is altogether different in character from the transmission of gases in general by the physical processes of transpiration and diffusion. It is evidently dependent upon some special relationship subsisting between the particular gas and metal, and has been shown by Mr. Graham to be preceded by an absorption or occlusion of the gas in the substance of the metal.

Platinum-wire, drawn from the fused and solidified metal, was heated to redness and allowed to cool slowly in a current of dry hydrogen gas. After cooling, it was exposed freely to the air for some time, and then placed in a tube of porcelain or hard glass, which was next exhausted by the Sprengel pump. After complete exhaustion, the tube was heated to redness, when the contained platinum began and continued to give off hydrogen gas, which was delivered by the pump. The quantity of hydrogen, measured cold, amounted to 21 per cent. of the volume of the platinum-wire. That the absorption did not depend upon surface, was shown by drawing out the same wire to four times its original length, and repeating the experiment when the absorption was found not to have increased, but rather to have decreased, as it amounted only to 17 per cent.

To show the effect of texture, a similar experiment was made with spongy platinum, which was found to absorb and deliver 148 per cent. of its volume of hydrogen. Experiments were also made with ordinary wrought platinum, a particular piece of which was found to occlude in three successive experiments, 553, 493, and 383 per cent. of its volume of hydrogen, measured cold, giving a mean of 476 per cent. Thus the intermediate form of platinum, more porous than the fused, but more compact than the spongy form, was found to be the most absorptive. In round numbers, 1 volume of this platinum absorbed about 5 volumes of hydrogen which, at the temperature of the experiment, would amount to some 15 volumes. Now to compress 15 cubic centimetres, for instance, of hydrogen into the space of 1 cubic centimetre would require a pressure of 15 atmospheres. But in this experiment the 15 cubic centimetres of hydrogen were condensed, not merely into 1 cubic centimetre of space, but into so much of 1 cubic centimetre of space as appeared to be entirely occupied by platinum, and was not so really occupied. So that assuming the pores of the wrought platinum to amount to $\frac{1}{1000}$ of its bulk, the above described condensation of the hydrogen corresponded to that producible by a pressure of 15,000 atmospheres.

To show the force with which hydrogen was retained by platinum, another piece of the wrought metal was charged with hydrogen as before, and then heated very gradually in a vacuous tube. During exposure for an hour to 220°, not a particle of gas was evolved. At a temperature slightly below that of visible redness, there was still no gas evolved. At a temperature sufficient to soften glass (500°), 1·72 c.c. of hydrogen were collected in ten minutes; and, heated for an hour in a combustion furnace, an additional 8·20 c.c. of hydrogen were collected, making altogether 9·92 c.c., or 378 per cent. of the volume of platinum employed in the experiment. The same piece of platinum, charged with hydrogen, was kept for two months sealed up in a glass tube, which it nearly filled. At the end of that time the air of the tube was found to be quite free from hydrogen, showing that none had been evolved by the enclosed platinum.

The absorption of hydrogen by platinum took place at a temperature much below that necessary to cause an evolution of the evolved gas. Thus some platinum-foil was found to absorb 76 per cent. of its volume of hydrogen at 100°, and 145 per cent. of its volume at 220°.

Palladium appears to be a metal altogether special in its relations to hydrogen. Foil of wrought palladium that had been maintained at a temperature not exceeding 245°, and allowed to cool slowly in a current of hydrogen, evolved, when afterwards heated in vacuo, no less than 52,600 per cent., or 526 times its volume, of the gas within a quarter of an hour. But even this comparatively low temperature was found to exceed that most favourable to gas absorption. For, maintained at a temperature between 90° and 97° for three hours, and allowed to cool down during an hour and a half, the foil absorbed 643 times its volume of hydrogen, measured cold. Even at ordinary temperatures it absorbed 376 times its volume, provided it had been recently ignited in vacuo. Palladium sponge heated to 200° in a current of hydrogen, and allowed to cool slowly, afterwards yielded no less than 686 times its volume of the gas. Now if the absorption by ignited platinum of 5 times its volume of hydrogen is difficult to realise, how much more difficult is it to realise the absorption of 5 or 6 hundred times its volume of hydrogen by moderately heated palladium? Notwithstanding the levity of the gas, this large absorption of hydrogen by palladium is sufficient to increase recognisably the apparent weight of the metal. The retention, however, of such a charge of gas is not complete, a portion of the condensed hydrogen being slowly evolved or volatilized by exposure of the charged palladium to air. The hydrogen condensed in palladium is capable of exerting those particular reducing actions, which under ordinary circumstances, are producible only when the gas is in the so-called nascent state. Thus the hydrogenised palladium quickly reduces permanganate of potassium, bleaches iodide of starch, throws down Prussian blue from ferric ferridcyanide, &c. Further, the absorptive power of palladium is manifested in a varying degree upon different liquids. Thus, 1,000 volumes of palladium-foil were found to absorb 1 volume of water, 5½ volumes of alcohol, and 1½ volumes of ether; results showing a special selective relationship of the metal to these different liquids.

The absorption of hydrogen by ignited copper, in the state of wire, amounted to 30 per cent., and, in the state of sponge, to 60 per cent. Gold, in the form of assay cornettes, was found capable of absorbing 48 per cent. of hydrogen, 29 per cent. of carbonic oxide, 16 per cent. of carbonic anhydride, and 20 per cent. of air; but of this absorbed air, nearly the whole was nitrogen. Before charging the cornettes with the above gases, it was necessary to ignite them for some time in vacuo, in order to expel the gas they had spontaneously absorbed in the muffle. This, which may be termed the natural gas of the cornettes, amounted to 212 per cent., and consisted principally of hydrogen and carbonic oxide. Silver, unlike the preconsidered metals, is characterised by its preferential absorption of oxygen. In different experiments, silver-wire heated to redness was found to absorb 74 per cent. of oxygen, and nearly 21 per cent. of hydrogen. Silver-sponge absorbed 722 per cent. of oxygen, 92 per cent. of hydrogen, 52 per cent. of carbonic anhydride, and 15 per cent. of carbonic oxide. A specimen of silver-leaf, exposed to the air at a red heat, absorbed 137 per cent. of oxygen, and 20 per cent. of nitrogen; so that while ordinary atmospheric air contains 21 per cent. of oxygen, and the air absorbed by gold only about 5 per cent., the air absorbed by silver contained no less than 85 per cent. of oxygen.

Iron, though tolerably absorptive of hydrogen, is specially characterised by its absorption of carbonic oxide. Ordinary iron-wire, that had been carefully cleaned and heated in different atmospheres, was found to absorb 46 per cent. by volume of hydrogen, and 415 per cent. of carbonic oxide. The natural gas of wrought-iron, derived from the forge in which it had been heated, proved to consist principally of carbonic oxide, and, in different experiments, ranged from 700 to 1,250 per cent.; so that, in the course of its preparation, iron would appear to occlude 7 times its volume of carbonic oxide gas, which it carries about with it ever after. The discovery of this absorbability of carbonic oxide by iron has an important bearing upon the theory of acieration. Carbonic oxide ($C_2O_2$) would appear to be actually absorbed by the substance of the iron, and then decomposed at a different temperature, into carbon (C) which, entering into combination with the iron, converts it into steel, and into carbonic anhydride ($CO_2$) which, escaping from the surface of the iron, gives rise to the appearance of blistering.

It became a matter of interest to determine whether sidereal iron, that is to say the iron of meteorites, contained any, and, if any, what natural gas. Accordingly, some 45 grammes, or 6 cubic centimetres, of meteoric iron from the Lenarto fall were heated in vacuo for two hours and a half, and found by Mr. Graham to give off 16·5 cubic centimetres of gas, which consisted substantially, not of carbonic oxide, but of hydrogen, to the extent at least of 85·5 per cent. of the entire yield of gas, the remainder being chiefly nitrogen and carbonic oxide. The inference that the meteorite, at some time or other, had been ignited in an atmosphere of which the prevailing constituent was hydrogen, is obvious; and, judging from the volume of gas yielded, the hydrogen atmosphere must have been a highly condensed one. For even under ordinary atmospheric pressure, telluric iron is found to absorb but somewhat less than half its volume; whereas this sidereal iron furnished fully two and a half times its volume of hydrogen. It is known that Father Secchi, in his classification of the stars according to their spectra, has distinguished one class, typified by *α Lyræ*, as having a spectrum which is essentially that of hydrogen.

In the year 1823, Mr. Faraday established the general proposition that a gas is nothing else than the vapour of a volatile liquid existing at a temperature considerably above the boiling point of the liquid; and that the condensing points of different gases are merely the boiling points of the liquids producing them. But the boiling point of a liquid, or the condensing point of its gas, is well known to be not a fixed point of temperature, but a point varying with the pressure to which the gas or liquid is subjected. Accordingly, every one of the many different gases known to chemists, with about six exceptions, has been actually condensed into the liquid state by a sufficient increase of pressure; whereby the existing temperature of the gas has ceased to be above the heightened condensing point, or boiling point, corresponding to the increased pressure. And since a gas cannot be reduced by pressure to a bulk less than that corresponding to the pressure necessary to liquify it, without its becoming liquefied, conversely, the reduction of any gas to a bulk less than that corresponding to the pressure necessary to liquefy it, must be taken as evidence of its liquefaction. Hence, from the extremely minute volume which oxygen, hydrogen, and carbonic oxide occupy, when occluded for instance in silver, platinum, and iron respectively, there can be little doubt but that these gases, though included among the half dozen which have never been liquefied by direct pressure, do nevertheless exist in the liquid state when occluded in the above metals; or, at any rate, do not exist in the gaseous state.

As regards the nature of this absorption and presumable liquefaction of gases by metals, there are facts which seem to indicate that the phenomenon is related, on the one hand, to the absorption of gases by their solution in liquids, or in those soft solids which Mr. Graham has denominated colloids; and, on the other hand, to the absorption of gases by their condensation in the minute pores of hard solids, such as compact charcoal.

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## ON A NEW APPARATUS FOR TECHNICAL ANALYSIS OF PETROLEUM AND KINDRED SUBSTANCES.

By S. F. Peckham.

In the "Chemical News" for August 31st, 1866, I noticed a paper in which was described a process with apparatus, for the assay of coals and other substances yielding illuminating and paraffin oils. After stating the fact that no process had hitherto been described, by which technical analysis of bituminous and pyro-bituminous substances could be made to yield analagous and satisfactory results, the author proceeds to describe what I should suppose to be a very valuable process for the primary distillation in the technical analysis of coals and shales. I do not repeat the description here, as it would require considerable space, and it can only be applied to the treatment of solid substances, which do not melt at a temperature below that required for their distillation. As the original paper is easy of access, I would recommend its perusal to all who wish to make technical analyses of either coals or shales. The apparatus is simple and inexpensive, and I am aware of no reason why the results furnished by it should not prove highly satisfactory, especially as its operation bears a striking resemblance to the most improved processes of manufacture on the largest scale.

But beyond the primary distillation of the coal or shale, I do not consider that our author has added anything to processes long in use. When he arrives at the second distillation, or that which corresponds to the primary distillation of petroleum, he is forced to return to the old process of fractional distillation from a common tubulated glass retort. This process is not only very unsatisfactory in its results, but it is quite expensive, and is attended with considerable danger from fire. It is unsatisfactory, because the separation of fluids of different densities and different boiling points is much less complete than by Warren's process, for any temperature below the boiling point of mercury; in fact, for any temperature necessary to ensure the complete separation of the light oils usually called naphtha, and the "photogen" or illuminating oil. It is expensive, for the reason that if the distillation is conducted to dryness the retort is sacrificed, and it is rarely possible to remove the coke with safety. It is attended with danger from fire, because the best retorts are liable to fracture from the high heat to which they are exposed, even when the greatest care is exercised in conducting the operation.

I was about to commence a technical examination of several specimens of Californian petroleum, when the above mentioned paper arrested my attention, and I was unpleasantly conscious when I had finished its perusal that in respect to apparatus for this department of research my want was just as far from being supplied as it was six years since, when I commenced the study of petroleums. I had but a small quantity of each specimen, and besides subjecting them simply to fractional distillation, I wished to test them by Young's process of distillation under pressure. To conduct the latter process in glass was an impossibility.

To answer my purpose therefore, my apparatus must fulfil the following condition. It should be capable of working not more than one and one-half litres, and admit of being heated by an ordinary gas-furnace. The retort should contain a pressure of 40lbs. per square inch, and it should be so constructed as to admit of the ready extraction of the coke. I could find no description of any such apparatus, but after numerous failures and corrections, in an apparatus of my own invention I found my wants so well and fully supplied, that I am led to offer a description, for the benefit of those who, like myself, have felt the need of such an instrument.

Upon each extremity of a piece of a wrought iron gas-pipe, 3-in. in diameter and 30in. in length, a cap is securely screwed. The caps should be heated nearly to redness and screwed on to the cold pipe in order that by their contraction they may be more firmly secured. The pipe is then put in a lathe and the caps turned off in such a manner as to leave a band upon each end of the pipe, about three-fourths of an inch in width, and two circular discs of iron, each about 4in in diameter, and one-fourth of an inch in thickness, having a projection upon one of their surfaces to which a wrench may be applied. The edges of each extremity of the pipe with the bands are now turned off, presenting smooth surfaces slightly bevelled inwardly. The plane surface of each of the discs is then so turned off upon its circumference, that it will exactly fit the bevelled edge of the pipe. This completes the retort.

A stout parallelogram is then made half an inch longer and wider than the retort, one of the shorter sides of which should contain in the middle a stout set-screw, and the other an orifice made to fit the projection upon the disc. This may be called the frame.

Two holes are then drilled a short distance from either extremity of the retort, and in a line parallel to the axis of the retort. One of these should admit a half inch, and the other an inch gas-pipe. With this arrangement the retort may be used either for pressure distillation, or for distillation by the ordinary process. It also admits of being connected with an apparatus for furnishing superheated steam or carbonic acid gas, either of which are sometimes used to assist the distillation of hydrocarbons. Both the goose-neck and valve should be connected with the retort by a short piece of gas-pipe and a brass "union" coupling, as the difference in the expansion of brass and iron would cause a joint of the two metals to leak very badly when subjected to a high temperature. The goose-neck may be made of the ordinary form, tapering from 1in. to one-quarter inch, and about 10in. in length. The material should be copper, brazed. The valve will be described hereafter.

In order to use the retort, one of the discs is luted with a very thin paste of plaster of Paris and firmly pressed into its seat. The retort is then slipped into the frame and left a moment for the luting to set, the open end being uppermost. The oil is next poured in and the other disc luted into its seat, the frame adjusted and the set-screw firmly set up, so as to securely fasten both discs in their places. The goose-neck or valve is then adjusted, and the connections made with the worm and receiver. It will be observed that all the expansion that takes place in this retort only brings the different portions of the apparatus more firmly together, instead of causing them to crack apart and leak with every slight variation of temperature, as is usually the case. With this arrangement I was able to distil 1,500 cubic centimetres of petroleum to dryness, the last portions coming over at a red heat. The distillation was commenced with two ordinary Bunsen's gas lamps, increased as required to four, and toward the end of the operation to six—the latter number being sufficient to bring the side of the retort in contact with the flame to a bright cherry-red heat.

Any one who has attempted the distillation of small quantities of petroleum in either iron or copper still, or retorts of whatever form, imbedded in coal fires or suspended over them, must be aware of the difficulty of so regulating the fire as to secure a constantly increasing heat from the beginning to the end of the operation. No such difficulty is experienced with this apparatus. In it the lightest oils may be distilled by means of a sand-bath, and the heaviest by applying the flame of a sufficient number of lamps directly to the retort. The joints of this apparatus when luted with the smallest possible quantity of finely pulverised calcined sulphate of lime, admit of the least loss by leakage of any metallic retort that I have ever used. With the exercise of proper care the amount of distillate from California petroleum averaged above 90 per cent. by measure, and with a pressure of 30lbs. per square inch the average was 87½ per cent. In the latter instance the loss was increased by the formation of gas and vapours that passed through the worm uncondensed at 8° C. The largest amount of distillate that I have seen recorded, as yielded by any material of undoubted natural origin, is ninety-five and one-half per cent, by measure. The distillation of which this was the product was performed wholly in glass, without pressure, the crude material being a California petroleum of medium density, yielding no permanent gases and no naptha. In this case the loss may be estimated at zero. I think it will be readily conceded, that any apparatus which admits of the ready extraction of the coke, and at the same time yields an average of ninety-two and one-half per cent. of distillate, furnishes results far more satisfactory than any hitherto in use for operating upon so small a quantity as fifteen hundred cubic centimetres.

A thermometer may be inserted in the smaller orifice, for noting the temperature at which light oils distill. A piece of gas-pipe of the requisite size and about two inches in length may be used for making the connection, the thermometer being luted into one end of it. When but one of the openings in the retort is in use, the other may be closed with an iron plug.

In making my experiments upon Young's process of distillation under pressure, I experienced much difficulty in contriving an apparatus that would enable me to register the amount of pressure, and at the same time prevent any loss of vapour. I first attempted to register the pressure by means of a U tube, the arms of which were of unequal length. The tube was filled with mercury to a level with the shorter arm and the long arm sealed with a column of air above the mercury. The pressure was indicated by the rise of mercury in the longer arm and consequent compression of the air, the shorter arm being in communication with the retort. The escape was badly regulated by an ordinary stopcock. The very unequal expansion of glass and iron prevented me from making a tight joint between the retort and U tube.

I next tried a small valve constructed like an ordinary safety valve. I found it impossible with this valve to prevent a large amount of loss from escape of vapour around the spindle.

I next tried a loaded valve, the load of which was placed directly upon the spindle, the whole contained in a chamber resembling a miniature steam-chest, from which the vapours could only escape into the worm. It was found upon trial with the safety-valve that an orifice three-eighths of an inch in diameter was too large in proportion to the size of the retort, the vapours escaping in too large volume to admit of a continued flow from the worm. The vapour escaped in intermittent puffs, thereby causing an undulatory movement from the requisite amount of pressure to no pressure at all. As a consequence, the results rendered were very imperfect. To obviate this difficulty, I made the orifice beneath the valve only one-sixteenth of an inch in diameter, the surface of the orifice being to that of the retort as one to sixty thousand. This arrangement enabled me to secure a constant flow of vapour from the retort, to maintain a constant pressure, and to preserve a constant degree of temperature. I found by computation that a pressure of two ounces avoirdupois upon an orifice one-sixteenth of an inch in diameter was equivalent to a pressure of forty pounds to the square inch, yet when I placed a weight of two ounces upon the spindle, which of itself weighed half an ounce, the steam gauge registered only ten pounds, and the oils passed through it unchanged in density. Although I employed one of the most skilful workers of brass in this city to grind the valve, I am satisfied that the fault was in the mechanical execution of the work, and that the bracing of the valve was upon the side of the cone instead of at its apex, leaving a minute cavity beneath the valve. This fault could only be remedied by increased pressure. The chamber being too small to admit of placing the requisite weight upon the spindle, I made use of a spiral spring, the force of which was adjusted by an ordinary steam-gauge. By this means I was enabled to obtain the required pressure and to estimate its amount, with but one source of error, viz., the diminution in the elasticity of the spring incident to the high temperature of the vapours of the oil. I am convinced that the amount of this diminution is considerable; I have estimated it at one-fourth. The original elasticity returns, however, as soon as the spring is cold.

The following is a description of the valve as finally arranged. A piece of wrought iron gas-pipe one inch in diameter and three inches in length is bored out true, and an orifice drilled in its side one and one-fourth inches from the upper end, into which is brazed a piece of quarter inch gas-pipe about three inches in length. Both ends are now turned off and threads cut upon them, to which are carefully fitted strong brass caps. The upper cap should be about three-quarters of an inch in thickness, perforated two-thirds through from the inside with an eighth-inch drill, the orifice to serve as a guide to the upper end of the spindle. There should be a nipple three-fourths of an inch in length upon the lower cap, to connect it with the retort. The cap should be about one-half an inch in thickness, and with the nipple, should be perforated with a sixteenth-inch drill. The seat of the valve should be excavated in the inside of the lower cap. A diaphragm should be placed within the iron tube, one inch from its lower end to serve as a guide for the spindle, through the centre of which the spindle should pass, while around it should be numerous small openings to allow for the free passage of the vapour. The valve itself should be turned upon the end of a spindle three-sixteenths of an inch in diameter and carefully ground into its seat. The length of the spindle should be one-fourth of an inch less than the distance from the seat of the valve to the bottom of the orifice upon the inside of the upper cap, when both caps are in position. This allows the spindle to lift well, with sufficient room for the passage of the vapours. The diameter of the spindle should be reduced to one-eighth inch above the diaphragm. A spiral spring, of a diameter nearly equal to the interior of the pipe, made of brass wire about one-sixteenth of an inch in thickness, is so adjusted that the valve would be raised against the elastic force of the spring. This is effected by gradually reducing the diameter of the coils of the lower end of the spring to one-eighth inch, when it will just rest upon the shoulder upon the spindle. The upper coil of the spring should just touch the inside of the upper cap, when it is firmly screwed up. It will thus be seen that a force sufficient to cause the spring to contract one quarter of an inch is equal to a direct pressure upon the valve of two ounces. This pressure may be regulated by an ordinary steam gauge, the force depending for the same length of spring and size of wire upon the number of coils employed.

With this apparatus and the one described by Mr. Attfield, small quantities of every variety of bituminous and pro-bituminous substance, may be subjected to treatment analogous to the most improved processes now in use upon the large scale. The results are reliable and admit of ready comparison. The cost of the retort with goose-neck and valve, made by the most skilful workmen, is about twenty-five dollars.

## ON THE PRECIPITATION OF COPPER AND NICKEL BY ALKALINE CARBONATES.

By W. Gibbs.

The precipitation of copper by zinc or by the electrolytic method requires that the metal should be present in the form of sulphate or chloride and does not succeed with the nitrate. The employment of the hypo-phosphites is limited to the case in which the metal exists as sulphate. The old mode of precipitating copper as oxyde by caustic potash has disadvantages which are familiar to all chemists, but on the other hand is independent of the nature of the solution of copper employed so long at least as no organic matter is present. According to Rose[*] the alkaline carbonates precipitate copper less com-

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[*] Handbuch der Analytischen Chemie, ii, 175. Sechste Auflage.

pletely than caustic alkalies. This statement, however, is not accurate for all the conditions under which the experiment may be performed; and I have found that copper may be completely precipitated from the sulphate, nitrate or chloride when the solutions are boiled together for a sufficient time and are sufficiently dilute. Mr. E. R. Taylor, who has made a careful study of this method of determining copper, has arrived at the following as the best method of conducting the process. The solution of copper is to be diluted with water until the liquid contains not more than about one gram of the metal in one litre. A solution of carbonate of potash or soda is then to be added in small excess, and the whole boiled for about half-an-hour. The boiling proceeds quietly and without succussions; the blue green carbonate soon becomes dark brown, and has a fine granular character which renders it extremely easy to wash. After washing it is to be ignited in an atmosphere of hydrogen, and the copper weighed as metal; it will be found to be free from alkali. In this manner Mr. Taylor obtained in five analyses the following results:

1·8384 gr. pure sulphate of copper gave 0·4688 gr. metallic copper=25.44 pr. ct.
1·7144 gr. „ metallic cop. dissolved in aqua regia gave 1·7161 gr. cop.=100·09 p. c.
1·3860 gr. „ „ „ „ „ „ 1·3853 gr. „ = 99·93 „
1·4657 gr. „ „ „ „ nitric acid „ 1·4670 gr. „ =100·09 „
1·4685 gr. „ „ „ „ „ „ 1·4634 gr. „ = 99·65 „

The filtrate is perfectly free from copper if the process has been well conducted.

The ignited oxyde is in a state of great subdivision, and the ignition must therefore be conducted with much care to avoid loss. A small portion of the oxyde or basic carbonate usually adheres to the sides of the vessel in which the boiling takes place. This is to be re-dissolved, and again precipitated, but great care must be taken not to add a large excess of the alkaline carbonate, which gives a solution from which the copper is not precipitated by boiling.

Nickel may be completely precipitated from its solutions by precisely the same process. The green basic carbonate may be washed much more readily than the oxyde precipitated by caustic alkali; it is to be ignited and weighed as oxyde. In two analyses Mr. Taylor obtained the following results:

1·9808 gr. anhydrous sulphate of nickel gave 0·9551 gr. Ni O = 37·79 p. c.
1·4601 gr. „ „ „ „ 0·7008 gr. Ni O = 37·64 „

The formula $NiSO_4$ requires 37·69 (Ni=58). Dr. F. A. Genth informs me that he has also used the alkaline carbonates in precipitating nickel, and with most satisfactory results.

The precipitation of cobalt by an alkaline carbonate can only with much difficulty and by long boiling be made complete. As a means of determining cobalt it is not to be recommended. On the other hand Mr. F. W. Clarke has found that cobalt is completely and easily precipitated by the process of oxydation first given by Popp,* which consists in neutralising the solution with carbonate of sodium, adding acetate of sodium and then boiling with an excess of an alkaline hypochlorite, taking care to keep the solution alkaline. The hydrated sesquioxyd (?) of cobalt thrown down may be readily washed. After reduction in hydrogen the metal is found to be free from alkali. Nickel may, as Popp has also shown, be precipitated in the same manner, but the process given above seems to me preferable.

In this connection I may be permitted to state that the method of separating cobalt from nickel by means of peroxyde of lead attributed to myself in the new edition of Rose's† Handbuch der Analytischen Chemie and also ascribed to me by Gauhe‡ was never even proposed by me.

Cobalt and nickel may be precipitated from neutral solutions of their sulphates, nitrates and chlorides by adding first an excess of oxalic acid to the concentrated solution and then a large excess of strong alcohol. After standing a few hours the filtrate is perfectly free from metal. The oxalates are very easily washed. This method is, however, rarely available for analytical purposes, since it fails entirely when salts of ammonium or of the alkaline metals are present. The oxalates are also in such a state of subdivision that it is almost impossible to ignite them without loss. The oxydes of copper, cadmium, zinc, manganese, and magnesium, are also completely precipitated from their sulphates by oxalic acid and alcohol, but not in the presence of alkaline salts. The same is true of both mercurous and mercuric nitrates. In the few cases in which this mode of precipitation will find application in practice it will probably be best to determine the oxalic acid in the oxalate by hypermanganate of potash.

In a former paper I have stated that the sulphides of cobalt and nickel thrown down from boiling solutions by a boiling solution of sulphide of sodium may be washed without oxydation upon the filter. The difficulty of preparing pure sulphide of sodium has, however, been an objection to this method. This difficulty may easily be removed by dissolving the crystallised tetrahedral sulphide, $Na_2S+9aq$, in alcohol of 90 per cent., filtering and allowing the solution to crystallize. After two or three crystallizations the pure sulphide may be dried over sulphuric acid in vacuo and the white effloresced mass preserved in a well stoppered bottle. The sulphide is chemically pure.

## NOTE ON THE ACTION OF PEROXYD OF MANGANESE UPON URIC ACID.

By C. Gilbert Wheeler.

The oxydizing action of the peroxyds upon organic substances varying to some extent according to the peroxyd employed, I have investigated the action of peroxyd of manganese upon uric acid.

If uric acid and peroxyd of manganese are heated together with a like quantity of water and sulphuric acid is added in small portions at a time until no further action is to be observed, the black pasty mass then filtered, and the filtrate evaporated to about one-fourth of its original volume, there is obtained after considerable time a quantity of large hexagonal crystals, which by analysis and characteristic reactions was found to be parabanic acid.

If uric acid is heated with a large quantity of water only, until the latter is brought to the boiling point and then peroxyd of manganese added as long as evolution of carbonic acid occurs and the mass filtered, there remains on the filter peroxyd of manganese and oxalate of manganese, while the filtrate on being somewhat concentrated yields crystals, which if again dissolved and treated with animal charcoal may be obtained colourless and quite pure. They were tasteless, rather difficultly soluble in cold but readily soluble in warm water; the solution gave with chloride of mercury no precipitate, while a very voluminous one was obtained on adding the nitrate of the same base; nitrate of silver and ammonia gave white glistening precipitate; on heating, cyanide of ammonium was evolved.

0·3595 grams yielded on combustion 0·133 water and 0·398 carbonic acid; which relation indicated the substance to be *allantoin*.

| | Found. | Theory. |
|---|---|---|
| C | 30·13 | 30·4 |
| K | 4·09 | 3·8 |

The mother-liquor contained much urea, also an amorphous substance; the quantity of which was too trifling to admit of an analysis. The action of the peroxyd of manganese may be explained by the following equation.

$$3(C_{10}H_4N_4O_6)+6MnO_2+8HO=2(C_8H_6N_4O_6)+2(C_2O_2H_4N_2)+4(MnO,C_2O_3)$$
$$+2(MnO,CO_2.)—$$

If uric acid is heated with peroxyd of manganese in the presence of but a small quantity of water there is formed urea, oxalic and carbonic acid, and but a very small quantity of allantoin; the action of peroxyd of manganese upon uric acid resembles therefore very closely that of peroxyd of lead.

## INSTITUTION OF CIVIL ENGINEERS.

### ADDRESS.

Charles Hutton Gregory, Esq., President, in the Chair.

The President delivered an address, on taking the chair, for the first time after his election as president.

He remarked that when the institution was founded, fifty years ago, on the 2nd of January, 1818, the members were six in number. Two years later, Thomas Telford became the first president; and the Royal Charter of Incorporation was obtained on the 3rd of June, 1828, by which the institution was firmly established as the recognised representative body of the engineering profession in the United Kingdom. There were now on the register 1,472 members of all classes, besides 95 students. The present condition and prospects of the profession were briefly alluded to, and it was observed that the railway system of this country had, by economy of transport alone, been productive of direct saving to the public of 15 per cent. on the capital expended.

A reference to the past records of the institution had brought to light one document which, Mr. Gregory believed, would be interesting to every engineer. This was a description of the nature and objects of civil engineering, by Thomas Tredgold, Hon. M. Inst. C.E., some of the expressions in which had been embodied in the charter; but as it had never yet been printed in a complete form, the president now gave it unabridged. After defining the duties required of the Civil Engineer, Mr. Tredgold concluded by saying that "the real extent to which Civil Engineering may be applied is limited only by the progress of science; its scope and utility will be increased with every discovery in philosophy, and its resources with every invention in mechanical or chemical art, since its bounds are unlimited, and equally so must be the researches of its professors." It could hardly however have been foreseen, that the attention of the Civil Engineer would have been directed to aid in constructions for defence from hostile attack, and even to the improvement of weapons of war. But as, more than two thousand years ago, Archimedes, distinguished first in mathematical science, after carrying out the great work of the embankment of the Nile, devoted the last efforts of his genius to engineering appliances for the defence of Syracuse against Marcellus, so now, less directly and less prominently, but with marked success, the combined labours of modern engineers had been applied to the purposes of national defence, and to this subject the president stated he proposed more particularly to allude.

The application of machinery to the manufacture of rotating fire-arms was first brought under the notice of the institution in the year 1851, by Colonel Samuel Colt, of the United States. In 1852 Mr. John Anderson, M. Inst. C.E., the engineer to the Board of Ordnance, suggested the construction and equipment of a government manufactory, in which, by the use of complete machinery, all the processes for the production of small arms should be carried on successively to completion. This issued, after inquiry before a select committee of the House of Commons, in the establishment of the small arms factory at Enfield, which was set to work in January, 1857, under the direction of Colonel Manley Dixon, R.A., the present superintendent. Up to December 26th, 1867, the total number of new arms made at Enfield was 616,828; while the number converted to breech-loaders on Snider's plan to the same date was 175,550. The long Enfield rifle consisted of 63 parts, and passed through about 7[illegible]0 processes of manufacture. The machines used were to a great extent varieties of copying machines, where a standard model was reproduced by a revolving cutter, in wood or metal, as might be required. The different pieces, as produced, were checked

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* Zeitschrift fur Analytische Chemie.

† Sechste Auflage, Bd. ii, p. 143.

‡ Zeitschrift fur Analytische Chemie.

with templates and gauges, and, finally, the stock, lock, barrel, bands, bayonet, plates, screws, &c., found their way in numbers to an "assembler," who, furnished only with a screw-driver and a chisel, took up the pieces indiscriminately and fitted them together; and so entirely interchangeable were the parts found to be, that a payment of 3.29 pence for each rifle put together, gave the workman wages of about fifty shillings a week. It was stated that the average cost of the long Enfield rifles, made at the Government factory, including an allowance of 5 per cent. on the cost buildings and machinery, for depreciation, had been about £2 each, and of the short Enfields complete £2 14s. each. The cost of converting to the Snider breech loader, including £10,000 for the alteration of old machines and the supply of new ones, as well as 5 per cent. for depreciation on buildings and plant, was said to be about 16s. 3d. per arm. It was stated that, with the present machinery, the Enfield factory was capable of turning out about 130,000 new arms annually. It had been estimated that the improvement arising from the accurate work produced by good machinery, coupled with better ammunition, had resulted in reducing by 50 per cent. the mean deviation in rifle shooting; while elements of precision and economy had been introduced, by the perfect convertibility of all the parts of small arms, which were previously almost entirely neglected by the gun-making trade.

Mr. Gregory next referred to the production of heavy armour plates and large guns, with their consequent results. He said that while, prior to the Crimean war, suggestions had been made and partial experiments had been tried, with a view to the use of iron for defensive purposes, the credit of the first great trial of a practical nature was due to the Emperor of the French, who built three floating batteries cased with thick iron plates, which were engaged in the attack of the allies of Kinburn, on October 17th, 1855. From that date public attention was drawn more closely to the protection of ships of war by armour plating, and various experiments were made in this country. It soon, however, became apparent that the subject of the use of iron for this novel purpose was so complicated by considerations of a purely technical character, that it was determined to submit the whole matter to the investigation of a mixed special committee, which was appointed in January, 1861. This committee continued in existence for between three and four years, and their investigations and experiments, which were of great value, formed the best history of the application of engineering science and practice to this particular subject; and it was to be regretted that the four large volumes, containing a full record of all their proceedings, had not been published. The president was, however, enabled to give a brief epitome of the results that had been early arrived at, on points which had previously been uncertain. For example, out of many varieties of material, it was found that the best for resisting shot was wrought iron; that this should be of the softest and toughest quality, any hardness or steely character being prejudicial; that *cœteris paribus*, the resisting power, up to a certain limit, varied nearly as the square of the thickness; that corrugations, bosses, or irregularities of surface were disadvantageous, plain surfaces being best; and that the plates should be as large and with as few joints as possible. Various constructions of iron fences, both for ships and for land fortifications, were examined and tested on a thoroughly practical scale. The experience thus obtained had reference not only to the strength and capability of the material generally to resist shot from given guns, but also as to the modes of fastening, the effect of various kinds of backing, and the general principles which should guide iron defensive construction. But perhaps the most valuable result, in an engineering point of view, was the improvement effected in the production of iron in large masses. When the committe began their labours, the manufacture of armour plates had only been attempted by one or two makers, and even in their hands it was little more than tentative. After three or four years' experience, many makers came into the field, the general average of quality was much improved and more certain, and plates of 5 inches and 5½ inches in thickness could be produced with their full resisting power. During the last few years, the size and thickness of iron plates had greatly increased; and thoroughly sound and uniform plates of large size, 10in. in thickness, might now be regarded as an accomplished fact. In the middle of 1864 the Iron Plate Committee was dissolved, a step which Mr. Gregory considered to have been injudicious; as the comparative question between guns and iron defences was at that time in a high degree progressive, and if improvement was to go on, the technical treatment of the subject must still be necessary. Recent circumstances had led to the temporary re-appointment of a Government committee to consider the question of the application of iron plates to land forts; and it was to be hoped that their labours might not be prematurely checked, nor until safe data were deduced from actual tests.

Concurrently with the production of iron plates, for purpoees of protection, had been the increase in the size and destructive power of guns. For many years before thr Crimean war, brass and iron guns had been made with very little change of form, although there were in existence compound or built-up guns of an early date. When public opinion was drawn to the application of mechanical improvements to the production of guns of great size and strength, many designs were brought forward, and the large wrought-iron gun of Mr. Horsfall, and the monster mortar of Mr. Mallet, M. Inst. C.E., were cited as examples. But the battle of the guns was between Sir W. G. Armstrong, C.B., M. Inst. C.E., and Mr. Whitworth, M. Inst. C.E. As far as the construction of the guns was then concerned, the leading points of difference were, that while the Armstrong gun was built up of several rings or tubes of coiled wrought iron shrunk over one another, and over a steel lining, with small grooves to take a soft coated projectile, the Whitworth gun was built of tubes of mild steel, forced with a taper over one another, and over a steel lining, the bore being polygonal, with a mechanically-fitting projectile. The details of both systems were subsequently more or less changed, and in January, 1863, a committee was appointed to make full experiments and to investigate, with two calibres, viz., 12-pounders and 70-pounders,—the comparative merits in construction, endurance, range, and accuracy, and in fact in all the qualities which a gun should possess. The information so collected showed, in both systems, results as to structural strength and efficacy, and accuracy of fire, which had not been previously attained; and while it was not in all respects conclusive as to the comparative merits of the guns, it brought out more prominently than ever the perfection to which artillery might be brought by the application of engineering skill. Irrespective of breech-loading, which had been abandoned for heavy guns in this country, and of rifling, in which the original mode had been to a great extent superseded by larger grooves cut in the chase of the gun to guide soft metal studs fixed on a hard metal projectile, the gun now generally manufactured for the service had undergone considerable structural changes. The most material were, the diminution of the number of parts, and the substitution of outer coils of fibrous Staffordshire iron, for coils of the best Yorkshire iron; tough steel being still maintained for the lining, as best resisting surface wear. The pattern at present in use for all guns consisted of only four pieces; 1, the steel barrel or lining: 2, a coiled tube over the barrel, extending from the muzzle nearly to the trunnions; 3, the breech coil, of three coils in alternate directions, welded together, with a trunnion piece welded on, the whole being shrunk on over the breech of the barrel, and lapping over the front coil; and 4, the cascable. It was considered by the authorities that guns of this pattern were less liable to injury by accident and less dependent upon perfection in manufacture, and that practically an equal amount of strength was obtained; while it was held that a fibrous iron was to be preferred as more workable, and as giving out its greatest strain over a greater distance than the best Yorkshire iron, which, while stronger, statically considered, did not yield so far before fracture. It was said that this change had diminished the cost of production by 35 or 40 per cent. Prior to the mechanical improvements which had led up to the present rifled guns, the greatest distance to which a projecttle was ever thrown from a smooth-bore gun was not much over 6,000 yards, and the limit of bombarding range, at high elevations, with the 13-inch mortar, was 4,500 yards. With the modern ordnance projectiles had been thrown, with greater precision, to a range exceeding 10,000 yards; and the guns of the service made good practice at 6,600 yards, indeed better practice than was formerly attainable at 3,000 yards. At 1,000 yards the rifled gun was eleven times, and at 2,000 yards thirteen times more accurate than the smooth bore. But these improvements would be of little avail in time of need, until smooth bores were much more largely replaced by rifled guns; as, for all practical purposes many of our defences, both at home and abroad, were at present almost unarmed.

While such important changes had been effected in ordnance, the advance recently made in naval construction was alike remarkable, and would have been equally impossible without the resources of modern engineering. Without attempting to trace the progress from wooden to iron ships, or all the steps by which naval architects had passed, from the earliest to the most recent types of armour-clad ships, Mr. Gregory illustrated the general results by some comparisons between the structures of the *Warrior* and the *Hercules*, as ships of 1860 and of the present period respectively. The arrangement now adopted for the broadside ships of the Royal Navy, provided a protected battery amidships, shut in by armour-plated bulkheads, and a belt of armour for the whole length in the neighbourhood of the water line. By these means, in addition to the battery and the whole water line, protection was given to the engines and boilers, and to the rudder-head and steering apparatus. In the *Hercules*, the sides of the ship were recessed before and abaft the central battery, so that by means of embrasures in the armour-plated bulkheads, the foremost and aftermost gun on each side could be traversed on a turn-table, and be fired at an angle of 15° with the line of the keel, while that line was commanded by the guns in the bow and stern batteries. The *Hercules* was 8in. wider in the beam than the *Warrior*, but 55ft. shorter, and of 883 tons less burthen. She would carry a smaller number of heavier guns, and possessed the elements of greater power, both for offence and defence; but in the former quality she was, perhaps inferior in some respects to a type of ship now on the stocks. The Royal Navy, at the present time, comprised thirty-one iron-clad ships, and eight more were building, four of the existing ships are being furnished with turrets, which were to be supplied to two of the new ones. Admitting that this number represented a formidable force, and that in structural qualities the vessels recently built were superior to those of other countries, it must be remembered that many were of doubtful strength, and that the sum devoted to the construction of new iron-clad ships for the current year, was less than one-twelfth of the vote for the navy, and was barely sufficient to build three iron-clad frigates—a fact meriting the gravest consideration.

The next point touched upon, related to the important bearing of railways in modern warfare. They were acknowledged to have been of great use in the movement and concentration of troops during the war in Lombardy, in 1859. In the German War of 1866, the Prussian Government organised a special corps, consisting of workmen and railway servants to act under the direction of engineers and traffic officers, to repair damages effected by a retreating enemy, to work lines occupied by the army, and in case of retreat, to destroy lines in the rear. Mr. Hozier, in his admirable account of the Seven Weeks' War, though conceding the value of improved roads and railways in shortening the duration of campaigns, especially in facilitating the transport of provisions, stores, and a siege train, and in relieving soldiers of heavy loads; yet he considered that the power of railways for the transport of troops had been overestimated. Mr. Gregory's opinion seemed to be at variance with these views; and reference was made to the number of volunteers transported by railway, on special occasions, within a given time, as not being consistent with the conclusions of Mr. Hozier. Again, in the American Civil War, railways and steamboats were found to be of inestimable advantage, of which several illustrations were given. The railway system of this country was believed to be one of the greatest elements of strength for national defence; and it was mentioned that the confidential reports to the Government, by the officers of the "Engineer and Railway Volunteer Staff Corps," commanded by Mr. Bidder, Past President Inst. C.E., showed that the completeness and the resources of the railway system, would enable the whole regular and irregular army to be moved upon any required lines of defence within a few days.

As a *resumé,* Mr. Gregory submitted, that while it was advisable to maintain the efficiency of the Government establishments, yet that it would be mistake to extend them so far as to cripple individual enterprise. In the next place he referred to the comparatively unprotected state of the Thames, the Mersey, the Clyde, the Tyne, and other rivers leading to rich towns, docks, and shipping; and he suggested the inquiry, whether if forts were thought to be desirable at such places, they might not be of small size, and capable simply of offering resistance to a sudden attack. And in regard to the navy, he thought the time had now arrived when the type of ship best suited for coast defence should be settled. The instinctive feelings of every Englishman called for the establishment and maintenance of a navy sufficiently strong, not only to defend our coasts, but also our colonies and our commerce; and if the Government would at once respond to that call, comfort would be brought to thousands at the present time suffering most grievous want.

In conclusion, the President expressed the earnest hope, that the future of the Institution of Civil Engineers might be as useful and as prosperous as its first fifty years had been; and that it would continue to supply men of character and intellect equal to every occasion, and who would join in the defence of their country, by contributing to her moral and material greatness, leaving England's future with confidence to the Great Source of all Power and all Intelligence.

At the ordinary general meeting on Tuesday, the 14th ult., Mr. Charles Hutton Gregory, President, in the chair; the following candidates were balloted for and duly elected: as member, David Phillips, Superintending Engineer, Peninsular and Oriental Steam Navigation Company, Bombay; and as associates, Thomas Philip Sherard Crosthwait, Assistant Resident Engineer, Vartry Water Works, Dublin; William Cooke Faber, Chicklade; George Farren, Engineer and General Manager to the Lundy Granite Company; Major James George Roche Forlong, R.E., Superintending Engineer, Public Works Department, Bengal; Thomas Ellis Owen, Executive Engineer, Public Works Department, Allahabad; Middleton Rayne, Kingston-on-Thames; Henry Yarker Richardson, Sunderland; Jagannath Sadasewjee, Bombay: James Stewart, Auckland, N.Z.; Captain Hector Tulloch, R.E.; and Charles Wawn, Howden, Yorkshire.

It was also announced that the Council, acting under the provisions of Section IV. of the By-Laws, had admitted as students of the Institution, Henry Adams, Charles Augustus Alberga, Robert William Peregrine Birch, John Montrion Campion, Lindsay Heath, Arthur Willoughby Hemans, Osbert Henry Howarth, William Henry King, Frank Howard Landon, Arthur Hemery Le Breton, Frederick Herbert Mollett, George Putlin Pocock, George Henry Roberts, Edward Lee Robertson, Dampier Seabrook Shaw, James Henry Waller, and Francis Wilton.

## ROYAL GEOGRAPHICAL SOCIETY.

The fourth meeting of the present session of this society was held at Burlington House on Monday evening, Jan. 13th. Sir R. I. Murchison, Bart., President, in the chair.

The following new Fellows were elected:—A. L. Elder, Dr. J. A. B. Horton, R. Jardine, B.A.; Eugene Morris, M. C. Morrison, A. H. Mounsey, G. Macnair, J. F. Pownall, J. Pender, J. B. Redman, C.E.; H. P. Stephenson, Dr. T. Staley, Bishop of Honolulu, T. O. Stock, M.P.; H. A. Tilley, Major G. H. Waller, R. Watson, and E. B. Webb, C.E.

Before the commencement of the ordinary business, the President read a letter respecting Dr. Livingstone, which he had received the same day from Dr. Kirk, of Zanzibar, dated 29th October; it ran as follows:—"I write now only to assure you that nothing further has reached us regarding the traveller in the Lake Regions, who must, without doubt, be Livingstone, since we have news of him from Quiloa as having been seen west of Nyassa, where gold is found. Bunduki, the native to whom the letters were given, has not yet reached the coast, being delayed, as we hear, by carrying ivory in double journeys from village to village; and he is still too far off to make it of any use sending men to receive the letters which he has in his possession. It will be some time before we can write to Johanna, but I hope that Moosa and his companions may be well watched, and, when the time comes, severely punished for the misery they have caused. They, however, press their claims for salary, and have even sent men here, in the hope of getting their wages paid."

A paper was read on "Explorations in the Isthmus of Darien," by M. Lucien de Puydt. The author, in this memoir, gave the scientific results obtained during two expeditions he had made, in 1861 and 1865, into the interior of the isthmus, having for object the discovery of a practical line for a ship-canal from ocean to ocean. He first directed his attention to the routes followed by Captain Prevost, Mr. Gisborne, and others; ascending the river Savannah, and crossing to the confluence of the Rio de la Paz and the Chucunaque, acquiring the conviction of the impossibility of constructing a canal in this direction towards Caledonia Bay. The statements made by Dr. Cullen on this subject he ascertained to be completely erroneous. He found, moreover, that the altitude of 152 *metres*—on which was built a host of projects for a canal—was founded on an erroneous reading of the tables of Colonel Codazzi, the New Granadian surveyor; this altitude being given as that of a village on the road, and not as that of the greatest height of a pass in the mountains. M. de Puydt afterwards turned south, and ascended the Tuyra River as far as Paya. The broken nature of the Andean chain there gave him hopes of finding a low pass; and he returned to Europe, organised a new expedition, and penetrated the Isthmus again in 1865, from the side of the Atlantic. With three companions and a party of eleven labourers he entered the River Tanela, north of the delta of the Atrato, and sending away his vessel to cut off the retreat of his men, he opened a path through the forest, and on the 25th of August discovered a break in the mountain chain, having an altitude of only 120ft. above the level of the sea. His observations for heights were taken by measuring the velocity of current of a river which flows from the pass to the sea. The memoir included interesting details on the orography, ethnology, &c., of the isthmus.

The President observed that the paper gave a well-written and attractive description of a country very little known to geographers, and that the author's enterprise was carried out with a gallantry deserving of all commendation. In so far as related to the course of the Tanela River, and the depression in the chain, the geographical facts communicated were new.

In the discussion which followed, Mr. G. W. Hemans, C.E., disputed the accuracy of the means employed by M. de Puydt for the determination of the altitude of the pass. Capt. Bedford Pim stated that should the line examined offer facilities for a ship-canal, the construction of one could not be carried out in the face of a treaty concluded on the 36th of August last, between the Government of New Granada and the Panama Railway Company, by which the former bound itself not to concede to anyone the right to construct a railway or ship-canal west of a line which would include the Pacific terminus of M. de Puydt's project.

A second paper was read "On the Physical Geography of the Belize River," by Mr. S. Cockburn: an account of the extent of the Belize River-basin, the rainfall, evaporation, and so forth, over the area.

The President announced that an exploration of the Belize region, of some interest to geographers, had been made by Lieut. Cooper Abbs, of the *Doris* frigate, an account of which had been that day communicated to the Society.

## LONDON ASSOCIATION OF FOREMAN ENGINEERS.

### ANNUAL MEETING.

The fifteenth annual meeting of the members of this Institution was held at the George Hotel, Aldermanbury, City, on the 4th ult. After the confirmation of the minutes of the December meeting, the nomination of several candidates for membership, and the disposal of sundry matters of interest to the Society alone, the auditors, Messrs. W. Ross, and J. Humes, produced their report and the balance sheet for the past year. These documents were both of a satisfactory nature, and from the letter it appeared that although no less a sum than £120 had been paid during the period named to unemployed subscribers, the ordinary funds invested and in the hands of the treasurer amounted to £483 on the 31st December, 1867. The superannuation fund presented a total of £767 13s., and the library fund showed a balance in hand of £13 6s. These items form a grand total for all purposes in connection with the Institution of £1,264 15s. The number of honorary and ordinary members on the books equalled 163, and this is being steadily if not rapidly augmented. The report of the auditors and the balance sheet were approved and accepted without hesitation.

The president, Mr. Joseph Newton, next proceeded to deliver his annual address. He congratulated his fellow members on the healthy condition of the society in a financial sense, and spoke gratefully of the fact that during the year 1867 they had not lost a single ordinary member by death or secession from their ranks. The only gentleman associated with them whose decease they had to deplore was Mr. Edward Humphrys; his loss, however, was a heavy one, for he had, as an honorary member, been always a firm and active supporter of their society. He (the president) had enjoyed the advantage and the pleasure of Mr. Humphrys' friendship for more than twenty-five years, and he would bear testimony to his many excellent characteristics.

Mr. Newton then reviewed at considerable length the events of the past year, so far as they bore upon the engineering trade generally, and the Association in particular. He expressed himself strongly in favour of increased exertions being made by the representatives of every section of manufacturing industry in this country to place themselves in an intellectual sense in advance of continental rivals. The recent exhibition in Paris had conclusively established the fact that those rivals were no contemptible opponents, and that any further apathy on the part of engineering foremen and workmen in Great Britain would be fatal to themselves and destructive of national interests. There had no doubt been hitherto a great deal too much of unconcern on the part of the imperial Legislature as to the establishment of technical schools, and in fact of instructional institutions generally. If it were as possible to estimate the value of the waste brain as it was to calculate the acreage of waste land in England we should be appalled by the vast aggregate sum. Unhappily waste brain, like waste land, was apt to generate weeds, which exhibited themselves in the form of idleness and criminality, and we had to pay more for eradicating them than it would have cost to make the soil which grew them fertile with the flowers and fruits of industry and virtue.

The educational machinery of almost all continental nations had been freely lubricated with the golden ointment of State assistance, whilst that of this country had been allowed to cut and fret itself into grooves from lack of it. The evil was now admitted, and the proper remedy must be applied. After making an energetic appeal to the Associated Foremen to increase yet further the usefulness of their own institution by furnishing a non-intermittent supply of papers for their monthly meetings, and by the employment of other agencies within reach, the president concluded his address and resigned his office.

Mr. Keyte proposed subsequently the re-election of Mr. Newton, and this was carried unanimously. Messrs. Lax, Swinburne, and Gibbon were chosen as members of the managing committee for the current year. After appointing the anniversary festival of the Association for the 15th February, and completing the arrangements of a Widows' and Orphans' Fund the members separated.

## EXAMINATION PAPERS

For Competitive Examination of Candidates for Appointments in the Engineer Establishment of the Department of Public Works in India, held at the India Office, London, in July, 1867.

George Preston White, C.E., Examiner.

### *On Water Supply, Reservoirs, Dams, &c.*

1. Describe briefly the different means employed to supply towns with water, and give illustrative examples.

2. Describe the gravitation and pumping systems, pointing out their comparative advantages, and state the principal conditions and requirements to be considered and attended to in adopting either system,

3. Describe briefly what are impounding, compensating, depositing, storage, and service reservoirs, residuum lodges, and collecting grounds.

4. Describe the geological formations which are the best water-bearing strata, and explain why the flow of water is generally more regular through the chalk than through the clay formation.

5. In constructing dams for impounding water, specify the precautions which should be adopted for security, and to render them impervious to water, and specify the difference between the forms of construction employed in this country and France.

6. Describe some of the most approved means for forming filter beds, as for example at the Lambeth, York, Chelsea, and other waterworks, as first introduced by Mr. Simpson, C.E., specify the best materials to employ for the purpose, and explain whether the action is chemical or mechanical, and what head of of water is necessary.

7. If employed to supply a town with water, state some of the principal conditions which would guide you as to the mode of supply; how you would ascertain the probable amount of supply, the quality of the water, and the number of gallons per day, on the average, it would be desirable to provide for per head of population.

9. Make a free-hand sketch to illustrate the most approved forms for cast-iron water pipes; describe the different means used gor jointing pipes, pointing out the advantages or defects of each system. What are turned and bored joints, and specify when they are particularly applicable?

9. In preparing a specification for cast-iron pipes, explain why it is desirable that large pipes should be cast perpendicularly with the faucet end downwards. Also as to the nature of the material which should be employed to cast them, the quality of the metal, and the mixture most approved; and describe how the pipes should be tested to ascertain their strength, and freedom from laps, air holes, or other imperfections.

### *On Pumping Engines, &c.*

10. To how many atmospheres of pressure would it be desirable to test water pipes as compared with the head of water to which they would be actually subjected in practice? And when under pressure what further test is then desirable?

11. Illustrate with free-hand sketches and describe the uses of the following, viz., bib cocks, crutch key cocks, spiggot and faucet joints, flange joints, stand pipes, reducing pipes, branches and bends, air vessels, scour cocks, hydrants, sluice valves.

12. Calculate the number of gallons of water which a pipe 30in. diameter is capable of delivering in 24 hours, with a fall of 20ft. per mile.

13. Describe briefly the different kinds of pumps and other contrivances for raising water, give a free-hand sketch of a bucket and plunger pump, with its suction and delivery valves, and state under what circumstances centrifugal pumps are most applicable.

14. Describe the mode of ascertaining the power of pumping engines required in any given case, supposing the quantity of water to be delivered per hour, size and length of main, and difference of level between the water in pump well and top of stand pipe or service reservoir, be given.

15. The following is a practical application of the foregoing question:—It is required to construct pumping machinery, consisting of two engines, two pumps, and two boilers, capable together of forcing 50,000 gallons of water per hour through 3,600yds. of 12in. main, and into a reservoir 370ft. above level of water supply. How would you determine the dimensions of the principal parts of the machinery?

16. Calculate head due to friction in preceding question.

17. Having ascertained head due to friction, which, if unable to give the formula for, assume at 36ft., making a total lift of 406ft., calculate the net horse power required, taking a horse power at 33,000lbs. raised 1ft. high per minute.

18. Having ascertained the net horse power, and added thereto 20 per cent. to obtain the indicated horse power, what would be the diameter of cylinder required, supposing 40lbs. of steam in boiler, and an expansion, say at half-stroke, assuming 30lbs. mean average pressure per square inch of piston during stroke, length of stroke being 3ft. and number of revolutions 30 per minute?

19. Supposing a bucket and plunger pump to be used, with stroke of 30in., calculate diameter of bucket or pump barrel for delivering each 25,000 gallons per hour, bearing in mind that there are 277 cubic inches to a gallon.

20. Assuming that at the pressure of 40lbs. in boiler the relative volume of steam to water is at 640 to 1, calculate the number of cubic feet of water consumed per hour in each boiler.

21. Assuming that 22 square feet of heating surface or boiler is required for evaporating a cubic foot of water, and that a single flued Cornish boiler, shell 6ft. diameter, with flue 3ft. 6in. diameter, be supplied for each engine, calculate the length of boiler required.

22. Make free-hand sketches and describe the rain gauge and hygrometer, and explain their uses for engineering purposes.

23. Describe the wrought-iron tube employed by Mr. Simpson, C.E., for the Bristol waterworks, for continuing the aqueduct across the combe or ravine; explain the arrangements to provide for expansion and contraction, and also to prevent leakage at the points of junction with the stone aqueduct.

24. Give the names of standard works of reference on the subject of water supply, and name, as examples, some of the principal works which have been executed in this country and abroad for the supply of cities with water.

### *On Harbours, Docks, Groins, &c.*

The accompanying plan* represents a harbour, possessing considerable natural advantages; but requiring certain engineering works to render it suitable for the purposes of commerce and navigation.

1. If professionally employed to make a report on this harbour as to its capabilities, and as to the works necessary to render it suitable for a naval station and harbour of refuge, state how you would proceed to make ths necessary surveys, take soundings and reduce them to a common datum, ascertain the nature of the bottom, and whether affording good anchorage, and also the direction of the prevailing currents, &c.

2. It will be seen that several rivers flow into the harbour; describe how you would guage them, ascertain the volume of water discharged, the drainage area, and the amount of solid matter either held for a time in solution or finally deposited.

3. There is a tendency to silt up at the head of the harbour; explain the usual cause of this, and how you would avail yourself of back-water or tidal-water to counteract this deposition, and describe the means adopted for this purpose by Smeaton at Ramsgate, or any well-known example.

4. Should it appear on investigation that in particular states of the wind or tide additional shelter is required in the outer harbour, mark on chart the position where you would recommend a breakwater to effect this object; give a cross section of it, showing sea slope or face, and specify how you would make the foundations, and the character of the masonry you would recommend for the purpose. Explain the nature of "pierre perdue" foundations.

5. Specify the character of the lime you would employ for the submarine portion of the work; and in the event of not being able to obtain, conveniently, natural hydraulic lime, explain how artificial hydraulic lime could be produced according to the experiments of Sir Charles Pasley and M. Vicat; describe the chemical difference between ordinary and hydraulic lime. In what time should good hydraulic lime set and harden?

6. If found necessary to remove some of the rocks in the harbour, dangerous to the navigation, describe the different means employed for the purpose, and if too large to be dealt with in this way, make a free-hand sketch of a simple form of beacon. If required to lay down permanent moorings, describe the Mitchell and mushroom anchor, and other forms in use.

7. One of the first requirements will be the formation of docks, quays, and landing stages. Mark on accompanying map where you would place them, showing position of locks and entrance gates.

8. It frequently occurs, as along the south-east coast of England that there is a movement of shingle, sand, or other material, which deposits itself at the entrance of harbours, and proves most detrimental; describe some of the means employed to arrest this, and explain the use of wave traps and beaching basins, and give some examples

9. It will also be necessary to establish lighthouses and beacons. Mark on the map the position you would place them in; state the chief conditions which would guide you as to the height of lighthouse, and the nature of the lights you would employ, whether fixed, revolving, coloured, or with flashes at intervals.

10. If a landing stage should be required, give a free-hand sketch of a simple form of one, and describe those at Liverpool, or any other well-known or important examples.

11. Having laid out the breakwater and other works included in the foregoing questions, point out what you consider will be the probable effect (if any) in altering the existing conditions of the harbour as to the currents and the deposition of mud and silt, or other materials, &c.

11. The Railway Commissioners recommended in their report that a railway should be carried over Garinish Island and across the harbour at the narrow entrance by a viaduct, where is there is 60ft. of water. Point out the engineering difficulties and disadvantages of such a line, and mark on map where you consider the best route for a railway, making the embankment subservient for docks and other purposes.

13. Give the names of standard works of reference and reports on the subject of harbour engineering, and the names of some of the engineers who have specially distinguished themselves in this most important branch of the profession.

### *On Lighthouses, Piers, and Miscellaneous Subjects.*

1. The accompanying design* design represents a simple form of lighthouse, 60ft. in height, suitable in cases where building materials are deficient, skilled labour expensive or not obtainable, or where there is a difficulty in forming foundations. It is intended to erect this structure on a sand bank, and found it on Mitchell's screw piles. Describe how you would get the piles into position, what depth it would be desirable to go to in sand or alluvial deposit, the size of pile, and the diameter of screw. Make free-hand sketches of the piles, screw, braces, &c., showing the means of securing the work together. Give an approximate estimate of the cost of such a structure, exclusive of lantern, and name some successful examples of structures of this character which have been erected either in this country or abroad.

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* The plans and sketches are not given, as the object in giving these questions is merely to serve as a guide to intending candidates.

2. The accompanying design represents a simple form of iron pier with T head, suitable in cases where there is a difficulty in obtaining a good foundation for structures of the ordinary character, or where suitable building materials or skilled labour cannot easily be obtained. Make free-hand sketches to illustrate the details of the work. Describe the form and material of the screw, the mode of manufacturing solid iron piles, the means of getting them into position, what batter it would be desirable to give, and the mode of bracing together the beams girders, and other parts of the work.

3. What are the comparative advantages of the hollow cast iron pile and the solid wrought iron pile? Explain the mode usually adopted for getting the former into position.

4. Give the names of any important examples of structures of this kind which have been erected either in this country or in India.

5. Describe the effect of sea water on iron, and specify what steps should be taken as a prevention to injury.

6. Describe and make free-hand sketches of the following forms of wrought iron girders—the Trellis, the Warren, the Tubular, and the Brunel girder. Specify which form would be most desirable for India, taking into consideration expense of carriage, facility of erection, or where skilled labour was either expensive or difficult to obtain, and describe which of the above forms require staging to get them into position, and what forms can, under certain conditions, be erected without staging.

7. Describe and make free-hand illustrations of some of the most approved modes of scarfing and trussing timber.

8. Name the different kinds of stone employed in building under the following heads, viz., Silicious, Argillaceous, Calcareous, Stratified, and Unstratified.

9. Describe with free-hand illustration the means adopted in the main sewers for the drainage of London to provide for storm water, and to prevent sewers from blowing up.

10. Describe and make free-hand illustration of the weirs employed at the Manchester waterworks to separate the storm and turbid water from that suited for the town supply.

11. Illustrate with free-hand sketches and give the meaning of the following terms:—facing point, falling point, blind siding, back shunt, chock block; and state what are the objections to facing points.

12. Photography, for the purpose of making "Photographic Reports," to illustrate the progress of works, copying drawings, &c., is most valuable for engineering purposes, especially in India; attention is therefore directed to the subject. State if you are able to use Photography for this purpose.

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## EXAMINATION PAPERS

### For Competitive Examination of Candidates for Appointments in the Engineer Establishment of the Department of Public Works in India, held at the India Office, London, in December, 1867.

George Preston White, Examiner.

### *On Architecture, Building Materials, and Construction.*

1. Describe briefly the characteristic Differences of the Doric, Ionic, and Corinthian orders of architecture, make free-hand sketches of their capitals and columns, and name some well-known examples, both ancient and modern, of each order.

2. Describe the leading features of what is commonly called Gothic architecture, but more correctly, Christian. Point out in what it mainly differs from Classic architecture.

3. Considerable constructive skill, combined with æsthetic feeling, is displayed in Gothic architecture. Give some examples.

4. Make a free-hand sketch of the pointed roof, and point out the combination of science and beauty in its arrangement.

5. Make a free-hand sketch of the ground plan of a cathedral, and name and describe the different parts. What is the difference between the Greek and Roman cross?

6. Explain the meaning, and describe with free-hand sketches, the following terms used in architecture, viz., Entablature, Fluting, Frieze, Intercolumniation, Metope, Pedestal, Pediment, Pilaster, Porch, Portico, Soffit.

7. Describe the nature of Ransome's patent concrete stone, and state under what circumstances, and for what parts of a building, it is most economical and desirable to employ it. Explain some of the means employed for the preservation of stone.

8. Describe the characteristic qualities of good bricks under the following heads, viz., as regards shape, sound when struck, appearance presented when broken, their absorption of water as compared to their weight, and the crushing load required per square inch.

9. Describe with free-hand sketches the different bonds used in brickwork, and explain the uses and application of hoop iron.

10. What is the best time for felling trees? Explain what changes timber undergoes in the process of seasoning, what is its *rationale*, what is the time required, and describe some of the most approved methods of preserving timber, and explain their chemical action.

11. Steel is becoming much employed instead of iron. What are the comparative advantages as regards cost, durability, and strength, for bridges and rails? and state the reasons why its substitution would be most advantageous in India.

12. The employment of good lime and cement is a matter of the greatest importance in construction; describe how you would mix mortar, the proportions you would use; specify the limes which are hydraulic, and what tests you would employ, and name some of the best authorities on the subject.

### *On Lighthouses and Constructions in Iron.*

The accompanying drawing represents the Buda Iron Lighthouse, designed by his Excellency Don Lucio del Vallé for the Spanish Government, and erected at the mouth of the Ebro, the ironwork being manufactured and the details of construction designed and carried out by Mr. J. H. Porter, at Birmingham. The height of the structure, from the pile caps to the platform of the gallery at the summit, is 150 feet, giving a height from the mean level of the Mediterranean to the centre of the light of about 169 feet. The total weight of iron employed above the piles is about 200 tons. The structure is supported on nine wrought-iron screw piles in a sandy foundation.

1. Make free-hand sketches of the section you would consider best for the eight principal ascending supports, and sketch details of the connection of these with the horizontal stiffening frames.

2. The central column contains an iron staircase. Sketch your ideas of the best mode of constructing this, and explain how the weight is distributed upon the external supports.

3. Specify some of the conditions under which the "screw pile" is superior to other supports for foundations,

4. What load per square foot of its surface would a cast-iron screw fixed upon a wrought-iron pile safely sustain in a firm sand?

5. What sized screws would you recommend for the nine piles upon which this structure is supported? Would you prefer a wrought or a cast-iron pile? Describe the effects of sea water on iron.

6. Give an approximate estimate of the cost of manufacturing a lighthouse of this description, not including the lantern and light, and specify the parts of this structure you would make of wrought and of cast-iron.

7. In designing a structure of this character, a very important element for consideration is the force of the wind during a cyclone. Give the result of the experiments of Smeaton and others on this subject. State at how many pounds per square foot you would estimate it, and how you would ascertain the amount of area exposed to it in this case.

8. Give the names of some important examples of lighthouses of iron and stone; their comparative height; and the names of standard works of reference on lighthouse construction.

9. Sketch, in detail, what you consider the best means and apparatus for screwing down the piles in dry land and under water.

### *On Iron Roofs.*

The accompanying design represents an iron roof, of 40 feet span, manufactured in England and erected at Calcutta. As a protection against heat, the roof is double, with an outer and inner covering of galvanised corrugated iron, with a space of 12 inches between. The principals, in order to interfere as little as possible with the inner covering, are formed of lattice work, ten inches in depth, and sufficiently rigid to dispense with the ordinary "trussing" of struts and ties. The tie-bar consists of a flat iron, supported in the centre by a lighter bar suspended from a connecting plate at the centre. The gutters are made very large, to provide against tropical rains. For ventilation, there is an opening of 17 inches at the top of the roof, and suspended beneath a plate of perforated zinc; a small raised roof, with projecting eaves, protects the opening from rain. The inner covering stops short at the end of the rafter at foot, to assist ventilation; a moulding below conceals this from view, and also serves as a gutter for any condensed moisture.

1. Make an approximate estimate of the cost of such a roof per "square" of 100 superficial feet, together with a specification. Make detailed sketches of the various parts of the roof, with dimensions figured on, and show mode of fastening the corrugated iron plates to principals, &c.

2. State what protection you would recommend to preserve the corrugated iron, and what wire guage you would adopt.

3. The columns, 11ft. in height, were necessary as supports for the shafting to drive machinery. Had they not been thus required, which would be preferable and least costly,—a roof of two spans of 40ft. or one span of 80ft?

4. Having regard to the heat of the climate, the heavy rain-fall at certain seasons, the great force of the hurricanes, and the necessity for good ventilation for a large number of people, would the single or double span be preferable, apart from the question of cost? and give your reasons.

5. What do you estimate as the maximum pressure of the wind per square foot on the surface of the roof? Explain what tests you would subject the roof to before its erection.

6. Make a free-hand sketch for a curved roof of 40ft. span. Sketch the kind of principals and purlins you would adopt, and state at what distance apart you would place them, and the pitch of corrugation and gauge you would specify for the covering, and what overlap at the joints.

### *On Irrigation, Drainage, Water Supply, &c.*

1. A great desideratum in irrigation is a module which will give a uniform discharge of water in small channels issuing from a large canal, of which the depth or head of water is constantly varying. Can you suggest any simple machine for effecting this?

2. The bed of a canal is 50ft. wide, the depth of water 5ft., the side slopes 1 to 1, the slope of bed 1 in 4,000; required the mean velocity and discharge in cubic feet per second.

3. Will the velocity in the above example be too great for a soil of firm gravel; and is it desirable to give a canal simply intended for irrigation as high a velocity as possible, consistent with safety?

4. The canal in question (No. 2) has to be carried over a country of which the general slope is 1 in 2,000. How will this be effected? Give a free-hand sketch of the section of any masonry works that may be required to keep the level of the water nearly the same as that of the country.

5. A canal, of discharge 25 cubic feet, and velocity 30 inches per second, has to be carried by a masonry syphon under the sandy bed of a torrent, which crosses the canal at a level of 15ft. below it. Give a sketch of the syphon you would build.

6. In the last question, what would be the diameter, and what the thickness of a wrought-iron pipe to be used for the syphon instead of masonry?

7. Make free-hand sketch, and describe the different means employed for jointing gas and water pipes, point out their comparative merits or defects, and explain the advantages of the bored and turned joints manufactured by Messrs. D. Y. Stewart and Co., of Glasgow, over the old systems.

8. Describe the different means employed to filter water, explain the chemical action of "Spencer's "Magnetic Carbide," and the modes of ascertaining the comparative softness and purity of water for domestic and manufacturing purposes by the soap and other tests.

9. State what are the chief requirements in water for town supplies.

10. Describe the pumping system of supply, give illustrative examples, and point out cases of combined supply where both gravitation and pumping are resorted to.

11. Explain shortly the system of supply from wells, and define what is called an Artesian well, and the best geological water-bearing strata.

*On Physical Maps, &c.*

There are many subjects which can be better illustrated by the aid of physical maps than in any other way. If required to report on the agricultural, mineral, and other capabilities and resources of a district, and the best means of developing them by opening up communications and by works of irrigation, &c., describe how you would illustrate your report by the aid of physical maps, and mark on the accompanying map, by colours and otherwise, the following features:—

1. The geological and mineralogical features of the district, as, for example, the stratified and unstratified rocks, coal fields, iron, lead, copper, tin, and other mineral productions, building stone, lime, &c.
2. Physical map indicating the river systems, mountain ranges, marking on natural drainage of the country, water shed, &c.
3. Hydrographic chart of the ocean, with soundings indicating direction of the currents, prevailing winds, trade routes, imports and exports, &c., from different harbours.
4. Meteorological map, marking on ranges of temperature, rain fall, &c.
5. Botanical map, showing geographical position of food-producing and other useful plants, as rice, corn, maize, sugar, tobacco, indigo, cotton, flax, opium, and forest timber.
6. Public works map, showing roads, tramways, canals of navigation and irrigation, works of drainage.
7. Map showing comparative density of population.
8. Traffic map, showing amount and direction of passenger, goods, and merchandise traffic.
9. Military map, showing forts, military stations, disposition of troops, electric telegraph stations, &c.
10. Describe the characteristics and topographical references usually employed in the Ordnance and other surveys to denote the following, viz.—boundaries of counties, parishes, baronies, and townlands; also, the marks used to denote lime kilns, brickfields, collieries, bridges, forts, gravel pits, waste or uncultivated land, trigonometrical points, weirs or dams, canal locks, quarries, coal, iron, copper, lead, and tin.

*Note.*—Physical maps are capable of being applied to many other subjects not hitherto used, and may be most usefully employed to illustrate reports I therefore wish particularly to direct your attention to this interesting subject.

## THE LATE PARIS EXHIBITION.

*(Reports continued.)*

### TELEGRAPH APPARATUS.

### Special Arrangements.

Siemens and Halske, Berlin, exhibit an apparatus constructed for indicating the height of water in a reservoir by means of magneto-electric currents. A pitch chain, fixed at one end to a float on the surface of the water, passes over a cog-wheel and carries at the other end a counterweight. When the water, therefore, rises, the float, rising with it, lets the counterweight down and turns the cog-wheel in one direction. When the water falls, of course, the cog-wheel is turned in the reverse direction. On the axis of the cog-wheel is fixed one end of a helical spring, which is wound up or unwound when the wheel turns. The other end of the spring is fixed to a soft iron barrel armature, the wire of which is wound longways. When the cog-wheel has made a complete revolution, and either wound up or unwound the spring, the barrel armature is released, and the spring in regaining its normal position twists round the barrel between the poles of a battery of permanent magnets. In turning, the sides of the soft iron barrel take alternately different states of magnetism, and therefore induce different currents in the wire upon it. The directions of these currents depend upon the direction of rotation, two currents being given for each revolution, one way positive-negative, the other negative-positive. This is essential for the indicating instrument, which is moved only by the last current each time. The currents which follow the rising and falling of the water are sent through different lines. This is attained by a mechanical arrangement, one end of the wire upon the barrel being attached to an insulated ring, on which is a clip with a short arm pressed against one or other of two fixed contact-points, according to the direction in which the barrel is turned. These two contact-points are in circuit with the two lines. Thus all the currents induced whilst the water is rising are sent through one of the lines; those induced during the time the water falls, through the other. At the receiving station, where the indication is required, the two lines are connected with the coils of two polarised electro-magnets, whose armatures end in spring pallets which catch into the teeth of two ratchet-wheels. Each of these wheels is fixed upon a hollow axis, which carries also a crown-wheel. The teeth of the two crown-wheels are directed towards each other, and between them gears a pinion turning upon an axis, fixed at right angles upon the central axis of the system. Whenever, therefore, one of the electro-magnets is set in action its armature, attracted and repelled, pulls round, step by step, one of the ratchet-wheels, and causes the pinion between the crown-wheels to turn half as many teeth in the same directions. The pallets of the armatures engage with the teeth of the ratchets on opposite sides, and therefore turn them in opposite directions. The central axis carries an index which denotes upon a circular dial the position of the float upon the surface of the water.

A. V. Bergmüller, Vienna, shows a system of police telegraphs, in which he proposes to use lamp-posts. &c., as branch stations. Two such branch stations are shown, one arranged for a lamp-post, the other for the corner of a building. The branch station consists of a box containing a clockwork and cylinder, with a series of contacts. When the clockwork is released, by pressing down one of a series of buttons, the cylinder revolves and gives the necessary signals to the line. The top buttons are marked "fire, thieves, &c., and the lower ones indicate the street or quarter in which aid is required.

The dial plate and buttons are protected by a small iron door, to which the policeman on duty alone has the key. Inside each door is a paper of printed instructions for the guidance of the operator, and above the dial a galvanometer, which indicates if any other station is signalling through the same line, in which case the operator has to wait until the magnet-needle becomes quiet.

The signals are to go to a central station, where they are received upon the paper strip of a self-starting Morse apparatus.

L. Bréguet, Paris, exhibits a system of automatic repeating signals, for use with his railway telegraph. This arrangement is intended for employment on lines having several stations in circuit. When the central station gives a signal, an alarm is sounded at the branch station.

This alarm is moved by clockwork released by the current, and gives exactly so many beats as represents the number of the station on the line. Each beat sends a current to the central station, where the receiver of the dial telegraph in circuit indicates the number of currents received.

The system is intended to prevent errors and to serve as a security that the right station is being corresponded with. Thus, if the central station "call" No. 5, and receives six beats in return, it is evident that the line is in circuit with a station beyond the required point.

### Lightning-Dischargers.

T. Picco, Alexandria, shows a novel construction of lightning-guard, called automatic. When the atmospheric electricity enters the station, it fuses a short piece of thin iron wire, and by this releases a spring, which puts the line directly to earth. The end of the line is connected with a brass pillar, on the top of which a metallic beam turns horizontally. One end of the beam is pressed against a contact leading to earth by means of a helical spring round the pillar. When in use, the other end of the beam is secured by about an inch of thin iron wire to the terminal leading to the apparatus separating the beam from the earth contact, to which it, however, returns as soon as the wire is fused.

L. Bréguet shows a lightning-discharger, the suggestion of Messrs. Lartigue and Tesse, electricians of the Chemin de Fer du Nord, upon the same principle as that of Mr. Picco—namely, the automatic connection of line with earth as soon as the lightning enters the station. The difference between this and the foregoing systems consists only in the employment of gravitation instead of the tension of a spring. This apparatus consists of a metallic hammer conected with the line and held suspended by a thin iron wire, which is in the line circuit. When this is fused by the lightning, the hammer falls down and makes contact with earth. This discharger is very small and neat, and is being introduced on the French railway lines.

Another form of lightning-discharger is shown by Mr. Bréguet, much used in France. It consists of a combination of the plate with the saw-teeth forms of discharger. The earth-plate is divided from that of the line by a thin sheet of writing-paper.

Siemens Brothers, London, and J. Leopolder, Vienna, show very handsome specimens of Siemens and Halske's plate lightning-discharger for four lines. This discharger is made of five plates of cast iron—the lower one, which is connected with earth, stands upon four feet upon the table; the other four are connected in the four line-circuits, and lie across the earth-plate. They are divided from it by four thin washers of insulating material, leaving a very narrow space of air between the lines and earth. These dischargers are the strongest and most reliable of any.

### Batteries.

Leclanché, Paris, exhibits specimens of a new galvanic element. The positive pole is formed by a prism of carbon in the middle of a porous pot containing also a mixture of powdered peroxide of manganese and carbon. The negative pole is formed of a rod of amalgamated zinc, about half an inch in diameter, contained in sal-ammoniac and water. The peroxide of manganese being a tolerably good conductor of electricity, the system may be regarded as a single fluid element, in which the positive pole is formed of a material having a great affinity for the liberated hydrogen. The current is formed by the decomposition of the chloride of ammonium. The chlorine, or negative element, combines with the oxide of zinc, forming a salt which is soluble in water; and the hydrogen and ammonia, being both positive, go to the carbon pole, which is of course negative, underneath the surface of the fluid, and reduce the peroxide of manganese. Such an element appears to be subject to a considerable polarisation, but to last a long time without requiring attention.

J. Thomsen, Copenhagen, exhibits his polarisation battery. This apparatus is based upon the separate polarisations of a number of platinum plates, which are discharged in series. The battery consists of fifty small cells, divided from each other by platinum plates, and containing dilute sulphuric acid. If *a*, *b*, *c*, *d*, *e*, . . . are such plates, and we bring the carbon pole of a galvanic element to *a* and the zinc pole to *b*, the opposite surfaces of *a* and *b* will be polarised, hydrogen will be developed on *b* and oxygen on *a*. Therefore, on removing the battery, *b* remains the + pole and *a* the — pole of the gas element. *a b*. Instead of removing the galvanic battery, let us shift the connections from *a* and *b* to *b* and *c*, so that oxygen is now developed on *b* and hydrogen on *c*, then to *c* and *d*; and so on. At the end we shall have the electro-motive force of so many oxy-hydrogen elements. Mr. Thomsen employs fifty such plates, and makes the contact by means of a rotating commutator, which shifts the contents of the battery on to the first two poles the instant after they leave the last two. The first and last plates are joined by a wire permanently with the terminals of the system, and between them a continuous current is kept up.

The writer made experiments in the Exhibition on the electro-motive force between the terminals when two Bunsen's elements were used for charging the battery, and the commutator rotated thirty-eight times (or charged 1,900 elements) per minute. The electro-motive force was equal to seventy Daniell's elements.

### Measuring Apparatus.

Siemens and Halske, Berlin, exhibit a complete testing board, with galvanometer for cable work. The board is arranged with two boxes of resistance-coils—one with duplicate 10, 100, and 1,000 units, for the proportion [resistances of Wheatstone's balance, the other with resistances from 1 to 10,000 mercury units. A commutator of novel construction allows these resistances and the circuits of the board to be arranged for measuring copper resistance; insulation by balance, deflection, and differential methods; charge, discharge, electro-motive force, and other necessary constants. The battery commutator is divided, to allow any number of elements from five to one hundred to be inserted at once.

The galvanometer is constructed upon the differential principle. An astatic needle is surrounded by a coil of thin copper wire, whose magnetic effect upon the needle is very great. A second coil, placed vertically upon a movable stage outside the case of the instrument, is adjusted so as to exert from 0·001 to 0·0001 times the magnetic effect of the large coil upon the needle. The cable whose insulation by differential method is to be measured if inserted, with a battery in the circuit of the larger, a known resistance and single element in that of the smaller coil, whose distance from the needle is varied until the latter rests over the zero line, at which moment, therefore, the magnetic effects of the two currents upon the needle are equal and opposite. Knowing the relation of the initial effects of the two coils at the same distance, the electro-motive forces, and resistance inserted in the smaller circuit, the resistance of the cable is easily calculated.

Siemens, Brothers, London, show a differential galvanometer for measuring small resistances without the aid of resistance scales. The needle is balanced between the opposite magnetic effects of two separate coils of wire. These coils retain always the same distance from each other, but are moved together horizontally in a plane at right angles to that of the magnetic meridian. Therefore the magnet-needle may be midway between them, in which case they exert, with equal currents, equal and opposite magnetic effects upon it; or it may occupy any other point between them, in which case the needle is balanced by the stronger current circulating in the more distant coil. A common battery is used for both coils, a constant resistance being included in the circuit of one of them, and the unknown resistance in that of the other. The coils are then shifted until the needle rests over the zero line. This is done by means of a metal curve moved by a micrometer screw at right angles to the stage which carries the bobbins, and against which an agate point on the stage is pressed by the force of a spring underneath. The curve is graduated in terms of the mercury unit, so that the resistance of any wire may be read off directly, without the intervention of resistance scales or the necessity of calculations.

Dr H. Meidinger, Carlsruhe, exhibits a galvanometer, consisting of a tangent-needle, with a long vulcanite pointer which indicates upon a dial divided into degrees of force. The unit of these degrees is the weight of hydrogen gas developed by the current in an hour. The instrument is supplied with three terminal screws, which may be variously connected in circuit, giving various values to the unit of weight expressed by the scale, as follows:—

| | | | | |
|---|---|---|---|---|
| With screw No. | 1 | each degree represents | 0·0001 | grammes. |
| ,, | 1 and 2 | ,, | 0·0010 | ,, |
| ,, | 1, 2, and 3 | ,, | 0·0100 | ,, |

the last being equivalent to 112 cubic centimetres of gas, at 0 deg. cent. temperature, and 760 mm. barometer.

By simple multiplication of the degrees of force indicated upon the circular dial-card with the equivalent weight of any metal, therefore, the absolute weight of metal reduced from its solution by the current in one hour is found.

## COAL MINING IN SCOTLAND.

The carboniferous system of Scotland has received considerable attention from geologists, and its nature and extent have been frequently described. Though fragmentary strata of coal occur in the Western Islands and at one or two other points, the great coal-fields occupy a well-defined position, extending across the country in the line of the valleys of the Forth and Clyde; and their superficial area is calculated to be about 1,750 square miles, or one-seventeenth part of the surface of Scotland. The uppermost of the coal strata is found at Fisherrow, and between it and the Old Red Sandstone, which forms the floor of the coal formation, there are 337 alternations of strata, having a thickness in the aggregate of 5,000ft. In the thickest part there are 62 seams of coal, counting the double seams as one, and about one-half of these are workable. The depth of strata at Musselburgh is, however, exceptional; and the average depth is estimated to be about 3,000ft. of which the coal seams occupy 126ft. The thickest bed of coal in the Lothians field is 13ft.; but at Johnstone, in Renfrewshire, there is a seam 100ft. in thickness. This latter owes its extraordinary bulk to the overlapping of the coal strata during some great convulsion in the locality. The most important of the coal-fields is the Clydesdale, on which one-half of the entire number of collieries in Scotland are situated. Thirteen counties lie over or touch upon the coal-fields, and of these Lanarkshire has by far the largest share of the store. Judging from the number of collieries possessed by each, Ayrshire, Fifeshire, and Stirlingshire come next in order. In nearly all the counties, more or less valuable beds of ironstone, shale, and limestone are intermixed with the coal. The Scotch cannel or parrot coals are very valuable on account of the high proportion of gas and oil which they yield. The Boghead variety gives 120 gallons of crude burning oil, or 15,000 cubic feet of gas per ton; and the brown Methil 90 gallons of oil, or 10,000 cubic feet of gas per ton. In the Edinburgh Industrial Museum, there is a collection of specimens of the different kinds of coal found in Scotland and elsewhere, together with the tools used in mining. The cannel coal found at Wemyss, Fifeshire, is carved into various articles of a useful and ornamental character—such as picture-frames, inkstands, brooches, &c.—and a table formed of it is exhibited in the Museum.

## CLYDE SHIPBUILDING.

The returns show that during 1867 the number of vessels built has been 212, representing a total of 113,095 tons, and 14,844 horse-power while there are building or contracted for 138 vessels, with tonnage of 120,713 and 17,158 horse-power, making in all 380 vessels, 233,808 tons, and 32,002 horse-power. This shows, as compared with 1866, an increase of 20 vessels, 17,435 tons, and 5518 horse-power—a state of matters which contrasts favourably with what was seen at the corresponding period of 1866, when a decrease was exhibited from the previous year of 88 vessels, 76,173 tons and 16,123 horse-power. The increase in the accounts this year arises from the extra amount of orders on hand, which give an increase as compared with the statistics for 1866 of 27 vessels, 39,019 tons, and 7803 horse-power. There is thus a manifest improvement in the state of trade from what it was at this time last year. The prospects for the future are likewise more favourable, and it is confidently expected that in the incoming year trade will be about what it was previous to the great demand for blockade runners and other British shipping which was occasioned by the American war. Previous to the lock-out the number of hands employed was about 21,000; the beginning of 1867 showed that this number had been reduced to less than 18,000; but at the start of 1868 probably 15 per cent. more will be at work, or about two-thirds of the number who were engaged at the busiest season. During the year now closing there have not, so far as has transpired, been any further disputes between the masters and the men, the latter of whom have continued, as on the conclusion of the late struggle, to work 57 hours per week for 57 hours' pay, good hands receiving about the same wages as they had prior to the lock-out, but second and third class hands being paid at a reduction from former rates of from 10 to 20 per cent.

## IRON.

The quantity of iron ore produced in this country last year was 6,665,012 tons. This was smelted in 613 blast furnaces, and of pig iron we produced:—

| | Tons. |
|---|---|
| In England | 2,576,928 |
| In Wales | 959,123 |
| In Scotland | 994,000 |
| Total of Great Britain | 4,530,051 |

Of this pig iron we exported 497,138 tons, reserving more than four million tons for conversion into merchant iron. The returns inform us that there were 256 ironworks in activity in 1866, in which there were 6,239 puddling furnaces and 826 rolling mills.

The proportions in which the iron ores of this country were used in our furnaces are given as follows:—

| | | |
|---|---|---|
| Argillaceous and black band carbonates | 42 | per cent. |
| Cleveland stone | 28 | ,, |
| Lancashire and Cumberland red ores | 15 | ,, |
| Brown ores | 13 | ,, |
| Spathic carbonates | 2 | ,, |
| | 100 | |

The general produce of iron ore was thus distributed.—

| | Quantities. Tons. | cwt. | Value. £ | s. | d. |
|---|---|---|---|---|---|
| Cornwall | 18,683 | 10 | 6,786 | 12 | 7 |
| Devonshire | 40,671 | 0 | 12,504 | 9 | 11 |
| Somersetshire | 35,323 | 2 | 17,661 | 10 | 0 |
| Gloucestershire | 162,129 | 0 | 72,981 | 18 | 0 |
| Monmouthshire | 60 | 0 | 15 | 0 | 0 |
| Herefordshire | 115 | 0 | 53 | 15 | 0 |
| Wiltshire | 75,645 | 0 | 30,258 | 0 | 0 |
| Oxfordshire | 1,552 | 0 | 543 | 4 | 0 |
| Northamptonshire, &c. | 476,981 | 0 | 118,940 | 15 | 0 |
| Lincolnshire | 175,720 | 0 | 41,733 | 10 | 0 |
| Shropshire | 285,907 | 0 | 71,476 | 15 | 0 |
| Warwickshire | 18,750 | 0 | 4,687 | 10 | 0 |
| Staffordshire, North | 612,243 | 0 | 206,530 | 0 | 0 |
| Do. South | 599,000 | 0 | 164,726 | 13 | 0 |
| Derbyshire | 329,500 | 0 | 82,375 | 0 | 0 |
| Yorkshire { North Riding | 2,809,060 | 18 | 741,197 | 16 | 0 |
| Yorkshire { West Riding | 357,000 | 0 | 89,250 | 0 | 0 |
| Lancashire | 685,726 | 10 | 342,863 | 5 | 0 |
| Cumberland | 838,048 | 0 | 538,153 | 5 | 0 |
| Northumberland and Durham | 105,000 | 0 | 27,250 | 0 | 0 |
| Wales, North | 56,682 | 8 | 17,005 | 0 | 0 |
| Do. South | 368,691 | 19 | 130,041 | 6 | 0 |
| Scotland | 1,587,000 | 0 | 396,750 | 0 | 0 |
| Ireland | 25,525 | 0 | 5,313 | 15 | 0 |
| Total | 9,665,012 | 17 | 3,119,018 | 19 | 6 |

It has not been possible in every case to separate the *calcined* from the *uncalcined* ore.

The foreign or imported was 58,689 tons, making a grand total of 9,721,701 tons of ore converted into iron. The number of furnaces in blast was 618. The pig-iron produced was:

| | Tons. |
|---|---|
| In England | 2,576,928 |
| In Wales | 952,969 |
| In Scotland | 994,000 |
| Total production of pig-iron in Great Britain | 4,523,897 |

This quantity, estimated at the mean average cost of the place of production, would have a value of £11,309,742.

## THE SUEZ CANAL.

We have been requested to insert the following letter addressed to the president of the Civil and Mechanical Engineers' Society:—

Sir,—My attention has been drawn to the interesting address, which, in your capacity as Vice-President of the Civil and Mechanical Engineers' Society, delivered at Birmingham, and of which a report appeared in the December number of The Artizan.

Perceiving, however, that observations made in a portion of your address, in so far as relates to the Suez Canal, are based upon insufficient information, I have availed myself of the earliest opportunity to supply you with the necessary documents embodied in the report of M. Ferdinand de Lessops, delivered at a general meeting of shareholders in Paris on the 1st August, 1867, and which I have had the honour to forward to you by post.

The passage to which I beg leave to take exception to is when you are reported to have said:

"The Suez Canal next claims our attention. It is plain now that its completion is within the bounds of possibility, though it is hard to believe that the investing public will continue to patronise such a vast scheme with such remote expectations of completion as it promises. M. Siccama, one of the members of the society, visited it some two years since, and has given us an account of it, in a paper read last year. The pith of his remarks was this, that out of 70,000,000 yards of excavation a total of 18,000,000 had already been removed. The remainder, it will be allowed, represents many years of hard work to come, and how the scheme is to be further prosecuted, and at the same time to defray the annual charge of interests on calls, is incomprehensible."

Now, in treating the subject of the greatest engineering work of the age, I apprehend it was, *à priori*, necessary to have not only the best and most reliable information, but the most recent that could be obtained, in order to satisfy that intelligent craving for scientific knowledge at the present time more than ever felt by the industrial classes of this country. All this could readily have been procured at the Institution of Civil Engineers, in London, the Royal Geographical Society, to which I have presented a series of reports and plans, or from the public journals, through the medium of which I have ever since the commencement of the Suez Canal never ceased to keep the public informed on all matters pertaining to it.

Without wishing to enter at any length into matters which are fully gone into in the reports which I have sent you, permit me to draw your attention to the very important fact—viz., that the agreements entered into with the contractors of the works guarantee the final completion of the Suez Canal on or before the 1st October, 1869.

It may not be out of place to mention that they have consented to the payment of a penalty of 500,000fr. for every month's delay. The company, on their part, agreeing to allow the contractors an equal sum of 500,000fr. for every month the canal may be completed anterior to the 1st October, 1869.

It may not unreasonably occur to you that the contracters have undertaken more than they are able to perform. Let us, therefore, proceed to examine in how far they were justified in entering upon such an agreement, and the grounds upon which their proceedings are based.

During the month of November last the excavations along the entire line of canal amounted to a total of 1,357,348 cubic metres. Up to the 1st of December 32,562,631 cubic metres have been removed. The original total being 74,112,130 cubic metres, it follows that 41,549,499 cubic metres still remain to be excavated.

When I mention that the above results have been obtained with 39 dredging machines, and that 21 more are fitting up on the spot, making thus a total of 60 dredges, capable, as experience has shown us, of removing 30,000 cubic metres each per month, and considering the aid of manual labour, consisting of 10,000 men, on the works, you will perceive that most substantial grounds exist for stating that in 21 months from the 1st December, which brings the date to the 1st October, 1869, the works will be entirely completed.

We next come to the means the company has at its disposal to carry out these intentions, and I do so with reference to that passage in the address in which you state, "and how the scheme is to be further prosecuted, and at the same time to defray the annual charge of interests or calls, is incomprehensible."

The financial position of the company, as shown by the last balance-sheet submitted to and approved of at the general meeting of shareholders, after the usual tests of scrutiny, verification, and credit had been rapidly gone through, is the best document to which I can refer, and which you will find appended to the report forwarded to you. From this it will be seen that the capital of the company is more than amply sufficient to complete the entire works, leaving, over and above, 15,000,000fr. for unforeseen contingencies.

Irrespective of the above, I may add that the Suez Canal Company is possessed of a most valuable territory in the shape of 10,000 hectares of land adjoining the canal. Thirty francs per metre has been offered for some localities, and 100fr. per metre for sites in the vicinity of the harbour of Port Said.

Without venturing to name any figure as representing the actual, not to say the prospective, value of these lands, it may be readily computed that at the lowest stated figure of 30fr. per metre, a sum would be realised which would go far towards paying for the entire outlay incurred in making the canal.

Let me, however, not be misunderstood; I merely enumerate this circumstance incidentally. Not that I need the aid of these prospective benefits in order to prove that the final completion of the Suez Canal is not so remote or visionary as you have led the Society of Civil and Mechanical Engineers to suppose; and when we consider the immense advantages which will accrue from it to this country, I think it is of the highest importance that we should be fully prepared for the inevitable contingency, and that no misconception on this subject should exist.

I have the honour to be, Sir,
Your very obedient servant,
Daniel A. Lange,
English Representative and Director of the Suez Canal Company.

B. Haughton, Esq., Vice-President of the Civil and Mechanical Engineers' Society, Birmingham.

## COMPETITION FOR THE RE-CONSTRUCTION OF THE SEACOMBE AND EGREMONT FERRY PIERS ON THE RIVER MERSEY.

On the 9th of January, at an adjourned general meeting of the Wallasey local board, held at the public offices, Egremont, the premiums were awarded for the best schemes for the improvement of the above ferries. J. C. Boyd, Esq., occupied the chair, and the other members present were, Messrs. Pooley, Percival, Dixon, McInnes, and Chadburn, and Captains William and Smith.

Two prizes of £100 each were offered for the best plans for improving Seacombe and Egremont ferries; and two prizes of £50 each for the second best plans; in response to which there were twenty-six competitors, who submitted about forty sets of plans. The plans were publicly exhibited for some weeks in the water tower at Liscard, and a sub-committee of the local board, together with Mr. Carson, the ferry manager, was appointed to make a selection. They chose out of the number, seven designs which were considered the most suitable, all displaying great ingenuity, which were marked as follows:—for Seacombe, "Justitia," 1 and 2, "Red Wafer," "Archimedes," and "Crux." For Egremont, "Crux" and "Old Stager."

These designs were submitted at the meeting of the board on the 9th ult., and after some discussion the prizes were unanimously awarded as follows, viz.:—for Seacombe, first prize, "Archimedes;" second prize, "Crux." For Egremont, first prize, "Old Stager;" second prize, "Crux."

The letters of the successful competitors were then opened by Mr. Ewer, the law clerk, when it was found that the plans marked "Archimedes," were those of Mr. Benjamin Haughton, C.E., and Mr. G. J. Crosbie, Dawson, Assoc. Inst. C.E., Engineers' office, London and North Western Railway, Euston Station. Those plans marked "Old Stager," were by Mr. Charles Cubitt, Assoc. Inst. C.E., of 3, Great George-street, Westminster (nephew of the late Sir William Cubitt.) Those plans marked "Crux," were by Messrs. A. C. Andros, M. Inst. C.E., and James Young, Assoc. Inst. C.E., Culford-road, De Beauvoir Town, London.

The average of all the estimates were for Seacombe, £36,003; and for Egremont, £16,800.

Messrs. Benjamin Haughton and G. J. Crosbie Dawson sent in two designs for Seacombe; the estimate of the one adopted was £45,418, and of the alternative one £54,736.

Messrs. A. C. Andros and James Young's estimate for Seacombe was £34,040.

Mr Charles Cubitt's estimate for Egremont was £16,186; and Messrs. Andros and Young's estimate for Egremont was £8,625.

## WATER PIPES FOR ABYSSINIA.

A large quantity of iron pipes have been demanded, by telegram, to be immediately sent out to Abyssinia, intended to convey water from the foot of the Koomaylo Pass to Zoula and it has since been confirmed by a further telegram on the subject from Sir Robert Napier. It is now about a fortnight since the first telegram was received, and it reflects great credit upon the India Office authorities that such expedition should have been attained that the first ship-load of pipes has sailed from Liverpool, and, within three weeks of the order first arriving, it is fully expected that the whole 18 miles of pipes will be on their way to their destination, accompanied by experienced pipe-layers and plumbers. In thus showing how a Government department can, on emergency, exercise an amount of despatch in the execution of business scarcely capable of being exceeded, the Director-General of Stores has clearly shown that he is possessed of great energy; and we may state also that on this occasion he has availed himself of the valuable services and advice of M. George Preston White, C.E., whose name is so well known in connexion with the annual competitive examinations of civil engineers for the Government service in India.

In order to expedite, as much as possible, the supply of these pipes, the order for them was distributed amongst the following firms, viz.: Messrs. D. Y. Stewart and Co., and Messrs. Edington and Co., of Glasgow; Messrs. Cochrane and Co., of Middleshoro'; and the Stavely Iron Company, in Derbyshire. The pipes are each 4in. in internal diameter, $\frac{3}{8}$in. thick, and 9ft. 3in. in extreme length, giving 9ft. in clear effective length when fitted; they are all supplied with bored and turned joints, as is now very generally done, in order to facilitate their being fixed together *in situ.* Each pipe weighs about 1½ cwt., and is calculated to resist a pressure of 400ft. The head, however, to which it will be subjected is only 170ft. In order to render the service complete, these pipes will be accompanied by screw-cocks and various other fittings which are being supplied by Messrs. Simpson and Co., of Pimlico.

The laying of water-pipes in an enemy's country by a besieging army is quite a new phase in military tactics; but as the telegraph in India was first similarly employed as the army advanced to the siege of Lucknow, so, perhaps, in future years portable water-pipes may come to be a usual accompaniment of advancing armies.

## CORRESPONDENCE.

*We cannot hold ourselves responsible for the opinions of our Correspondents.*

*To the Editor of* The Artizan.

Sir,—In your late article on hydro-carbon as fuel, you describe my experiments at Woolwich from the report published by the House of Commons. In that report the average of the whole experiments is given as 13·2lbs. of water evaporated by 1lb. of oil, and this you take as the result.

This conclusion is not quite fair. I was groping my way to discover by what means I could obtain the largest results from the oils consumed. The report shows that in the 15 experiments there were no fewer than six different arrangements of steam pipes in the furnace, and the results were most uncertain and capricious till I arrived at the last and most perfect arrangement. I could then have gone on for months with the same result—18·38lbs. of water for 1lb. of oil or creosite. In January, 1867, I obtained with creosite 18·91lbs., and this, please remember, was the average during the ten hours full working.

The trials were in a small boiler—in April last I had a large boiler given me; this requires a little of the same working up that the smaller one did. I fully expect as good a result, but, as you may suppose, it is not to be obtained all at once.

Yours, etc.,
C. J. Richardson.

34, Kensington-square, W., January, 1868.

## REVIEWS AND NOTICES OF NEW BOOKS.

*The Railway, Banking, Mining, Insurance and Commercial Almanack for* 1868. Edited by William Page Smith. London: Railway Record Office, 13, Red Lion-court, and Simpkin, Marshall, and Co.

Though this publication is called an almanack, it is chiefly remarkable for the vast amount of useful statistics connected with almost the entire industry of Great Britain. These statistics appear to be very complete and comprehensive, and worked out with great care; consequently, as a work of reference for such information, it will be found of great value. The statistics respecting the general produce of iron ore in Great Britain for last year, given in the present number of The Artizan, is extracted from this work.

*The Waterworks of London, together with a series of articles on various other waterworks.* By Zerah Colburn and William H. Maw. London: E. and F. N. Spon, 48, Charing-cross.

In this work, which is reprinted from "Engineering," will be found very complete descriptions of the various waterworks established in and near London. Beginning with the New River, an accurate detailed account is given of the sources of supply, including the various levels and quantity of discharge, together with the estimated capacity and peculiarities of construction of the various reservoirs belonging to the company. The machinery is afterwards treated with, and full description, including details of such parts as may be of interest, are given, assisted by numerous well executed plates. The other waterworks, including the East London, West Middlesex, Chelsea, Lambeth, Grand Junction, Southwark and Vauxhall, and the Kent waterworks are each described in a similar manner. The second part of the book describes and, to some extent, canvasses the merits of the various schemes that have from time to time been brought forward for a more perfect supply to the metropolis. The latter portion furnishes various useful and interesting accounts of the principal waterworks in America, and also those of Paris, Dublin, Aberdeen, Bombay, and Madras, concluding with an account of the Crossness pumping station, which, though not exactly used for supplying drinking water, may, so far as the machinery is concerned, be fairly included in this treatise.

*Railway Junction Diagrams.* By John Airey, of the London Clearing House, Euston Square, London. Published by him at the London Clearing House.

This very useful work has been already noticed in The Artizan of last August: since which time its value has been increased by the addition of upwards of twenty junctions, making it complete up to the end of the year 1867. We have again much pleasure in bearing testimony to its general accuracy and utility.

## NOTES AND NOVELTIES.

### MISCELLANEOUS.

Chair of Engineering at Edinburgh.—The Government has accepted the offer, made through the Senatus Academicus of Sir David Baxter, to found a Chair of Engineering, provided that a supplementary vote, equivalent to the interest of his benefaction were asked from Parliament. A letter from the Treasury to this effect has been received by one of the deputation appointed by the Senatus to urge the claim.—*Scotsman.*

The Chicago Tunnel.—The tunnel under the Chicago river is again under way with every chance of a thorough and successful prosecution of the work. It is under the management of Mr. Cheshorough, city engineer for Chicago, and originator of the famous Lake Tunnel, as well as the plan for raising the entire city, which has been so successfully carried out. The bottom of the tunnel, or top of invert in the middle of the river, is to be 32·4ft. below low water. The length of tunnel will be 838ft., with open approaches of 770ft. in all. The tunnel under the river is to consist of three passage ways, one 10ft. wide for foot-passengers, the others 11ft. each, for vehicles.—*American Gas Light Journal.*

The Reaping Machine.—The testimonial subscribed among Scotch agriculturists and others to the Rev. Patrick Bell, minister of Carmylie, Forfarshire, for his inventions of the "first efficient reaping machine" was presented at Edinburgh on Wednesday by the Marquis of Tweedale. The gift consisted of a salver, bearing a suitable inscription, and an engraving of Bell's reaping machine, and of a sum of money, which Mr. Scot Skirving, on the part of the committee, stated only fell short of £1,000 by about £20 or £30. The noble chairman said that, so highly did he appreciate Mr. Bells invention, he would be happy to make up the sum to £1,000. Mr. Bell, in acknowledging the gift, said it was just forty years since he came to Edinburgh to exhibit the model he had constructed of a machine to save the labour of the reapers. On that occasion he had received such encouragement from the then secretary to the Highland Society (Sir C. Gordon) and others that next year he had a machine constructed, which was successfully tried in cutting grain on his brother's farm. The original model, the property of the Highland Society. was exhibited on the table,

From the North.—Upon the whole, industrial affairs are considered to have slightly improved of late on Tyneside. There is not, however, much doing in rails, although a few orders continue to drop in.

The French Navy.—Warlike preparations in France have lately extended to the naval forces. The most marked activity is observable in the Government ship-yards. At this moment no less than 39 ships of different sizes are building for the Admiralty. Four of these are rams, on the "mixed" principle, being half of wood and half of iron. One ram, the *Ocean*, is to carry eight guns of the heaviest calibre in battery, and four in towers. On the same system four corvettes are also being constructed to carry two guns on each side, and four others in as many immovable towers. These vessels will be comparatively small, and provided with powerful engines, so as to attain great speed in the water.

Steel Hoops.—Messrs. Taylor Brothers and Co., Leeds, have just completed some very large steel-hoops, which are 10ft. 6in. in diameter, 6 in. broad, and $1\frac{3}{8}$in. thick. These hoops have been made from solid cast-steel ingots, which, after hammering, were rolled in a tyre machine. The extraordinary size of the hoops will speak for the very superior quality of the steel.

Additions to Greenock Shipping.—The Greenock shipowners are investing largely in new iron sailing ships, and the shipbuilders on the Clyde have more orders from Greenock firms on hand at present than has been built for Greenock merchants for the last two or three years, and scarcely a week passes but we hear of some new contract having been signed. Amongst the vessels Messrs. Steel and Co. have an iron ship building for each of the following Greenock firms:—Messrs. R. Shankland and Co., one of 1,280 tons; J. and W. Stewart, one of 1,280 tons; Messrs. Bane and Johnstone, one of 900 tons; Messrs. Barclay, Curle, and Co., one of 1,100 tons, for Messrs. Carmichael and Co.; Messrs. R. Duncan and Co., one of 1,900 tons, for Messrs. A. O. Leitch and Muir; and one of 1,200 tons for Mr. Robert Cuthbert; Messrs. M'Millad and Sons have two ships of 780 and 1,100 tons, for Mr. John Kerr. Total, eight vessels of 8,500 tons. Besides the above, we believe other two vessels, if not contracted for, are about to be fixed by Greenock firms with Clyde builders.

The heavy weather which prevailed at Southport on the 18th ult., has been attended with considerable damage to the extension works of the new pier. The girders had been laid, but not for the entire width of the new portion, and being incomplete and not sufficiently stayed near the point of junction with the old pier, they gave way. The result was that the adjacent lengths for some distance having no support gave way also leaving a gap of several yards in extent in the roadway.

### NAVAL ENGINEERING.

Institution of Naval Architects.—The ninth annual meeting of the Institution of Naval Architects will take place on Thursday, Friday, and Saturday, the 2nd, 3rd, and 4th of April next, at the Hall of the Society of Arts, John-street, Adelphi, London; morning meetings at 12, and evening ditto at 7. Papers on the Principles of Naval Construction, on Practical Shipbuilding, on Steam Navigation, on the Equipment and Management of Ships for Merchandise and for War, will be read at this meeting. Naval architects, shipbuilders, naval officers of the royal and merchant services, and engineers who propose to read papers before the Institution, are requested to send immediate notice of the subject and title of the paper to the secretary; and it is requested that the paper itself, with illustrative drawings, be deposited at the offices of the Institution, on or before the 1st of March next.

An artesian boring in the vicinity of Geneva to a depth of 742ft., and at an elevation of 1,600ft. above the sea level, showed the increase in heat at the rate of 1 deg. Fah. for every 55ft., while another at Mendorff, in Luxembourg, which penetrated to a depth of 2,394ft. gave a result of 1 deg. Fah. for every 57ft.

A process for the extraction of indigo from rags dyed with that substance has lately appeared. The rags are first saturated with a weak solution of caustic soda, then placed in a boiler with a double bottom and exposed for some time to steam at 45lb. pressure. The indigo in the rags is reduced and may be washed out. It may afterwards be precipitated from the soda solution and recovered in a state equal to the best commercial sort.

### STEAM SHIPPING.

The following is from the Panama, New Zealand, and Australian Royal Mail Company (Limited):—"The twin screw-steamer *Ruahine*, 1,503 tons register, and 350 horse power, nominal, employed in the mail service across the Pacific, made one of the quickest passages ever known on her last voyage to Panama, having run from Sydney to Wellington (1,250 miles), and from Wellington to Panama (6,670 miles), without stoppage—in all 8,920 nautical miles, in 31½ days.

### TELEGRAPHIC ENGINEERING.

Proposed Telegraph between Newcastle and Denmark.—A new line of telegraph is about to be laid from the Tyne to Denmark by a company entitled "The Danish, Norwegian, and English Telegraph Company," which promises to give not only much cheaper messages to Denmark, Norway, Sweden. and the north of Russia, but much greater speed and accuracy, if the arrangements of the promoters are fairly carried out. One-fifth of the whole capital, it is said, has been subscribed by the Danish government; that altogether £85,000 have been already subscribed; and that the specification for the cable is to be settled by the Danish government. The United Kingdom Telegraph Company are to work the line direct from London to Copenhagen—a distance of about 1,000 miles.

Telegraphs throughout the World.—It may be interesting to our readers to know the total length, approximately at least, of the telegraphic lines throughout the world, and the proportion which exists in each of the several countries in which this agency of correspondence has been adopted. The total length of telegraph lines in the world is 178,086 miles. In 1866 there were in Germany 28,347 miles of telegraph: in Russia, 22,992; in France, 18,694; in Great Britain and Ireland, 16,297; in Turkey, 8,665; in Italy, 8,216; in Sweden, 3,507; in Belgium, 1,089; in Switzerland, 2,160; in Canada, 5,050; and in the United States, 52,957. Besides these, there are the two Atlantic cables, which measure 3,369 English, or 3,755 nautical, miles. The total length of the other submarine cables is nearly 6,000 miles. One of the most marvellous examples of the value of telegraphic communication was afforded on the recent occasion of M. Gladstone's tour. The addresses delivered at Southport and Ormskirk contained 16,882 words. The report of the speeches reached Liverpool by train at 11.25 p.m. The transmission to London by telegraph began at 11.30 p.m., and was completed at 1.40—that is to say, in little more than two hours. The last slips were delivered at the offices of the daily papers before 2.30. Mr. Gladstone's speech on the following day at Oldham contained 30,745 words, and was transmitted with corresponding rapidity.

A proposal has been made for the submersion of a submarine cable between Callao Guayaquil, and Panama. Communication would be effected with Europe by this means, in thirteen days, and this time would be reduced to a few hours if Panama were united to the Atlantic cable.

Telegraphic intelligence has arrived from Tiflis that the Persian Government has joined the Russian and Prussian Governments in establishing a two-wire telegraph line from the town of Nordeney (which is the terminus of Reuter's cable between England and Prussia) to India. Each Government will provide for the portion of the entire line which lies within its own territory. The three Governments have also agreed that this new line is to be exclusively set apart for Indo-European correspondence; the existing State lines. from the time of its completion, being confined to local or non-Indian messages. They have also agreed to intrust the execution and working of the proposed line to Messrs. Siemens Brothers, of London, who have branch firms at Berlin and at St. Petersburg. That firm propose to carry out the work by means of an English company, thus securing that telegraphic communication to India shall be under British control and under one management. The cost of the line, as far as Teheran, where the Government of India commence, will be £600,000, including a submarine cable in the Black Sea, which will be laid in order to avoid the Caucasian mountains, where the existing lines are subject to frequent interruptions. The co-operation of the Government of India has also been promised, on the representations of the Prussian and Russian Ministers in London. The proposed line will establish a powerful competition to the existing route through France or South Germany, Austria, Turkey, and Asia Minor, to the head of the Persian Gulf, with the advantage of being executed and worked by an English company, which will appoint English telegraph clerks at all the stations. The existing lines to India have no English telegraph clerks at any of their stations, and are under various administrations until the Persian Gulf is reached. The three Governments interested in opening up the proposed telegraph line to India have evidently adopted a prudent course in departing from the principle they have hitherts acted upon of retaining all telegraphs in the hands of the State, and in committing its execution and working eo English hands. The completion of the undertaking is promised within a twelvemonth from its inception, and it is stated that forty words per minute will be transmitted between London and Teheran; the tariff is also to be reduced to £3 10s. for 20 words, and £2 for 10 words, in the place of the existing tariff of £5 1s.

## RAILWAYS.

The Great Northern Railway Company has opened a new station at Cambridge adjoining the Great Eastern station in the Hills-road.

Accounts have been received of the Great Southern Indian Railway having effected a junction with the Madras company's south-west line at Errode, the through traffic commencing on the 1st of January. By this junction the rich and populous districts of Tanjore and Trichinopoly are brought into unbroken communication by railway with Malabar, Mysore, and Madras, and also with the northern and central districts by means of the Madras north-west line. On this line the completion of the important bridge over the Chittravntty river was to be signalised about the same time, his excellency the Governor having been invited to secure the last rivet and to drive the first engine over the new structure. This bridge is half way to Tandpntre, thirty-two miles in advance of the present terminus, to which station the railway is nearly finished, and will open in time to bring down this season's crop of the cotton districts to which it leads.

Traffic Receipts on Railways in the United Kingdom for 1867.—The traffic receipts on railways in the United Kingdom amounted for the year 1867, on 13,802 miles of railway, to £38,670,540, against £37,415,927 on 13,424 miles of railway in the year 1866, showing an increase of £1,254,613. The increase of traffic in 1866 over 1865 amounted to £2,080,089, so that the increase of traffic in the past year over the preceding year was less by £825,476 than the increase of traffic in 1866 over 1865. Owing to the very severe weather in the first quarter of 1867, the increase in that quarter was only £71,500 over the same quarter in 1866, while the increase in the first quarter of 1866 over 1865 amounted to £673,500, being £602,000, and thus accounting at once for the greater part of the comparative deficiency. The increase of traffic in the second quarter of 1867 was £352,700, against £524,000 in 1866 over the same quarter in 1865; the increase in the third quarter amounted to 598,000, against £297,500 in 1866 over 1865; and in the fourth quarter to £361,490, against £446,000 in 1866 over 1865. The traffic receipts on the fourteen principal lines of railway in the United Kingdom for the year 1867 amounted, on 9,497 miles, to £32,031,588, and for the year 1866, on 9,242 miles, to £31,145,948, showing an increase of £882,640.

From the Atlantic to the Rocky Mountains.—An unbroken railway communication is now open from the Atlantic seaboard to the Rocky Mountains, a distance of more than 2,000 miles. The line passes over the Mississippi and Missouri rivers on bridges—at Rock Island on the former, and Omaho on the latter—so that, if necessary, the entire journey can be performed in the same carriages.

Four locomotives will be shortly at work in Abyssinia upon the railway formed in connection with the English expeditionary force now in that country. Two of these locomotives were obtained from the Kurracbee Harbour Works, one from the Bombay, Baroda, and Central India Railway, and one from Messrs. Wells and Glover.

Chili.—An additional railway section has just been opened for traffic in this interesting republic. All the ports of the Chilian coast are now united by steam lines, which also extend from Valparaiso to Panama and San Francisco, and by these two points to China and Japan, on the one hand, and, on the other hand, to Europe by borrowing the American railway from Panama to Colon. As regards railways already completed, Chili possesses a line from Caldera to Copiapo, traversing the principal mining districts, and throwing out branches to Pabellon and Charmacille. This line cost £6,030,721. A line from Coqnimbo to the Serena, and another from Valparaiso to Santiago cost, between them, £13,300,000. Finally, a southern line from San Fernando to Curico cost £8,,021,533.

Devon Valley Railway.—It is very gratifying to learn that satisfactory progress continues to be made in the construction of the uncompleted portion of the Devon Valley line of railway. In addition to the workmen engaged on the line from Tillicoultry to Dollar, squads of men are working to the east of Dollar, some of them being engaged at present in the lowering of Dollar burn. Notwithstanding the recent heavy rains, the banks along the line are all standing in good condition, and there has within the last few days been a large delivery of permanent sleepers, rails, and chairs.

Ciudad Real and Badajoz Railway.—This company has this month completed its branch line to the Belmez Coal Basin. This result is expected to have an important influence upon the original undertakings, as it will not only lead to the development of a coal traffic, but will also assist the reduction of the working expenses.

## WATER SUPPLY.

The Silicated Carbon Filtering Tap.—The advantage of being able to obtain pure water cannot be too highly estimated, and more especially in districts where the inhabitants are too poor to supply themselves with filters. The Silicated Carbon Filter Company, of Church-road, Battersea, have lately introduced a most useful invention for purifying water as it flows from the cistern, and is especially recommended to the proprietors of tenements in poor localities, and where the water required for daily use is liable to every kind of contamination. The filtering medium is placed in the front part of the tap, and which is made to unscrew. The filtering tap may be easily cleaned by simply unscrewing the front part and blowing strongly through it, and the whole process can be done without running the water from the butt. The medical journals have very highly commended the invention.

## DOCKS, HARBOURS, BRIDGES.

Hartlepool Headland.—The joint committee of the Hartlepool Port and Harbour Commissioners, and the Hartlepool Corporation, who some time ago offered a premium for the best design for the protection of the headland, have selected the plans and estimates of Mr. Thomas Fenwick, C.E., of Leeds.

## MINES, METALLURGY, &c.

The Foreign Coal and Iron Trades.—The Belgian coal-markets continue dull. In the Liége basin a fall in prices is anticipated, and it is difficult to obtain in consequence a renewal of contracts. Wages have been reduced in some of the Belgian collieries, and in others the men are not working full time. There is little change to report in connection with the French iron trade; the Compagnie des Chantiers de l'Océan has completed two monitors for M. Arman, which have formed the subject of some litigation; the o vessels are supposed to have been built for one of the South American Republics. The Russian Government has been making great efforts of late to develope mechanical and metallurgical enterprise on the soil of Russia, and has announced that the Oboukhow Steel Works, near St. Petersburg, are in a position to supply cast steel, especially that used in the rolling stock of railways. The prices at which steel is produced at the Oboukhow works are stated to compare favourably with those current at the great works at Essen, conducted by Herr Krupp. It is understood that the Russian Government contemplates the construction of a line of railway from Koursk to the Sea of Azoff; the districts through which the line will run are said to comprise a great number of bearings of coal and iron minerals, which remain at present unworked from the absence of the railway communication now proposed to be supplied.

## LATEST PRICES IN THE LONDON METAL MARKET.

| | From | | | To | | |
|---|---|---|---|---|---|---|
| | £ | s. | d. | £ | s. | d. |
| COPPER. | | | | | | |
| Best selected, per ton | 75 | 0 | 0 | 76 | 0 | 0 |
| Tough cake and tile do. | 73 | 10 | 0 | 74 | 0 | 0 |
| Sheathing and sheets do. | 79 | 0 | 0 | 80 | " | " |
| Bolts do. | 83 | 0 | 0 | " | " | " |
| Bottoms do. | 85 | 0 | 0 | " | " | " |
| Old (exchange) do. | 66 | 0 | 0 | 67 | 0 | 0 |
| Burra Burra do. | 82 | 0 | 0 | " | " | " |
| Wire, per lb. | 0 | 1 | 0 | " | 1 | 0½ |
| Tubes do. | 0 | 0 | 11½ | 0 | 1 | 0 |
| BRASS. | | | | | | |
| Sheets, per lb. | 0 | 0 | 9 | 0 | 0 | 10 |
| Wire do. | 0 | 0 | 8½ | 0 | 0 | 9½ |
| Tubes do. | 0 | 0 | 10½ | 0 | 0 | 11 |
| Yellow metal sheath do. | 0 | 0 | 7¼ | " | " | " |
| Sheets do. | 0 | 0 | 6¾ | " | " | " |
| SPELTER. | | | | | | |
| Foreign on the spot, per ton | 20 | 5 | 0 | " | " | " |
| Do. to arrive | 20 | 5 | 0 | " | " | " |
| ZINC. | | | | | | |
| In sheets, per ton | 26 | 0 | 0 | 27 | 0 | 0 |
| TIN. | | | | | | |
| English blocks, per ton | 96 | 0 | 0 | " | " | " |
| Do. bars (in barrels) do. | 97 | 0 | 0 | " | " | " |
| Do. refined do. | 99 | 0 | 0 | " | " | " |
| Banca do. | 90 | 0 | 0 | " | " | " |
| Straits do. | 87 | 0 | 0 | " | " | " |
| TIN PLATES.* | | | | | | |
| IC. charcoal, 1st quality, per box | 1 | 6 | 0 | 1 | 8 | 0 |
| IX. do. 1st quality do. | 1 | 12 | 0 | 1 | 14 | 0 |
| IC. do. 2nd quality do. | 1 | 4 | 0 | 1 | 6 | 0 |
| IX. do. 2nd quality do. | 1 | 10 | 0 | 1 | 12 | 0 |
| IC. Coke do. | 1 | 1 | 6 | 1 | 2 | 0 |
| IX. do. do | 1 | 7 | 6 | 1 | 8 | 6 |
| Canada plates, per ton | 13 | 10 | 0 | " | " | " |
| Do. at works do. | 12 | 10 | 0 | " | " | " |
| IRON. | | | | | | |
| Bars, Welsh, in London, per ton | 6 | 10 | 0 | " | " | " |
| Do. to arrive do. | 6 | 10 | 0 | " | " | " |
| Nail rods do. | 7 | 0 | 0 | 7 | 10 | 0 |
| Stafford in London do. | 7 | 10 | 0 | 8 | 10 | 0 |
| Bars do. do. | 7 | 10 | 0 | 9 | 10 | 0 |
| Hoops do. do. | 8 | 10 | 0 | 9 | 12 | 6 |
| Sheets, single, do. | 9 | 5 | 0 | 10 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 5 | 15 | 0 | 6 | 0 | 0 |
| Do. mrch. Tyne or Tees do. | 6 | 10 | 0 | " | " | " |
| Do. railway, in Wales, do. | 5 | 0 | 0 | 5 | 10 | 0 |
| Do. Swedish in London do. | 10 | 5 | 0 | 10 | 10 | 0 |
| To arrive do. | 10 | 5 | 0 | 10 | 10 | 0 |
| Pig No. 1 in Clyde do. | 2 | 12 | 0 | 2 | 17 | 0 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | " | " | " |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 7 | 0 | 0 | 7 | 10 | 0 |
| STEEL. | | | | | | |
| Swedish in kegs (rolled), per ton | 14 | 5 | 0 | " | " | " |
| Do. (hammered) do. | 15 | 5 | 0 | 15 | 10 | 0 |
| Do. in faggots do. | 16 | 0 | 0 | " | " | " |
| English spring do. | 17 | 0 | 0 | 23 | 0 | 0 |
| QUICKSILVER, per bottle | 6 | 17 | 0 | " | " | " |
| LEAD. | | | | | | |
| English pig, common, per ton | 19 | 0 | 0 | 19 | 5 | 0 |
| Ditto. L.B. do. | 19 | 10 | 0 | " | " | " |
| Do. W.B. do. | 21 | 10 | 0 | " | " | " |
| Do. sheet, do. | 20 | 0 | 0 | 20 | 5 | 0 |
| Do. red lead do. | 20 | 15 | 0 | " | " | " |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 0 | 0 | 23 | 0 | 0 |
| Spanish do. | 18 | 10 | 0 | 18 | 15 | 0 |

* At the works 1s. to 1s. 6d. per box less.

## 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 13th, 1867.

3550 J. G. Settle—Door bolts and indicators
3551 T. Pebardy—Improvements in surgical appendages, &c.
3552 W. E Newton—Bench planes, &c.
3553 L. Christophe and J. Moutigny—Cannon

### DATED DECEMBER 14th, 1867.

3554 H. Atkinson—Gas retort ovens and furnaces
3555 F. Berry—Self-acting metal breaker
3556 A. McMurdo—Apparatus for saving life, &c.
3557 J. Sharples and J. Schofield—Improvements in shuttles employed in weaving, &c
3558 W. Bates and F Bates—Washing machines
3559 J. Hargreaves—Improvements in the manufacture of soda and potassa
3560 R. Tinkler—Churns
3561 J. H. Kidd—Improvements in brattice cloth
3562 G. Clark—Guns, projectiles, cartridges, &c.
3563 E. H. Bentall—Improved apparatus for controlling the draught of water
3564 T. C. Parson—Skates
3565 O. Hollingworth—Improvements in feeding furnaces, &c.
3566 A. M. Clark—Improvements in the extraction of ammonia from fermented and other liquids, &c.
3567 E. Tatham and A. Tatham—Sinkers for hosiery and other machines
3568 E. Rimmel—Portable fountain
3569 L. A. W. Lund—Studs, &c.
3570 W. Conisbee—Chromo lithographic and typographic printing machines

### DATED DECEMBER 16th, 1867.

3571 J. Booth, J. Booth and J. Booth—Cutting or dressing stone
3572 J. E. A. Gwynne—Sinking tubes or cylinders for obtaining water, &c.
3573 W. Huskisson—Manufacture of soda, &c.
3574 J. Dawson—Treatment of sugar syrup.
3575 J. M. Shackleton—Umbrellas
3576 G. D. Kittoe—Engines actuated by air, &c.
3577 W. H. Kerr—Material used in the manufacture of porcelain and pottery
3578 W. Jackson and J. Dyer—Valves and valve cocks
3579 Major Chevalier Cesare Bernieri—Invulnerable cloth armour
3580 J. Stanfield—Application of hydrogen gas to furnaces, &c
3581 W. Huskisson—Manufacture of bicarbonate of potash and soda

### DATED DECEMBER 17th, 1867.

3582 N. Haley and J. Hodgson — Machinery for twisting wool, &c.
3583 T.V. Mackintosh—Machines for making drains or trenches.
3584 A. Shrimpton—Papering needles
3585 W. Simons and A. Carmichael—Moulding, &c
3586 W. Ross—Preventing and removing incrustation in steam boilers
3587 E. M. Du Boys—Liquid meters
3588 S. Marsters—Machine for rubbing, washing and sizing ropes, &c.
3589 F. L Hancock and C. L. Hancock—Propellers and propelling vessels
3590 W. A. Gilbee—Raising Water
3591 W. E Newton—Manufacture of tinned leaden pipes

### DATED DECEMBER 18th, 1867.

3592 H. Green—Furnaces for steam boilers
3593 W. Vaile—Stereotypes and electrotypes
3594 R. D. Dwyer—Metallic bedsteads and mattrasses
3595 J. Patterson—Capstans
3596 J. Murray—Construction of roads or streets
3597 T. Comfield—Railway and other carriages
3598 W. Preston and C Walker—Condensers
3599 J. Hall—Furnace grates and casings
3600 J. Cockshoot—Carriages, landaus, &c.
3601 H. A. Bonneville—Rims of hats
3602 M. H. Collins—Improved lamp
3603 O A. Hebert—Musical boxes
3604 H. H. Murdoch—Propelling canal boats, &c.

### DATED DECEMBER 19th, 1867.

3605 E. T. Bellhouse—Fireproof floors
3696 G. H. Ellis—Cleaning boots and shoes
3607 W. A. Hubbard—Compasses and dividers
3608 J. S. Gisborne—Electric telegraphs
3609 L. M. Becker—Telegraphic wires, &c.
3610 J. Atkins—Metallic bedsteads
3611 J. Clay—Saddles
3612 A. Cochran—Machinery for finishing woven fabrics
3613 E. Breffit—Glass bottle house pot carriages
3614 W. H. Richardson—Manufacture of iron and steel
3615 R. Chauncy—Substitute for emery paper
3616 J. Kerr—Breech-loading fire-arms
3617 J. Simmons—Optical illusion of apparently beheading or dismembering a human being
3618 W. B. Pullar—Manufacture of fabrics to be made into skirts
3619 C. Beck—Joining horn and whalebone
3620 B. Monson—Apparatus for sliding the sash frames of windows, and for sliding shutters

### DATED DECEMBER 20th, 1867.

3621 H. A. Bonneville—Machinery for carding and spinning wool
3622 G. Davis—Circular knitting machines
3623 E. Field—Cowl for chimney tops
3624 L. L. Tower—Vessels for measuring liquids

### DATED DECEMBER 21st, 1667.

3625 B. Engel—Ink and iron-mould extractor
3626 J. T. Kershaw—Improved ventilator
3627 J. Kenyon—Apparatus for boiling size
3626 E. Lord—Revolving and sliding shutters
3629 C. de Bergue—Construction of railway carriages, &c
3630 W. Walker—Steam pumps
3631 B. Browne—Camp or folding bedsteads
3632 J. Hadley—Cleaning grain or seeds
3633 J. Davidson—Central fire cartridges
3634 W. Hurst—Flyer, throstle, and doubling frames
3635 C. G. Wilson—Machinery for pressing cotton
3636 E Ludlow—Cartridge cases
3637 J. Davison—Rigging
3638 I. Pick—Bags, portmanteaus
3639 J. G. Tongue—Pomade

### DATED DECEMBER 23rd, 1867.

3640 J. Rowe—Miners' safety lamps
2641 W. Dixon—Elastic coupling
3642 C. W. Lancaster—Cannon and other fire-arms
3643 W. W. Urquhart and J. Lindsay—Machinery for softening jute, &c.
3644 R. Crawshaw—Shuttles for looms
3645 W. Walker—Cotton ties
3646 H. F. Beugnugh—Tobacco pipes
3647 C. J. Adams—Fire alarm and extinguisher
3648 S. Salter—Rotary engines
3649 J. Dawkins—Tanning.
3650 W. H. Chase—Couplings for driving belts
3651 M. J. Rice—Cutting and heading nails

### DATED DECEMBER 24th, 1867.

3652 F. A. Abel—Explosive compounds
3653 S Myers—Roasting coffee
3654 W Burley and W. H. Glasson—Plummer blocks, &c.
3655 P. F Tranchat—Universal machine
3656 C. Pottinger—Motive-power engines
3657 A. M. Clarke—Colouring matter
3656 P. Demeure—Railway carriage brake
3659 G Layton—Soap
3660 F. Rendel—Traps for pigeon shooting
3661 T. Harrison—Rails for railways
3662 W. E. Newton—Alcoholmeter
3663 J. Addie and F. Kohn—Furnaces
3664 G. E. Allshorn—Artificial manure
3665 S. Lennard—Warp fabrics
3666 W. Hewitt—Holders
3667 G. J. Hinde and T. C. Hinde—Iron and steel

### DATED DECEMBER 26th, 1867.

3668 J. Lightfoot—Printing textile fabrics
3669 N. Greenhalgh, W. Shaw, and J. Mallison—Steaming certain yarns
3670 R Bowen and J. B. Bowen—Gloves
3671 E C. Jetot and E. Hortensius, C. Cros, and M. M. A. o'Emar de Jahrun—Hat protector

### DATED DECEMBER 27th, 1867.

3672 E. G. Rafer and E. E. Rafer—Braiding machine
3673 J. Edge—Rag-rolls or heaters
3674 E. J. Hughes—Blankets for printing textile fabrics
3675 T. J. Ellis—Apparatus for carburetting gas and atmospheric air
3676 J. Cockshoot, jun., and H. Weatherill—Railway breaks
3677 J M. Rowan—Casting steel
3678 D. Steele—Heating and agitating liquid or fluid substances
3679 H. Higgins and S. Whitworth—Machinery for spinning cotton, &c.
3680 J. Clarke—Envelopes for needles
3681 A. V. Newton—Soles for boots and shoes
3682 J. W Lewis—Warming apparatus
3683 A. Dunn and A. Liddell—Metallic vessels or casks
3684 C. E. Brooman—Application of electricity to clocks

### DATED DECEMBER 28th, 1867.

3685 J. Goodfellow—Metallic pistons
3686 J Cooper—Chimney tops or caps
3687 W. Fryer—Self-closing taps
3688 A V. Newton—Shot and shells
3689 W. E Newton—Butt hinges
3690 W. E. Newton—Motors for generating motive power
3691 C. Morfit—Apparatus for cutting soap
3692 R. Howarth—Carriages &c.
3693 L Hasluck—Watchman and reporter
3694 E. Evans—Sash frames
3695 J. Jowett—Furnaces
3696 C. Churchill—Gas burner

### DATED DECEMBER 30th, 1867.

3697 J. E. Gowen—Raising sunken vessels
3698 R. Fothergill—Producing heat, &c.
3699 T. Robertshaw and J. Robertshaw and J. Greenwood—Looms for weaving
3700 W. Kendrick and J. Woodbridge—Consuming smoke
3701 G. Glover—Lamps
3702 J. Davison—Furnaces for smelting glass
3703 J. Aschermann—Cutting the hair or fur from skins
3704 A. M. Clarke—Permanent way of railways
3705 A. Grainger—Construction of roads or carriage ways

### DATED DECEMBER 31st, 1867.

3706 M. A. F. Mennons—Combining the vapours of liquid hydrocarbons with oxygen
3707 M. A. F. Mennons—Substitute for animal hair
3708 M. A. F. Mennons—Concrete or artificial stone
3709 T. Messenger—Steam engines and boilers
3710 G. McCulloch—Thread-polishing machines
3711 W. Barnes—Carriage lamps
3712 J. Novikow—Drawing and spinning hemp
3713 V. L Daguzan—Paving
3714 H. Bessemer—Malleable iron and steel
3715 C. G. Hill—Floss silk
3716 W. Wilson—Hats and wearing apparel
3717 N. Smith—Stoves
3718 A. Allan—Brakes for carriages
3719 J. H. Johnson—Spinning cotton
3720 A. M. Clark—Road sweeping machines
3721 R Tooth—Evaporating liquids
3722 W. Mitchell and T. Mitchell—Carding engines
3723 J. G. Crompton—Felt hats

### DATED JANUARY 1st, 1868.

1 W. R. Lake—Regulating the speed of steam and other engines
2 W. R. Lake—Fire and burglar proof safes
3 W. R Lake—Electric telegraph apparatus
4 G. A. D. Goodyear—Propelling boats
5 W. Stroudley—Re-railing carriages
6 W. Wood and J. W. Wood—Cardings and yarns
7 A. M. Clark—Breech-loading ordnance
8 H. Milward—Needle cases
9 R. W. Morrell and P. Craven—Spinning and doubling fibrous substances
10 W. J. Fraser—Furnaces or fireplaces
11 J. Imray—Locomotion
12 C. W May—Meigs metallic cartridge
13 A. Beard—Furnaces and firebars
14 T. R Daft—Iron ships and vessels
15 J. Ramsbottom and T. M. Pearce—Engines and generators
16 B. Vette—Crossovers and scarves
17 D. Foster—Anvils

### DATED JANUARY 2nd, 1868.

18 M. A. Hamilton—An improved churn
19 E. J. Kruss and W. A. Kruss—Camera
20 E. Izod—Stays

### DATED JANUARY 3rd, 1868.

21 J. Cox—Fastenings for sleeve links
22 J. S. Cockings—Welded iron tubes for gas
23 T. P. A. Key—Scaffolding
24 C. Long—Decarburators
25 J. Dellagana and B. Dellagana—Printing machines
26 M. E. Roy and L. Prevett—Receptacle for needles
27 M. J. Frisbie—Apparatus for feeding fuel into furnaces

### DATED JANUARY 4th, 1868.

28 J T. Emmerson and J. Murgatroyd—Iron
29 W. W. Morley—Printing of paper bags
30 W. J. Blinkhorn—Snuffless dip candles
31 W. E. Newton—Converting power into speed
32 P. Spence and W. A. Smith—Storing meat for transport
33 W. H. Atkinson—Compositions for cleansing casks
34 A. Albini—Belts or pouches
35 W. B. Gray—Spinning machines
36 G. Mudge—Adjustable lock furniture
37 J. Nixon—Transferring coal, &c.

### DATED JANUARY 4th, 1868.

38 G. Platts and W. Tate—Safety for signalling
39 E R. Southby—Separating paraffine
40 E. Goudin—Lighting cane
41 T. Stokes—Piled fabrics in imitation of the fleece or fur of animals.
42 J. R. T. Mulholland—Creel or bobbinholder
43 J. Combe—Winding or balling
44 F. Chamberlain—Steam boiler
45 J. Gardner—Projecting liquids

### DATED JANUARY 7th, 1868,

46 F. W. Hartley—Optical illusions
47 E. Myers and G. A. Cannot—Permanent way of railways
48 C. D. Abel—Removing sulphur
49 C. Hutchinson—Liquid metre tap
50 S. Etey—Publication of journals, &c.
51 H. McEvoy—Fastenings for wearing apparel
52 J. Maury—Metallic straps
53 W. T. Tongue—Lamps
54 J. Granville—Lowering boats
55 G. Smith—Lubricating machinery
56 J. B. Dunn—Buckle or tie
57 H. Smyth—Umbrellas
58 W. Avery—Needle cases
59 G. Davies—Combining wrought or cast iron
60 G. Warsop—Mangles
61 J. L. Norton and W. H. Bailey—Indicating the pressure of fluids
62 G. Warsop—Washing machines
63 G. E. Donisthorpe—Joints and catches
64 P. Spence—Roasting or calcining copper
65 B. J. Heywood—Coffeeroaster

### DATED JANUARY 8th, 1868.

66 M. Grant—Playing cards
67 J. Tomlinson—Machinery for twisting and untwisting flax
68 L. Simon—Laying metal leaves
69 S. Goldstein—Wearing apparel
70 M. Walker—Breech loading small arms
71 F. F. Ommaney—Forcing and raising water
72 C. Pontifex—Expressing wort from spent hops
73 W. H. Bailey and J. W. Lowther—Lubricating tallow cups
74 G. W. Bacon—Gymnastic apparatus
75 R. Girdwood—Bugs
76 J. Dawson and J. Howorth—Looms for weaving
77 S. Benjamin—Receptacles for coins
78 W. E. Kenworthy—Purifying drains
79 W. E Newton—Propelling vessels
80 T. Greenwood—Machinery for preparing to be spun silk
81 J. Petrie—Brats or travelling surfaces
82 J. Tucker—Dressing fabrics and yarns
83 J. Tucker—Manufacture of paper
84 W. R. Lake—Cutters for forming wood mouldings

### DATED JANUARY 9th, 1868.

85 C. J. B. King—Tanning
86 C. H. Newman—Malt liquors
87 S. G. Archibald—Tablets
88 G A. Heath—Sash fastenings
89 R. Winder—Folding machine
90 O. H. McMullen—Mashing machine

### DATED JANUARY 10th, 1868.

91 J. Vivez—Lamps
92 J. Lewitus—Blinds
93 J. H. Glew—Boots and shoes
94 S. Mortimer—Combing wool
95 J. Fawcett—Cattle food
96 J. M. Rowan—Artificial fuel
97 G. Davies—Self-supplying pen
98 J. G. Tongue—Sewing the backs of books

### DATED JANUARY 11th, 1868.

99 H. Cochrane—Moulds for hollow and other castings
100 W. Champness—Ornamenting wearing apparel
101 C. S. Lemon—Shirt fronts
102 A. Budenberg—Steam hammers
103 J. Pilling and R. Scaife Spinning, twisting
104 J. Hirst and W. Hirst—Clog soles
105 J. Somervell—Alimentary substances
106 W. W. Hooper—Signals on board ships
107 J. C. Ellison—Machinery for folding fabrics
108 N. Hougson—Engines
109 J. G. Tongue—Stringing carpets
110 W. D. Young—Wedging fences
111 J. H Johnson—Pipes for smoking
112 T. Whitwell—Furnaces
113 G. Ireland—Cruet frames
114 T. S. Ellhu—Self-securing skate

### DATED JANUARY 13th, 1868.

115 M. A. Hamilton—Device for holding pens
116 P. Pittar—Rock drilling
117 J. M. Kirby—Generating steam
118 W. Firth—Valves
119 C. A. Watking—Ties for painting

### DATED JANUARY 14th, 1868.

120 T. Wood—Railway carriages
121 W E. Gedge—Breech-loading fire-arms
122 C D. Abel—Woven fabrics
123 C. W Lewis—Spirit level
124 A. Cowling and W. Turner—Tape measure cases
125 J. C. Ramsden—Looms

### DATED JANUARY 15th, 1868.

126 T Sagar—Looms
127 A H. Boyer—Aerial cradles
128 F. Alekan and I. Alekan—Studs
129 W. E Gedge—Moveable blades
130 L. M. Becker—Wires used for electric telegraphs
131 G. Nimmo—Composition for furnace linings
132 J. Lang—Music printing
133 D. Hodson—Cutting grass
134 J. Hodson and C. Catlow—Looms
135 W. Ayliffe—Boats
136 J. Williamson—Fastening ships
137 J. Parker—Textile fabrics
138 J Kidd—Artificial light
139 J. Head—Furnaces for puddling
140 W. Wilkins and W. G. Pollard—Gaiters

### DATED JANUARY 16th, 1868.

141 T. Travis and W. H. Prince—Clearing yarn
142 J. Eggleton—Bellows regulators
143 J. J. Ashworth—Looms
144 J. Tolson and J. Boothroyd—Spinning
145 R. Schneider—Piled fabrics
146 C E. Brooman—Gas-heating
147 H. B. Mullord and A. Mullord—Matarial bonnets
148 J. Wood—Windows
149 J. A. Jones—Iron and steel
150 W. Betts—Material for capsules
151 J. G. Rollins—Baskets
152 T. Mash—Stoves
153 G. E. Reading—Busk fasteners
154 C. D. Abel—Moveable switches
155 F Postill—Kilns or ovens
156 W. E. Newton—Polishing sword blades

### DATED JANUARY 17th, 1868.

157 J. Batchelor—Power loom
158 R. Heathfield—Nails and tacks
159 J. Moorhouse—Cone drawing
160 H. C. Lobnitz and A. Boguet—Propelling ships
161 S. Burrows and E Burrows—Waste steam
162 J. Hosking—Boring instruments
163 J. Young. Washing
164 H. Aitken. Iron ores
165 J. Crossley. Washing yarns
166 J. M. Napier. Dressing metals
167 D. A. Fyfe. Paper pulp
168 N. H. Rolfe. Cutting laths
169 W. R. Lake. Wood veneer
170 G S. Fisher. Cutting hay
171 J. Winter. Filling glass bottles

### DATED JANUARY 18th, 1868

172 J. Millward. Propelling ships
173 T. B. Kay. Carding engines
174 H H. Lloyd. Coffins
175 B. T. Moore. Water pipes
176 E. Dorsett. Coal tar
177 J. Whiteley. Twining jennies
178 H. Kershaw. Spinning worsted
179 H. A. Bonneville. Fly cover.

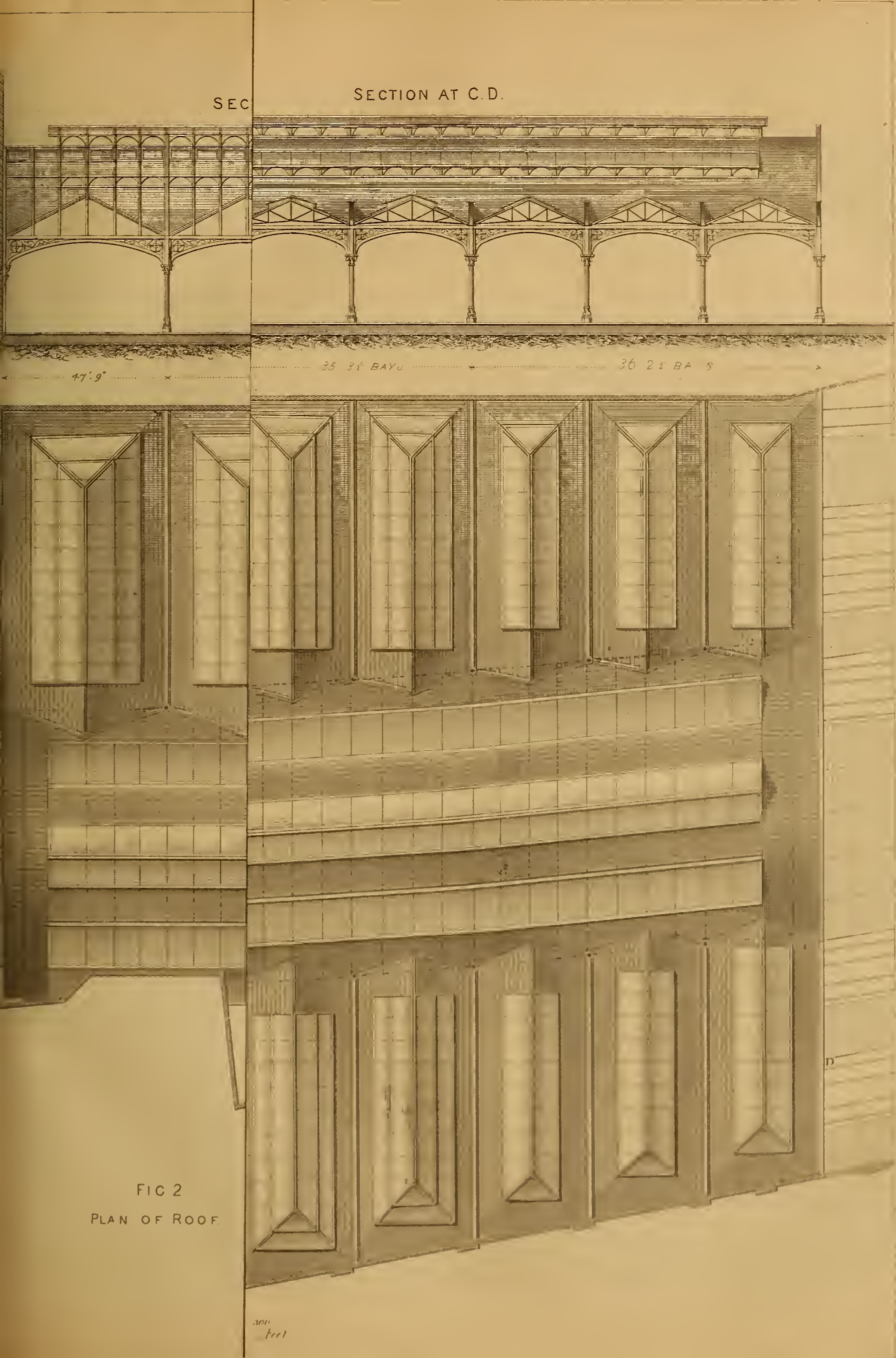

FIG 2
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# ROOF OF THE LONDON BRIDGE TERMINUS,

## L. B. & S. C. RAILWAY.

FIG. 1.

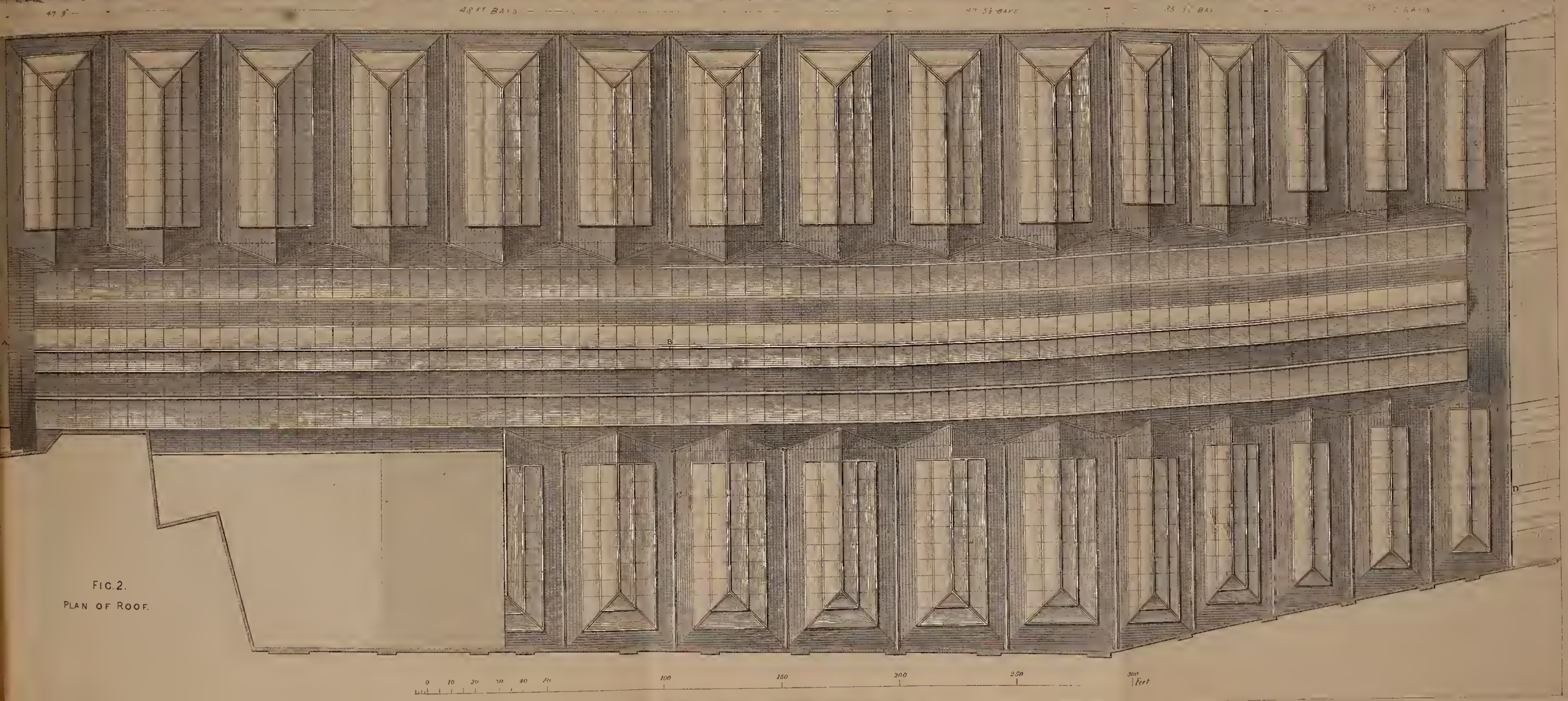

FIG. 2.
PLAN OF ROOF.

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3564 T. C. Parson—
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3568 E. Rimmel—l
3569 L. A. W. Lau
3570 W. Conisbee—
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3601 H. A. Boune
3602 M. H. Collin
3603 O. A. Heber
3604 H. H. Murd

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3605 E. T. Bellho
3606 G. H. Ellis—
3607 W. A. Hubt
3608 J. S. Gisbo
3609 L. M. Beck
3610 J. Atkins—
3611 J. Clay—Sa
3612 A. Cochran
fabrics
3613 E. Breffit—
3614 W. H. Rich
steel
3615 R. Chauncy
3616 J. Kerr—Br
3617 J. Simm n
beheading or d

# THE ARTIZAN.

No. 3.—Vol. II.—Fourth Series.—Vol. XXVI. From the Commencement.

1st. MARCH, 1868.

## ROOF OF THE LONDON BRIDGE TERMINUS OF THE LONDON, BRIGHTON, AND SOUTH COAST RAILWAY.

(*Illustrated by Plate* 327.)

In plate No. 327 is illustrated the works recently carried out for the purpose of enlarging and renewing the London Bridge terminus of the London and Brighton Railway Company. Most of our readers, no doubt, are aware that the termini of this and of the South Eastern Company are contiguous near London Bridge, and that they are raised to a considerable height above the original level of the ground, being carried by arches, girders and columns; the space thus covered over by the floor of the stations being used as cellar warehouses, except where appropriated for public traffic.

The enlargement or widening of the London and Brighton Station took place on the southern side, near the former site of St. Thomas's Hospital, for the purpose of accommodating the traffic of the South London line. In this portion the floor of the station is carried by a series of longitudinal brick arches 4ft. 2in. span springing from and abutting against stout rolled joists 12in. deep and 14ft. span; these joists rest upon cast iron girders, 2ft. 6in. deep with spans of 21ft., 25ft., and 37ft. 6in. respectively; and these rest upon wrought iron, single-webbed plate girders, 3ft. 9in. deep, carried upon cast iron columns at distances of 21ft., 24ft., and 28ft. These girders were all tested at the works of the contractors (Messrs. H. Grissell and Co., of the Regent's Canal Iron Works), before being fixed into place; and in the subjoined table is a record of the test of the three girders of 37ft. span, which is interesting as showing the great range of variation in the elasticity of cast iron of the same make, and proving how utterly unreliable must be any rules for calculating the deflection of cast iron beams under given loads:—

| Load in Centre. tons. | | No. 1. | | No. 2. | | No. 3. |
|---|---|---|---|---|---|---|
| 35·2 | ... | $\frac{1}{32}$ | ... | $\frac{1}{32}$ | ... | $\frac{7}{32}$ |
| 7·04 | ... | $\frac{1}{16}$ | ... | $\frac{1}{16}$ | ... | $\frac{7}{16}$ |
| 10·56 | .. | $\frac{5}{32}$ | ... | $\frac{5}{32}$ | ... | $\frac{19}{32}$ |
| 14·08 | ... | $\frac{7}{32}$ | ... | $\frac{7}{32}$ | ... | $\frac{25}{32}$ |
| 17·60 | ... | $\frac{9}{32}$ | ... | $\frac{9}{32}$ | ... | $\frac{31}{32}$ |
| 21·12 | ... | $\frac{5}{16}$ | ... | $\frac{5}{16}$ | ... | $1\frac{1}{16}$ |
| 22·88 | ... | $\frac{3}{8}$ | ... | $\frac{3}{8}$ | ... | $1\frac{3}{32}$ |
| 24·64 | ... | $\frac{13}{32}$ | ... | $\frac{13}{32}$ | ... | $1\frac{3}{16}$ |

This table shows that beam No. 3 started with a deflection seven times that of the other two, and with the greatest load its deflection was treble that of the others; when the load was removed it kept a permanent set of 1-16th of an inch, but the others returned to their original condition.

The station, which is about 650 feet long, is covered in by one central arched roof, 88ft span, carried by two parallel rows of columns, and by a series of triangular side roofs of 48ft. and 36ft. span, running from the arched roof towards the wall on either side of the station; the principals of these roofs are carried by a series of lattice girders running parallel to the ridge of the roofs, and resting at one end on the top of the columns before mentioned, and at the other end, on the side walls of the station. This general arrangement will be readily understood by reference to the illustrations, plate 327, which give in Fig. 1 longitudinal sections through the whole length; and in Fig. 2 a general plan of the station. The arrangement of the side roofs has been carried out in a very neat manner by supporting the principals on the bottom flanges of the lattice girders, which are thus virtually on the outside of the roofs, and as they are not visible from below, this portion of the structure has an appearance of great boldness.

This arrangement of the side roofs having their ridges at right angles with the side walls, has the obvious advantage of relieving them from all thrust, which was a great desideratum, considering their great height from the level of the streets below,—and the only drawback entailed by this arrangement is, that the sides of the station are rather wanting in loftiness when compared with the arched roof; care, however, has been taken to provide spacious ventilators, to allow the steam and smoke to escape.

The height from the rails to the springing of the principals, and of the main ribs of the arched roof is 32ft., and the rise of the arched roof is upwards of 27ft., whereas that of the triangular roofs is only 12ft. and 9ft.

The columns, which are 18in. in diameter in the shaft, are very ornamental in design, being fluted and fitted with ornamental bases and capitals of leaf-work in relief; they are connected longitudinally by wrought iron girders, consisting of a straight top member, and of an arched bottom member, made in the shape of a true ellipse. Each of the members is 9in. deep and is made of a couple of ┳-Irons 5in. × 4½in. × ⅜in. section, united by means of a continuous layer of plates ¼in. thick on each side of the web, riveted together by a row of ¾in. rivets through the web of each of the ┳-irons. At the ends these two members are connected by vertical struts of the same cross section, the depth of the girders being 7ft. 6in. there. In the centre, where the top and bottom members touch each other, and are rivetted together through the tables of the ┳-irons, the depth of the girders is 18in., and in cross section they assume the shape of a treble flanged girder. They are all provided with a top flange, 9in. wide by ¼in. thick, for the sake of lateral stiffness, and they are bolted together sideways through a prolongation of the column, cast loose and bolted to the top.

The triangular open space in these girders on either side of their centre is fitted with an ornamental cast-iron spandril filling; to each of the columns also a cast-iron ornamental bracket is fixed and made to project to the under side of the transverse lattice girders, which are thus made to appear to be carried by them, and similar brackets are fixed to the walls under the opposite ends of the girders.

The arched roof forms an arc of a circle, with a radius of 49ft. 8in., and the main ribs, which are 16ft. square, are made of a light web, 7in. deep by ⅜in. thick, provided with angle iron flanges 3in. × 2½in. × ⅜in. These ribs are trussed in the customary manner, the tie-rods being made of 2½in. round iron, of uniform thickness throughout. The vertical struts are made of 3in., 3½in., and 4in. gas tubes; the cross braces of 1⅜in., 1¼in. and 1⅛in. round iron, and at their meeting points with the tie-rods and with the ribs, they are connected by wrought iron plates, small cast-iron brackets and bolts. At the springing the ribs are bolted to the top flange of the longitudinal girders, and those over the columns are bolted to the ends of the transverse girders.

The purlins, which are 6 in number, consist of light girders of the same depth as the main ribs, with ¼in. ribs and 2½in. × 2½in. × ⅜in. angle iron flanges, and they are rivetted together endways through the webs of the main ribs.

Light intermediate ribs are placed midway between the main ribs made of two angle irons 2½in. × 2in. × ¼in. in section, trussed by ¾in. tie-rods and ⅝in. struts; these ribs run from purlin to purlin to which they are riveted, and at the foot they are riveted to the longitudinal girders through the medium of a cast-iron shoe.

The covering of this roof consists of $1\frac{1}{4}$in. boarding tongued and matched, covered over with zinc of No. 16 zinc gauge, excepting a space about 13ft. wide at the crown, where a light triangular ventilator roof has been raised upon the main ribs and covered in with glass, and two other spaces about 15ft. wide on either side of the roof where ventilators have likewise been provided, and which parts also have been covered in with glass. The whole of the glass used is Hartley's patent rough glass $\frac{1}{4}$in. thick.

This roof abuts at one end against the wall of the offices, and at the other end it is filled in with a glazed gable to the level of the springing of the arch of the roof; this gable consists of a rib like that of the other main ribs, provided with a horizontal tie beam of the same cross section as the rib, and stiffened with $1\frac{1}{2}$in. truss rods and cast iron struts. The main ribs of the sash frames consist of horizontal and vertical ⊤ irons bolted together at their meeting points, and to the tie beam and arched rib at their ends, and trussed with $\frac{7}{8}$in. and $\frac{3}{4}$in. rods.

The transverse lattice girders are from 95ft. to 73ft. long, and are 7ft. 3in. deep; in cross section they assume the shape of a box girder 7in. wide inside, the top and bottom members being made of a couple of dwarf webs 12in. deep and $\frac{3}{8}$ thick, to which the lattice bars are rivetted in parallel pairs to the inside of the dwarf webs. At the ends of the girders the webs are made full for a length of about 2ft. with $\frac{3}{8}$ plates, stiffened by stout ⊤ irons. The flanges which are 17in. wide, consist of angle irons, $4\frac{1}{2}$in. × $3\frac{1}{2}$in. $\frac{1}{2}$in. and of plates whose thickness varies with the span of the girders and the span of the roofs which it carries; in all the girders however the bottom flange consists in part of a channel iron, rivetted in between the dwarf webs throughout the length of the girders; the trough which is thus formed is lined with a coating of asphalte, and made to answer as a gutter to collect the rain water of the roofs which is then discharged at the column end through a leaden spout and through the columns conveyed into the drains below.

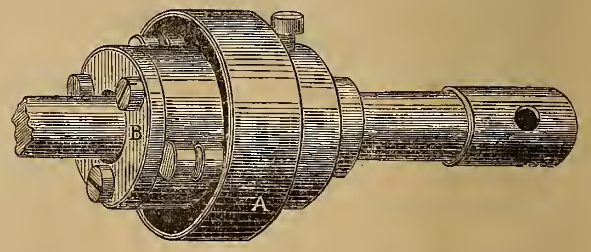
The lattice bars of the girders consist of angle and ⊤ iron for the struts, and of flat bars for the ties, increasing in size from the centre towards the abutments. The struts lean from the top flange downwards towards the abutment, and the ties rise from the bottom to the top flange leaning towards the abutments, so that each strut is crossed by a tie towards the neutral axis of the girder. At the column ends the girders are bolted to the columns and to the main ribs of the arched roof, as already described, and upon the wall-abutments they rest loosely upon roller frames to allow for expansion.

The triangular roofs are hipped off at the ends, abutting on the walls, but are made to intersect the arched roof, in the covering of which there are consequently a corresponding number of triangular spaces left out, starting at the springing of the roof. The principals of the triangular roofs are placed at distances of from 7ft. to 8ft. apart, and are trussed on the king and queen rod system, both rafters and struts being made of ⊤ iron. A great portion of these are made of the materials of the roofs of the old station taken down and re-erected, with certain additions and modifications, consequent upon the alteration of the design of the roofs. The rafters of the 48ft. bays are 4in. × 4in. × $\frac{1}{2}$in. in section; the tie rods are $1\frac{1}{4}$in. diameter at the ends, and $1\frac{1}{8}$in. between the queen rods; the king and queen rods are respectively 1in. and $\frac{3}{4}$in. in diameter, and the struts of the secondary trusses are 3in. × $2\frac{1}{2}$in. × $\frac{3}{8}$in. in section; the scantlings of the corresponding parts in the 36ft. bays are of course proportionately less. The ridges are all made of ⊤ iron 3in. × $2\frac{1}{2}$in. × $\frac{3}{8}$in., bolted to the cast iron king heads. Ventilators of about 17ft. in width in the 48ft. bays, and 13ft. in the 36ft. bays are raised upon all these roofs, except in the two end bays towards the exit to the lines. These consist chiefly of cast-iron louvre standards connected at the top with the king heads, by means of ⊤ iron ties, and covered in by glsss of the same description as that used in the arched roof; the glass being carried by wooden ridge and bottom cills and wooden sash bars. Into the open space between the louvre standards four rows of louvre blades of galvanised iron, $\frac{1}{8}$in. thick, are inserted; the girth of these blades is 8in. and 9in. Another portion of these roofs below the ventilators of about 8ft. 6in. and 6ft. 3in. in length, in the 48ft. and 36ft. spans respectively, is covered in with glass, which in some of the bays is carried by wooden cills and sash bars, and in others by cast-iron cills and wrought-iron ⊤ sash bars; these variations in the details of construction, arising out of the fact of using up some of the materials of the old station roof.

The portions of the roofs not covered with glass are covered in with slate resting upon a layer of $1\frac{1}{4}$in. boarding tongued and matched. The roofs are made good against the transverse girders by spacious cast-iron valley gutters, caulked tight with iron cement against the dwarf webs, and the water is discharged from these into the trough of the girders, as already stated, through one or more apertures.*

## R. DUDGEON'S ROLLER TUBE EXPANDER.

It would be difficult to form an estimate of the number of boilers annually injured, if not destroyed, by injudicious tinkering at the ends of the tubes and the tube plates, but that their number is very considerable will be conceded by all experienced engineers. It is well known that when a few tubes in a boiler begin to leak, they are usually caulked, and afterwards, when the boiler is filled with water, other tubes, that before were perfectly tight, are now found to leak in their turn; and thus a constant round of drifting, caulking, and ferruling goes on until the tube plate itself gives way. The little tool, an illustration of which is given below, has been designed by Mr. Dudgeon for the purpose of doing away with drifting and hammering altogether. The method of expanding the tube into the hole in the tube plate by means of rolling out the metal is evidently more correct than hammering, and the principal difficulty that has hitherto been experienced in performing this operation has been in old boilers where the holes in the tube plates were considerably out of their true circular form. In this tool, however, by using only three rollers, it will be evident that holes can be perfectly filled even when they are very far from a true circle, as the rollers can follow up the metal even in an oval hole, which is, of course, impossible when four or more rollers are used. The outside ring, A, can easily be shifted so as to adapt the tool to any thickness of tube plate, and at any time, by simply unscrewing the cap, B, the rollers can be replaced when necessary.



## DAVISS SECTIONAL CENTRE-BOARD.

The great advantages obtained by the use of a centre-board in yachts for racing purposes, and in cargo boats for bar harbours and other places where a light draught is indispensable, are too well known to be here insisted upon. The excessive inconvenience, however, of the usual arrangement has operated as a bar to its general introduction. Yacht owners objected to having the cabins of their vessels cut in half, while the obstruction caused by the water-tight trunk in trading boats prevented the proper stowage of cargo. Mr. Davis, of Boston, U.S., has contrived a very simple and neat way of obviating these disadvantages, by constructing the centre-board in several pieces, fitting into one another, and working on the same pin, so that they can be opened and shut somewhat after the manner of a lady's fan. In the annexed wood cut fig. 1 is a cross section through the vessel and centre-board, showing the centre-board closed, or the position it would assume when not required; fig. 2 is a similar section

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* The whole of the design was matured at the offices of Mr. F. D. Bannister, the engineer of the company, assisted by Mr. H. E. Wallis, to whom the ornamental portions do great credit; and the works were carried out by Mr. Henry Grissell, of the Regent's Canal ironworks.

with the centre-board expanded, or the position it would assume when being used; and fig. 3 is a side elevation, showing the centre-board in section.

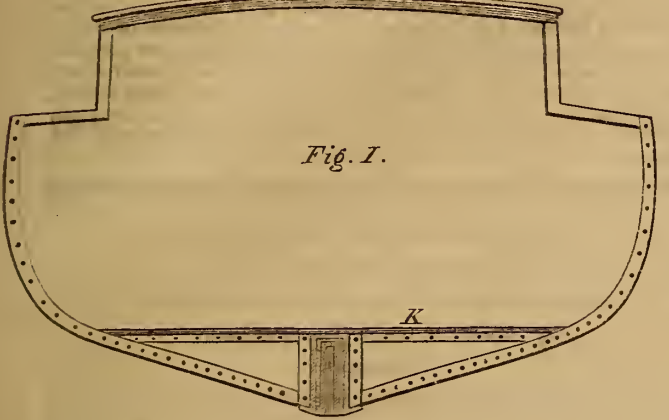
Fig. 1.

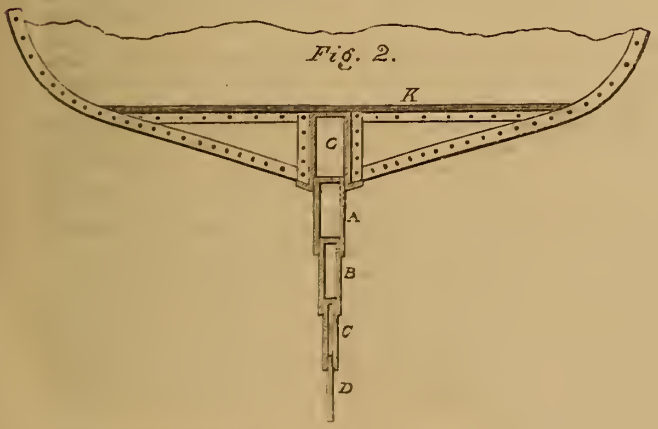
Fig. 2.

In this case it will be seen that a long box, G, is fitted to the bottom of the vessel, open at the under side, and which fulfils the double purpose of kelson and case for the centre-board. The centre-board is composed of four separate leaves, A, B, C, and D, revolving upon the same pin, I, fitted through one end of the box. The lower leaf, D (figs. 2 and 3), is a single plate, and each of the other leaves is comprised of two plates rivetted together with a longitudinal strip between of sufficient width to allow the leaf next below to slide freely therein. To the bottom leaf, D, and at the opposite end to the pin, I, a flat linked chain is attached which passes through holes provided in the other leaves, and is then joined to a common chain passing up a hollow stancheon, H, which may serve the double purpose of supporting the deck and forming a channel through which to raise or lower the centre-board. Upon referring to the drawings it is evident that the cabin of a yacht, or the hold of a cargo boat, is in no way interfered with, nor is the strength of the vessel deteriorated; while, from the position of the centre-board being always below the floor, it takes the place of ballast. It is also said to possess considerable advantages over the old system in the facility with which it is handled, being easily taken up or lowered without luffing into the wind. In America, where centre-boards are in much more general use than upon this side of the Atlantic, this system has been highly spoken of; and, although the yacht clubs in this country prohibit their use for racing purposes, we should not be surprised to find them much more frequently adopted in yachts used for more sensible purposes. For our coasting trade, where vessels are very generally required to draw so little water that their sailing qualities are seriously depreciated, a centre-board would be exceedingly advantageous; while, if the centre-board were made in a sufficient number of sections, it would be advantageously employed to replace the clumsy lee boards of sailing barges and billy boys.

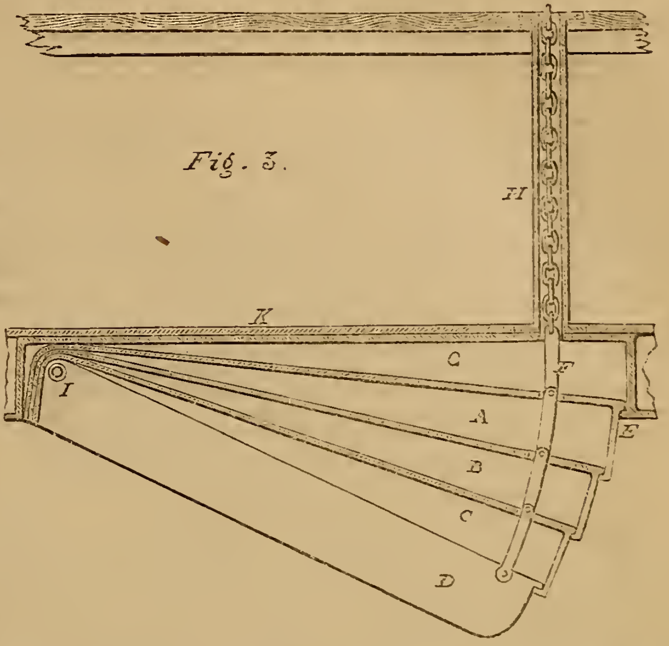
Fig. 3.

## NEW BLACKFRIARS BRIDGE.

The work of bridge building is necessarily a slow one, and is made slower still when the structure to be erected is intended to defy the assaults of time and tide for centuries to come. London-bridge took years to build, and so long was it, in fact, that Southwark-bridge, which was begun after it, was opened first. Waterloo, old Westminster, and old Blackfriars each took their many years to complete, and even new Westminster was, from various and unforeseen causes, so long in coming to maturity, that the public began to disbelieve in its completion altogether. Judged by these standards, therefore, new Blackfriars-bridge has made good progress. It is little more than two years since it was begun, and another year will certainly see it finished—indeed, at a pinch, it might be used as a thoroughfare for passengers as early as next June or July. This is quick work, considering that not only a new bridge had to be built, but an old one to be removed, and the very stumps of its decayed piers rooted out of the bed of the river, before a stone of the new structure could be laid.

The new bridge is to have five arches, and therefore requires four piers and two abutments. The abutments were easy enough built, and built with such tremendous solidity deep into the earth, that they are as little likely to move as the counties on which they rest, Middlesex and Surrey. Building the piers, however, was a much more difficult matter. There are only four of them, but each of these four goes to an average depth of more than 30ft. below the bed of the river. In no case were the foundations of any of these piers commenced till the blue London clay had been reached. Then the concrete was laid, and on the concrete the hardest bricks were set in cement to a thickness of about 10ft. deep, and over this again, up to above high-water mark, comes the granite, deposited in immense blocks, weighing from 5 to 12 tons each, and all firmly keyed together. In some cases the work of sinking these piers was very simple, and mere matters of engineering routine and care; in others, especially the No. 4 pier, the difficulties seemed for a time almost insurmountable. This No. 4 pier is that which is first on the Middlesex side. The caissons were sunk to a depth of 52ft., yet still no good foundations could be found, nor could the water be kept from percolating up through the soil; and it was not till after a great delay and no little expenditure of money that the clay was at last reached. The cause of this extraordinary looseness of the soil was afterwards found to have arisen from an old channel which once formed an entrance to one of the chief tributaries of the Thames—the old River Fleete; or as it was afterwards called from its use, or abuse, Fleet ditch.

All the piers of the new bridge may now be said to be virtually completed—so much so, in fact, that two of the iron arches are already placed and nearly finished. As we have said the bridge is to consist of five arches. The centre one will have a span of 185ft., the two arches immediately adjoining this on either side a span of 175ft. each, while the two smallest shore arches joining the abutments will have a span each of 155ft. The height of the centre arch from the water will be 25ft; the two next arches, 21ft. 6in., and the two shore arches, 17ft. 3in. All the arches will be very flat or elliptical in shape, and will altogether give a waterway more than one-third greater than that afforded by the old structure.

The total length of the new bridge from end to end will be 960ft., or as nearly as possible that of Westminster. Its breadth will be 80ft., or almost exactly double that of the old bridge. The roadway will be 45ft. wide, or 2ft. wider than the whole of the old bridge from outside to outside, and there are to be two pathways, each about 17ft wide. In fact, in space and public convenience, in beauty and in finish, it will surpass even Westminster-bridge, which certainly, up to the present time, enjoys the reputation of being the handsomest structure of its kind in Europe.

Each arch of new Blackfriars will be built of nine massive, wrought-iron ribs, set at a distance of 9ft. 6in. apart. This is a very much greater distance asunder than that at which those of Westminster are placed, but, on the other hand, those of Blackfriars are very much more than twice as strong, being 3ft. 10in. at the crown of the arch, and 4ft. 7in. at the springing. The cross braces between these ribs are of proportionate strength and depth, and are placed at intervals of 17ft. apart. Above these again come what are termed bearers, and bolted over these again will be buckle plates for the roadway. These buckle plates will be thickly coated with asphalte, then a layer of stone rubble, and over all the usual granite paving, such as that on London-bridge. There will be no test used to prove the strength of the bridge before it is open, simply because the sectional area of the wrought iron under each part is ten times in excess of the strain it would have to bear under the most trying exigencies of metropolitan traffic. The gradient of the whole bridge will only be one in 40, a great relief to traffic, when it is remembered that the rise in the old bridge was one in 22.

The junction of the iron arches as they rest on the granite piers will be concealed by a series of columns of polished red granite. There are to be eight of these—one at each side of each stone pier. Each column weighs over 30 tons, is nearly 11ft. high, and 7ft. in diameter. Each also costs more than £800. From their dimensions the width may appear to be too great for their height, but this is not so in fact, as the effect of one erected, though still under cover, on the works at Blackfriars sufficiently proves. Each column is to stand on a richly carved pediment of white Portland stone, and each is to be surmounted by a massive capital, carved in foliage and flowers. Above these capitals will be placed the recesses of the bridge, of which there will be four on each side, so that the somewhat bare and monotonous outline of parapet at Westminster is done away with. These eight recesses are each to be 13ft. wide by 10ft. deep. They will be fitted with plain granite benches, but their outer or river side will be richly carved. The design for the lamp-posts will be very handsome, and in keeping with the character of the whole edifice. The outermost edge of each rib—which will be seen on coming up or going down the river—is also to be very ornamental, and a cornice will run over each arch, so as to connect its decoration with that of the cast-iron parapet above, which will join the stone-work of each recess. The whole outlay on the bridge will scarcely exceed £320,000, or at about £4 the superficial foot.

## AMERICAN ENGINEERING.

### DIMENSIONS OF STEAMERS "BRISTOL" AND "PROVIDENCE."

*Hulls built by W. H. Webb, and Engines by the Etna Iron Works, New York.*

Length at load line, 362ft.; breadth of beam, 48ft. 4in.; depth of hold, 16ft. 6in.; area of immersed section at load draft of 10 feet, 450 square feet; tons, hull, 1,861·87; accommodation, 1,160·33; total, 3,022·2; description of engine, vertical beam (overhead); description of boilers, return fire tubular; diameter of cylinder, 110in.; length of stroke, 12ft.; diameter of water wheel over boards, 28ft. 8in.; length of wheel blades, 12ft.; depth of do., 26 to 33in.; number of do., 24; number of boilers, 3; length of do., 35ft.; breadth of do., 12ft. 7½in.; height of do. exclusive of steam chimney, 12ft. 5in.; number of furnaces, 4 in each; breadth of do., 5ft. 7¾in.; length of grate bars, 7ft. 6in.; number of tubes, above, 128; number of tubes, below, 10; diameter of smoke pipes, two of 70 in.; height of do., 81 feet; draft forward and aft, 10 feet; date of trial, June, 1867; grate surface, 510 square feet; heating surface, 13,850 square feet; consumption of fuel per hour, 7,000lbs.; maximum pressure of steam, 25lbs.; point of cutting off, 5-12; maximum revolutions at above pressure, 18; frames, molded, 17in.; depth of keel, 3in.; independent steam, fire, and bilge pumps; number of bulkheads, 2; intended service, New York to Bristol.

### DIMENSIONS OF STEAMER "NEBRASKA."

*Hull built by Henry Steers, and engine by Etna Iron Works, New York. Owners, North American Steam Ship Company.*

Length on deck, 269ft.; breadth of beam, 40ft.; depth of hold, 19ft.; depth of hold to spar deck, 26ft.; area of immersed section at load draft of 17ft., 600 sq. ft.; description of engine, vertical beam, overhead; do. boilers, horizontal tubular; diameter of cylinder, 81in.; length of stroke, 12ft.; diameter of water wheels over boards, 33ft. 3in.; length of wheel blades, 10ft.; depth of do., 1ft. 10in.; number of do., 26; number of boilers, 2; length of do., 10ft. 10in.; breadth of do., 26ft. 7in.; number of furnaces, 14; breadth of do., 3ft. 2in.; length of grate bars, 6ft. 9in.; number of tubes above, 588 each boiler; internal diameter of do., 2⅞in.; length of do., 6 and 7½ft.; diameter of smoke pipe, 8ft. 4in.; length of do., 63ft. 6in.; date of trial, October, 1867; grate surface, 295 square feet; heating surface, 5,802 square feet; maximum pressure of steam, 25lbs.; point of cutting off, 4ft.; maximum revolutions at above pressure, 19; frames, molded, 18in., sided 16in., 32in. apart from centres, and strapped with diagonal and double laid braces, 4½ by ¾in.; depth of keel, 8in.; independent steam, fire, and bilge pumps, 1; masts, two; rig, brigantine; number of bulkheads, 3; intended service, Panama to San Francisco.

## THE LATE PARIS EXHIBITION.

*(Reports continued.)*

### LIGHTHOUSES AND COAST ILLUMINATORS.

By Captain M. Close (Trinity House).

#### Light-ships.

The objects chiefly aimed at in the construction of these vessels are as follow—namely, that of ensuring as far as possible their permanence of position, especially in stormy weather. The form, therefore, that offers the least resistance to the sea, and thereby the least motion to the vessel, is the one most likely to ensure permanence of position. The best proof that this has been attained is the fact that, of the fifty light-ships that guard the coast of the United Kingdom, there is no record of accident accruing to any ship owing to the absence of a light-ship from her station. The form of hull that ensures easiest riding also affords the best exhibition of the light she carries, and, moreover, tends to reduce the cost of repair, inasmuch as she will strain less than one where the motion is quicker. To ease the rolling as much as possible, rolling-chocks are bolted along the bilge of these vessels. By far the larger portion of these light-ships belong to the Trinity Board. These are all painted red, as in case of accident any one may at a moment's notice have to be substituted for another.

As distinction of character is only second in importance to permanence of position, these vessels are furnished with from one to three masts, each surmounted by a globe 18ft. in circumference. So, should a one-masted light ship have to be suddenly relieved by a three-masted one, the fore and mizen masts are instantly hoisted out; the name, which is that of the shoal she guards, and is painted along two thirds of her side, is changed, and by the time a tug is ready to take her to the required station she is in a condition to proceed there.

The lantern has a strong gun-metal frame, glazed with the best plate glass, the argand lamps in which vary according to the character of the light exhibited. The reflectors are silvered, and, with their oil cisterns, are hung upon gimbles, so as to keep the focus of the flame (no matter what the motion of the vessel is) always in the plane of the horizon. The lantern is kept in a deckhouse during the day, where the keepers trim the lamps and polish the reflectors, and at sunset it is hoisted by a powerful winch into its place on the mast.

A warning-gong, suspended in the fore part of each vessel, is beat during fogs, and each vessel is furnished with two guns to warn ships running into danger, or to be fired as signals of distress at night, in case of a ship getting on the shoal, when rockets are fired in the direction of the stranded ship to point her position out to whatever succour may be sent from the shore. These vessels are furnished with a strong jib and mizen, either for ease in canting to the tide or in case of breaking adrift. The average cost of a light-ship fully equipped (exclusive of stores) is £3,600, and the average cost of maintenance about £1,100 per annum.

France has three light-ships. They are in all respects nearly identical with ours. Two of them are in the roadstead of Dunkerque, both showing red lights, one fixed, the other revolving every thirty seconds. These were first lighted on Nov. 15, 1863. The third light-ship guards a dangerous reef in the Bay of Biscay, in as exposed a position as any of our English vessels. Our method of mooring with heavy iron mushrooms is also in use in France, and their internal arrangements for the accommodation of the crew or the reception of shipwrecked men, as also their oil and other store rooms, are identical with our own.

A model of the light-ship at the Goodwin Sands is exhibited, the planking being omitted on one side so as to show the internal fittings and arrangements. She is three-masted, and shows her lanterns hoisted up for night service. The organisation of the light-ship service round the coast of England is shown in another portion of this report.

The following models are shown in this department :—A model of "apparent light "—a beam of light projected on a beacon from a lighthouse on the shore is reflected and shows the position of the beacon; model of first-class iron beacon; model of electric induction spark for illuminating beacons at sea; model of a first-class holophote revolving, the light which passes above and below the prisms collected into eight horizontal beams; model of a dioptric holophote fixed; model of a dioptric mirror, rendered holophote; a 12in. light-ship reflector; and a catadioptric holophote, with spherical mirror.

The following are models of the lighthouses exhibited :—Bell Rock lighthouse, Kerryvore, Hamois, Skerries (Holyhead), Bishop's Rock, Reculvers, Menai, South Bishop's Rock, Eddystone, Needles, Wolf Rock (in course of erection), Cocket (and dwellings), Smalls (old pile lighthouse), Maplin (iron ditto), and Gunfleet (iron ditto).

The geometric signals are also shown in this department. Each lightship and every rock lighthouse is furnished with a set. These signals can be used when the distance is too great to make out the colours of flags or where there is not wind enough to blow them out.

Photometer by Captain Nisbet (Trinity House).—This instrument has two electro-plated metal tubes, 10in. by 2½in. The tubes are placed over each other, with a sight tube between for observing. The lower tube is glazed at the end, and inside it is a small telescope working like a piston in a stuffing-box, with rack and pinion; a communication between the tubes allows a neutral tinted fluid with which the upper end is charged to flow into the vacuum till its density is sufficient to eclipse the light of a candle; the fluid can be made to represent any condition of the atmosphere from "clear" to "dense fog." A graduated scale on the side of the instrument shows the different degrees of density through which lights can be seen, and by this the comparative value of distant lights are calculated.

### Buoys, &c.

It should be observed that there is a uniform system of buoyage adopted by the Corporation of the Trinity House.

White buoys for many years were used by the Elder Brethren as a distinctive character; but as experience has proved that, under certain conditions of light, white is difficult to be seen, buoys of this colour alone have been entirely abandoned.

There has also been found a difficulty in distinguishing the colours black and red at all times. The Corporation have, therefore, now adopted the following system—viz., the side of the channel to be considered starboard or port with reference to the entrance to any port from seaward.

The entrances of channels or turning points shall be marked with spiral buoys, with staff and globe, triangle, &c.

Single-coloured can buoys, either black or red, will mark the starboard side; and buoys of the same colour, either chequered or vertically striped with white, will mark the port side. Further distinction will be given, when required, by the use of spiral buoys, with or without staff and globe or cage; globes being on the starboard hand and cages on the port.

Where a middle ground exists in a channel, each end of it will be marked by a buoy of the colour in use in that channel, but with annular bands of white, and with or without staff and diamond or triangle, as may be desirable, when required the outer buoy being marked by a diamond and the inner by a triangle.

When a middle ground divides a channel into two, and it is necessary that each should be buoyed, the right-hand channel will have red as the predominating colour, and the left-hand black; each side of the middle ground being marked by buoys proper to it as the side of a channel. The end buoys would be coloured in annular bands, as provided in the preceding paragraph, the outer red and white, the inner black and white.

When a middle ground is passed, and two channels thus buoyed merge into one again, the colour of the right-hand channel shall be continued as if no other existed.

Wrecks will still continue to be marked with green nun buoys.

Should two channels in close proximity to each other require to be marked, the same buoys and same colours may be used, only inverting the buoy—i.e., mooring them in one channel from the apex or small end and in the other from the base.

In the Trinity Board department of class 66, eleven models of different descriptions of buoys are exhibited, either in wood or iron. The total number in use belonging to this Board is about 400, and as these are brought into store, for painting and repairs, every six months (for in that period salt water and exposure destroy their distinctive character) it is necessary to have the same number of duplicate buoys to replace those brought in. This buoy-shifting, which takes place twice in the year, is one of the most arduous duties the Trinity steamers, as a rule, have to perform, seeing that these buoys for the most part mark dangerous shoals, and the change is effected at times, and frequently under circumstances, of considerable difficulty. Iron has of late years superseded wood in the manufacture of buoys, as being more durable and buoyant. The following diagrams of wooden buoys will explain their difference in form—viz., first, the wreck buoy, always painted green, with "Wreck" in white on the upper portion of it; next, the can buoy—these are black, with the name in large white letters on the flat exposed surface; then the "can" reversed—this was intended not merely as a distinction, but to render the buoy more visible, three iron legs being fixed to a strong hoop round the lower part of the buoy and the moorings atached to a ring where these meet, the buoy exposes a much larger surface above water than before. These buoys are much used, and painted in every variety of way to indicate the different shoals they mark—*i.e.*, checked and ring stripes horizontal and vertical, &c.

The iron buoys are those most deserving notice in the small space afforded for the subject here. These vary in size from 9ft. to 20ft. The latter, which are termed "monster" buoys, guard dangerous shoals, where the traffic is great, such as the back of the Goodwin Sands, &c.; they are built of wrought-iron plates, riveted on a strong iron frame, the lower portion of which is divided into water-tight compartments. The "egg"-shaped or "water-ballast" buoys are those which retain their upright position best under all circumstances of high sea, wind and tide, &c.

Herbert's buoy is much the same in appearance afloat, but is the inverse of the "egg" buoy, the base of it being an inverted cone. The idea is that the sea striking the inside of the cone, opposite to the outside struck by the same wave, would counteract the effect of the outer blow and keep the buoy in its position, and that the mooring-ring, being nearer the centre of gravity, would tend to lessen the motion of the buoy. Neither of these positions has resulted in practice; and, though the buoy is a conspicuous one, the hold offered to the wave by the hollow cone, in a monster buoy, brings a greater strain on the moorings than in the egg-shaped one.

The bell buoy is the only one now to be noticed. Either of the above buoys cut down to where the ring-fender is fixed, and decked over so as to be water-tight, and a light iron framing substituted for its original one (thus preserving the form of buoy), constitutes the frame for a bell-buoy. A bell being fixed in the centre of this frame with four clappers hung from the apex, and having a guide-rod to ensure their striking the bell, every movement it makes will cause one or other of the clappers to strike the bell, and thus a continuous ringing is maintained, while the sea washes over the deck of the buoy beneath the bell. The bell is a fixture, the clappers hanging loose.

The distinctive character given to the monster buoys is not merely in their colour, but also in the form, of the beacons that surmount them, which are as follows, globe; diamond; cage; triangle; triangle inverted. These are so constructed so as to show their form from every point of the compass.

### Hydraulic Lift Graving Dock.

Model of "Hydraulic Lift Graving Dock" (11), by Edwin Clark, 24, Great George-street, Westminster, London. This lift is a direct mechanical appliance for raising vessels completely out of the water by means of hydraulic presses. It consists of two rows of cast-iron columns, 60ft apart; in each row there are sixteen columns, 20ft. apart, each column inclosing a hydraulic press, of 10in. diameter, and 25ft. length of stroke. Between each pair of columns, extending entirely across the dock, are suspended girders, lying at the bottom of the water when the presses are lowered, but rising above the surface when the presses are raised, forming a large wrought-iron platform or gridiron, which may be raised or lowered at pleasure, with a vessel upon it. The lifting power of each press amounts to 200 tons, or 6,400 tons for the whole lift. The girders are designed for carrying the vessel as a load at the centre, although the load is distributed by a pontoon beneath the ship, and the wide base used for the blocks. The raising of a vessel occupies about twenty-five minutes, and is effected as follows :—An open pontoon, proportioned to the size of the vessel, with keel blocks and sliding bilge-blocks adapted to her shape, is placed on the girders and sunk with them to the bottom. The vessel is then brought between the columns and moored securely over the centre of the pontoon. By lifting the girders, the keel blocks are first brought to bear under the keel of the vessel; the side blocks are then hauled in, and the gridiron and pontoon, with the vessel upon it, is raised clear out of the water. The pontoon by means of valves empties itself into the water; the valves are then closed, the girders again lowered to the bottom, leaving the pontoon with the vessel upon it afloat.

Thus, in about thirty minutes, a vessel drawing 18ft. of water is left afloat on a shallow pontoon drawing only 4ft. 6in., and may be taken into the shallow dock prepared for its reception.

The principal features of this system may be summed up as follows :—

1. Its economy, as well in its first construction as in its subsequent maintenance.

2. Its adaptability to almost any situation, especially in harbour or tideless seas.

3. The capability of almost indefinite extension, by the construction of additional pontoons, or, as regards the lift, by the addition of extra columns.

4. The simple and durable character of all its parts and their perfect accessibility.

5. The short time required for its construction and erection.

6. The rapidity of its manipulation and the small staff required.

7. The convenient access afforded to all parts of the ship, and especially in painting iron ships; and their free exposure to light and air.

8. The freedom from strain with which vessels, even in cargo, may be docked.

9. The means afforded of rendering any area of shallow water available as a dock for the largest vessels.

### Life-Boats and Boat Lowering Apparatus.

Collapsing life-boats, invented by the Rev. L. Berthon, M.A., &c. These boats are constructed of a framework of wood arranged in a longitudinal direction, consisting of a number of flat segmental timbers hinged together at the tops of the stem and stern-posts. These timbers, when opened out, extend two skins of an extremely strong, flexible material, one of which is attached to their outer edges and the other to the inner, thus not only completing the form of the boat but dividing the whole body into as many separate air spaces as there are intervals between the timbers. The edges of the timbers are furnished with bands of iron outside the skins to defend them at these salient points. The expansion of the boat by its own weight is kept up by the bottom boards, thwarts, and certain gunwale supports, all of which are jointed. The advantages of those boats are the following:

1. Being collapsible, they stow in less than one-fifth of their breadth.

2. Very large boats are capable of being stowed "outboard" against the bulwarks or nettings, ready to expand or lower at any moment.

3. They may be quite supplementary to the ordinary boats of a ship, not interfering with such arrangements, and can be lowered from the same davits.

4. They are insubmergible, and have proved themselves excellent sea-boats in all weathers. The largest yet made would carry nearly 300 persons.

Wood and Rogers's patent boat lowering, suspending, and detaching apparatus is shown in the Trinity House department of class 66. The boat is suspended from four points at the sides and not, as usually, from two central points; this method prevents the possibility of its canting while hanging to the davits or during the time of lowering.

Clifford's Boat-lowering Apparatus.—This plan of boat-lowering is now so thoroughly known and appreciated that upwards of 2,000 have been fitted on Mr. Clifford's principle. The boat is lowered by one of the crew in the boat itself, who, from the perfect ease and safety with which the lowering gear detaches itself, can at any convenient instant drop the boat into the water perfectly free of all tackle and while the ship's way is unchecked. Many lives have been rescued by the rapidity with which succour has been thus despatched to them.

### Steering Apparatus.

Money Wigram and Sons' arrangement of steering, planned with a view to remove the steering compasses from the stern of a ship at which point the magnetic current acts strongest on the compasses. The tiller is placed athwartships, and fitted with a travelling collar, having on its lower side a nut working in fore and aft guides on a horizontal fixed screw, the shaft of the screw being continued under the deck beams to below the steering wheel. An endless chain working on two pitched wheels, one on the wheel and one on the shaft, communicates motion to the screw. This chain may be carried either direct down from the wheel and over directing pullies, or, if it is required to gain speed or power, motion may be communicated by working the chain on increasing or diminishing geared wheels.

To obviate the wear caused to screw steering gear by the continued shaking of the rudder, the head of the main piece of the rudder is in two lengths; each length having one part of a clutch-box forged on or keyed to it. Each part of the clutch-box has four projecting segments, so arranged that when the clutch-box is placed in contact these segments come at the degrees of the circle, the space between the segments being filled in with blocks of indiarubber. The clutch-box is held together by bolts and nuts, which, though fast in the lower portion, do not fit tight in the upper, and admit of sufficient play for the indiarubber blocks to receive the blow caused by the sea, and thus prevent the constant wear and injury to the screw and nut.

Lumley's patent rudder is in shape and form the same as the old rudder, but is divided vertically into two pieces, the "body" and the "tail" which are hinged, jointed, or articulated together by pintles and braces; the result is, that in putting the helm over either way a self-acting increased movement is given to the "tail," giving increased effect to the power the ordinary rudder exerts on the ship. It is said collisions have been avoided by the increased handiness thus given to a vessel.

### Galleys and Cooking Apparatus.

Benham and Sons, of Wigmore-street, London, exhibit half a dozen models of various ships' cooking apparatus, which they have fitted in passenger-vessels for the Peninsula and Oriental and Royal Mail Steam-Packet Companies, and and in the new Indian troop-ships, and other ships of the Royal Navy. There are several varieties of form and arrangement; but the leading features in all are the same, and in all the same advantages appear to have been secured, which are of special importance on board ship—viz., compact bulk, external coolness, simplicity of management, and economy of fuel.

The most novel arrangement is seen in their circular apparatus, of a pattern which is in use in the new West India Mail steamers, and which consists of two roasting-ovens, two pastry-ovens, two hot closets, a broiling-gridiron, a large hotplate, a steam and hot-water boiler, four steam-kettles, two bainmain pans, a rack-shelf for saucepans, &c., two furnaces, &c., all within a diameter of 7ft., yet capable of cooking for 300 or more saloon passengers, and baking all their bread and pastry. There are, of course, guard rails to steady the stew-pans, and there is also a guttered edge to the hotplate, to prevent overflows from a sudden lurch of the ship. The oven doors are curved, and slide in grooves; there are catches to secure them in in their places; there is a water-guage to show the level in the boiler, and all necessary arrangements of soot-doors and dampers for the cleansing of the flues and the complete control of the draught. The fuel consumption is said to be very moderate, and the radiation of heat surprisingly small.

The next apparatus in importance and bulk is the troop fire-hearth for the navy, pattern, E. This of oblong form, and has its furnaces at the front and back, the sides being protected by wood casings; so that all radiation is effectually prevented. It consists of three very large iron boilers for meat, soup, tea, cocoa, &c., capable of cooking for 1,400 men, and with large draw-off cocks for filling the soup-pails; six long iron ovens, shaped like gas retorts, and two large side ovens; the eight being capable of baking 900lb. of bread, or, by opening a valve, of roasting the meat rations for 800 men; also a large hotplate for boiling, stewing, frying, &c., with two large ovens under it for baking or roasting; these latter being appropriated to the use of the non-commissioned officers, the married men, and the invalids; the whole apparatus is put together in three sections, so that either of them may be disused for repairs, without interfering with the full action of the others. The management is perfectly simple, and the fuel consumption very small for the work performed. The fire-hearth represented by the model is the size recently fitted in H.M.S *Himalaya* and the five new troop-ships for the Indian service; but smaller ones have been in use for some time in H.M.S. *Asia* and *Hector*; and one previously in the *Emerald*, now out of commission, has been refitted in the *Phœbe*.

Of the remaining models two represent the officers' apparatus and the crews apparatus, as fitted in the same ships; and a third the saloon apparatus fitted in several ships of the Peninsula and Oriental Company. All alike have ovens for baking and roasting, efficient boilers and roomy hotplates, and the latter has, in addition steam-kettles for vegetables, fish, &c. All are very compact and handy, and in all the two essential points of coolness and economy of fuel have been well secured.

### Miscellaneous.

The following objects of interest are exhibited by England in class 66:—Model of floating dock for ships of 4,800 tons, bought by France and sent to Saigon, in China, 300ft. long, 94ft. broad, and 27ft. deep, by Randolph, Elder and Co. One for ships of 10,000 tons; dimensions, 432ft. long, 110ft. broad, and 53ft deep. One in operation at Bermuda. Patent fuel economiser for using the waste heat from steam-boiler, a saving of 25 per cent of fuel, by Edward Green and Son, Manchester. Lenses for ship-lights, by Wilkins, London. Side-lights for ships used by the Trinity steamers, economical and of great power, having dioptric lenses in lieu of bull's-eyes, by Wilkins. Model of Sunderland harbour and docks, Thomas Meck, Esq., engineer, showing the harbours and basins of Sunderland, with their various entrances, &c. Life-raft built in 1850 (presented by Captain F. B. Williams) by Richardson. Life-raft forming a portion of the waist of a ship, and therefore taking up no room for carriage. It is detached instantaneously, leaving an open space for the crew to escape. The raft carries a sail and compartments for food and water, and is very simple and buoyant, by Hurst. Models of ships, by Laird Brothers, of Birkenhead, beautifully executed. Some fine models of ships by Samuda Brothers. Models of ships by Randolph, Elder and Co., Glasgow. Models of engines by Humphreys, of London.

A new Steering Compass (5) by John Lilly and Son, of London, entirely differs from others, as the needles only are placed in a vessel containing liquid which will not freeze at ordinary temperatures, and the indicating card is placed on the upper part of the compass bowl, thus avoiding any discolouration from the action of the spirit. It is fitted with a simple lifting apparatus, so that when not in use the needles and card can be raised from the point and thus very much preserved; and it is so constructed that it is perfectly steady in bad weather and exceedingly sensitive in smooth water.

A screw propeller for shallow water, the flanges or blades having the action of a man's arms and hands in swimming. It is ingenious, and the experiments made with it give reason to believe that, if perfected, the invention may prove extremely valuable for the navigation of shallow rivers Invented by Peter Nolan, of 51, Newman-street, Oxford-street.

## INSTITUTION OF CIVIL ENGINEERS.

### SUBJECTS FOR PREMIUMS.

### Session 1867-68.

The Council of the Institution of Civil Engineers invite communications on the subjects comprised in the following list, as well as upon others; such as 1° Authentic Details of the Progress of any Work in Civil Engineering, as far as absolutely executed (Smeaton's Account of the Eddystone Lighthouse may be taken as an example); 2° Descriptions of Engines and Machines of various kinds; or 3° Practical Essays on Subjects connected with Engineering, as, for instance, Metallurgy. For approved original communications, the Council will be prepared to award the premiums arising out of special funds devoted for the purpose.

The Council will be glad to receive, for the purpose of forming an "Appendix" to the Minutes of Proceedings, the details and results of any experiments, or observations, on subjects connected with engineering science, or practice.

1. On the theory and details of construction of metal and timber arches.
2. On landslips, with the best means of preventing or arresting them, with examples.
3. On the principles to be observed in laying-out lines of railway through mountainous countries, with examples of their application in the Alps, the Pyrenees, the Indian Ghauts, the Rocky Mountains of America, and similar cases.
4. On railway ferries, or the transmission of railway trains entire across rivers, estuaries, &c.
5. On the pneumatic system for the conveyance of passengers and goods.
6. On the systems of fixed signals at present in use on railways.
7. On the most suitable materials for, and the best mode of formation of the surfaces of the streets of large towns.
8. On the construction of catch-water reservoirs in mountain districts, for the supply of towns, or for irrigation, or manufacturing purposes.
9. Accounts of existing waterworks, including the source of supply, a description of the different modes of collecting and filtering, the distribution throughout the streets of towns, and the general practical results.
10. On the benefits and expedients of irrigation in India and in other warm climates; and on the proper construction of irrigating canals, so as to avoid erosion or silting, and to prevent the growth of weeds.
11. On the best mode of deodorising and filtering, or otherwise of precipitating sewage, and of applying it to the land.
12. On the ventilation of sewers.
13. On the ventilation and warming of public buildings.
14. On the best means of manufacturing gas of high illuminating power; and on the construction of gas works, the most economical system of distribution of gas, and the best modes of illumination in streets and buildings.
15. A history of any fresh water channel, tidal river, or estuary, accompanied by plans and longitudinal and cross sections of the same, at various periods, showing the alterations in its condition, including notices of any works which may have been executed upon it, and of the effects of the works, particularly of the relative value of tidal and fresh water, of the effect of enclosures from the tidal area upon the general regime, of sluicing where applied to the improvement of the entrance or the removal of a bar, and of groynes, or parallel training walls. Also of dredging, with a description of the machinery employed, and the cost of raising and depositing the material.
16. On the construction of tidal or other dams, in a constant or variable depth of water; and on the use of wrought iron in their construction.
17. On the arrangement and construction of floating landing stages, for passenger and other traffic, with existing examples.
18. On the different systems of swing, lifting, and other opening bridges, with existing examples.
19. On the construction of lighthouses, their machinery and lighting apparatus; with notices of the methods in use for distinguishing the different lights.
20. On the measure of resistance to bodies passing through water at high velocities.
21. On ships of war, with regard to their armour, ordnance, mode of propulsion, and machinery.
22. On the measures to be adopted for protecting iron ships from corrosion.
23. On the construction and performance of turbines of all classes.
24. On the comparative cost of conveying coals by railways and by screw colliers.
25. On the present systems of smelting iron ores; of the conversion of cast-iron into the malleable state, and of the manufacture of iron generally, comprising the distribution and management of iron works.
26. On the manufacture of iron for rails and wheel tires, having special reference to the increased capability of resisting lamination and abrasion; and accounts of the machinery required for rolling heavy rails, shafts, and bars of iron of large sectional area.
27. On the Bessemer and other processes of steel making; on the present state of the steel manufature on the Continent of Europe; and on the employment of castings in steel for railway wheels and other objects.
28. On the use of steel for the tires and cranked axles of locomotive engines; especially with reference to its durability and the cost of repairs, as compared with iron of acknowledged good quality; and on the use of steel bars and plates generally in engine-work and machinery, for boilers and for shipbuilding, as well as for bridges.
29. On the safe working strength of iron and steel, including the results of experiments on the elastic limit of long bars of iron, and on the rate of decay by rusting, &c., and under prolonged strains.
30. On the present state of submarine telegraphy, and on the transmission of electrical signals through submarine cables.
31. On the present relative position of English and Continental engineering manufactories, especially with reference to their comparative positions in respect of the cost, and the character of the work produced.

The Council will not consider themselves bound to award any premium, should the communication not be of adequate merit, but they will award more than one premium should there be several communications on the same subject deserving this mark of distinction. It is to be understood that, in awarding the premiums no distinction is made, whether the communication has been received from a member, or an associate of the institution, or from any other person, whether a native or a foreigner.

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## ON THE RELATION OF THE FRESH-WATER FLOODS OF RIVERS AND STREAMS, TO THE AREAS AND PHYSICAL FEATURES OF THEIR BASINS; AND ON A METHOD OF CLASSIFYING RIVERS AND STREAMS, WITH REFERENCE TO THE MAGNITUDE OF THEIR FLOODS—PROPOSED AS A MEANS OF FACILITATING THE INVESTIGATION OF THE LAWS OF DRAINAGE.

By Lieut.-Col. P. P. L. O'Connell, R.E., Assoc. Inst. C.E.

After referring to what might be termed the first stage of natural surface drainage, subsequently carried on and completed by rills, streams and rivers, the author observed that streams draining large areas were not subject to sudden floods caused by short smart showers, and that a lake, like the extension of the area of a drainage basin, was a moderator of the flood discharge, resulting from a given rate of rainfall. There were other natural moderators which were more or less effective, as, for instance, a porous, absorbent soil, and the foliage of dense forests, but the latter had apparently the property, in some situations, of increasing the actual amount of rainfall, which counterbalanced its effect as a moderator of river floods. Snow might, according as it thawed slowly or rapidly, be a moderator or the reverse. Again, when a tributary in flood flowed into a large main river, the channel of the latter also acted as a moderator. If a series of natural basins could be found, increasing regularly in area, having physical features as to slope, soil, &c., all tending in the same degree to discharge the rain falling on them, and if the distribution of the rain were the same in all these basins, then, doubtless the rate of discharge in floods might be described graphically by some regular curve, the abscissæ of which would denote the area drained, and the ordinates the flood discharge per second. This curve would be concave to its base, and the tangent at its origin would have a value representing exactly the maximum rate of rainfall. Such, however, were the diversities of physical features in river basins, and in the distribution of rainfall in the world, that the search after the desired series of natural basins possessing exactly similar characteristics would probably be a vain one. This was to be regretted, for rivers small and great might alike be referred to some such curve, and classified as flood dischargers, according as they took up positions near to or distant from the curve.

To supply the place, as a classifier, of this unknown curve, the author suggested the use of the common parabola, as follows: Let $x$, the abscissa of a point in the curve, represent the area in square miles drained by a river, and $y$, the ordinate of the same point, represent the number of cubic yards discharged per second by that river. Then, in the common parabola, $y = M. \sqrt{x}$, where M might be termed the modulus of the river, or of its drainage basin, as a flood producer. When M was large, it would indicate that the physical features were were such as to slope, soil, total amount and distribution of rainfall, as to give the river and its drainage basin a high place in the classification. When M was small, it would, on the contrary, show either that but little rain fell on the basin, or that it possessed some of those physical features which tended to moderate floods.

With the view of illustrating how far this method of classifying rivers as flood producers was likely to prove useful, reference was made to some facts respecting the Mississippi and its tributaries, as recorded in the report on that river, by Capt. Humphreys and Lieut. Abbot, which tended to show, in the author's opinion, that the method might be usefully, it cautiously, applied.

Certain exceptional cases of river floods were next alluded to, and regret was expressed, that data sufficiently extensive and accurate for the purpose of testing very rigidly any method of classification had not yet been collected. The author had, however, prepared a table, exhibiting a few of the physical features of some of the principal rivers of North America, Europe, and India. This table gave the area of the drainage basin of each river in English square miles, the flood discharge of the river in cubic yards per second, with the name of the authority for this statement, the flood discharge of the river in cubic yards per second per square mile drained, and the values of M in each case. The facts so collected were also exhibited in diagrams. After commenting upon the range in the values of M thus recorded, it was observed, that whereas, in the case of large rivers, the parabola expressive of the relation between the area drained and the discharge per second might, without sensible error, be supposed to have its apex situated at the origin of the co-ordinates, in the case of small districts this supposition would lead to error. In the latter instance it became necessary to ascertain, at least approximately, what was the maximum rate at which rain fell in the district, and to place the origin of the co-ordinate at a point in the curve where the inclination of the tangent to the axis of $x$ should correctly represent that maximum rate.

For the sake of illustration, it was assumed, that a district existed in which the maximum rate of rainfall was 5in. an hour, and the maximum value of the modulus M was 20. This required that the origin of the co-ordinates should be situated at a point in the parabola where its geometrical tangent was inclined to the axis of $x$, at an angle whose trigonometrical tangent was 120. If $x'$ and $y'$ were the rectangular co-ordinates of the curve, measured from this point, its equation was $y' = 20\sqrt{x' - \frac{y'}{120}}$, the areas being measured in square miles, and the discharges in cubic yards per second. But as, for small districts, it would be more convenient to measure the areas in acres, and the discharge in cubic feet per second, the formula became, when adapted to these new measurements, $y' = 21{\cdot}4\sqrt{x' - \frac{y'}{5}}$ very nearly, or after the solution of this quadratic equation, $y' = -45.796 + \sqrt{2097.28 + 457.96\,x'}$.

A table, computed by this formula, was then given, showing the discharge in cubic feet per second from districts increasing in size from 10 acres to 5 square miles; and it was stated, while the discharge from an area of 10 acres represented a rainfal of 3.56 inches an hour, that from a district having an area of 5 square miles represented a rainfall of only .36 of an inch. It was stated, that in rivers whose basins were by no means small, very extraordinary floods might occur in years not remarkable for large totals of rainfall; and in conclusion a few statements and quotations were given, as affording examples of flood moderators.

## FLOODS IN THE NERBUDDA VALLEY: WITH REMARKS ON MONSOON FLOODS IN INDIA GENERALLY

By Mr. A. C. Howden, Assoc. Inst. C.E.

This valley was described as being bounded on the north by the Vindhya and on the south by the Santpoora ranges of mountains, and as consisting principally of black cotton soil, which was renowned for its fertility. The drainage of the valley supplied nearly the whole volume of the waters of the Nerbudda River, which traversed it in a direction nearly due east and west. The river took its rise in the Vindhya Mountains, at an elevation of 3,500ft. above the sea; its fall to Jubbulpore, 190 miles distant, was 10ft. per mile, and thence to the Gulf of Cambay, the fall might be estimated at about 2ft. per mile, the total length of the river being 800 miles. The width at its source was only 1 yard, while a little above its confluence with the Towah, 360 miles down stream, it was 900 yards, and at its mouth upwards of 1 mile. In an ordinary monsoon the level of the water rose between 30 and 40ft., but it had been known to rise nearly 60ft., when it overflowed the banks. Midway between the river and the Sautpoora Mountains, this valley for a length of about 270 miles was traversed by the north-eastern extension of the Great Indian Peninsula Railway, which crossed all the tributaries falling into the river on its southern bank; and it was the floods to which these feeders were liable that formed the subject of the present paper.

The floods of this region were divisible into two classes, according as they affected the plains, or the rivers. With regard to the former, it was remarked that the greater part of the Nerbudda Valley traversed by the railway was almost a level plain; and that although the average rainfall in the district, 46in., or 11½in. for each of the four monsoon months from June to September, could easily be provided for by the natural watercourses, yet that as much as 10.50in. fell in eighteen hours, in August, 1864, causing sudden and disastrous floods. It was observed that, in constructing a railway across plains of this description, great attention should be paid to the rainfall of the district, and ample provision should be made for carrying off the maximum amount speedily, without allowing it to dam up; as few embankments (especially those formed of black soil) could withstand the immense pressure then brought upon them, although the period of danger might not exceed twelve hours during the year, and should an opening once be formed, the scour was such that the embankment speedily melted away.

The principal rivers crossed by the railway in the Nerbudda Valley from Bhere to Bagra, a distance of 100 miles, were the Towah, Gungal, Matchock, Karlee Matchock, and the Suktha or Chota Towah, besides the Sconce Jamnee, Hurda, and other nullahs. The greatest flood known for ten or fourteen years, or according to native report for thirty years, occurred in 1864, when, on the 15th of August, the River Towah rose 47ft. in a few hours; and it was estimated that the velocity at the surface was 16.58ft. per second, the fall 4.25ft. per mile, and the discharge 976,629 cubic feet per minute. It had been asserted that the flood of 1864 was an unusual one, but that of 1865 was of a similar character; while the flood of 1866 exceeded its predecessors, both in force and magnitude. The next important river was the Gungal, the highest known flood in which took place on the 22nd of July, 1864, when with a fall of 3ft. per mile, the mean velocity from calculation being 166.14in. per second, the discharge amounted to 732,123 cubic feet per minute. Two subsequent floods occurred in this river on the 8th and the 29th of August, 1866, and then, the fall being as before 3ft. per mile, the mean velocities were found to be from observation 153,68 and 110.22 inches per second respectively, the relative discharges being 477,820 and 109,494 cubic feet per second. Some idea of the force of the current in Indian rivers on such occasions might be gathered from the fact, that in a comparatively small river, 30ft. plate-girders had been carried seven miles down stream; while, in 1866, masses of masonry weighing 1,600 tons and 1,000 tons had been washed away from two of the piers of the Towah Viaduct, without a single stone being recovered.

In conclusion, the author expressed the opinion that, in bridging rivers of the description referred to, in the first place, wide spans were indispensable; for the current was so swift, and the rise of water so rapid, after a heavy fall of rain, that any contraction of the waterway caused a dangerous scour and backing up. Secondly, he thought that next in importance to having as few piers as possible, was the necessity of giving them the greatest strength, by building them of solid block in course, set in cement. Thirdly, that the face of the cutwaters of piers should always be tool-dressed to reduce the friction, the "bush" frequently left on forming an obstruction. And, fourthly, that when rubble backing was used, care should be taken in suspending work, to finish off below high-water level with a bed of solid block in course, as otherwise the water would penetrate the work, and speedily blow up the pier.

At the monthly ballot, the following candidates were ballotted for and duly elected, as Members—John Wolfe Barry, James Craig, Charles Henry Denham, and David Reid Edgeworth; and, as Associates—Fritz Bernard Behr, Richard Broome, William Henry Cock, Frederick Charles Danvers, Edwin William De Rusett, Charles William Dixon, William Frederick Faviell, Alfred Francis John Fisher, John Henry Greener, Capt. John Tunstall Haverfield, R.M.L.I., Capt. William Robert Johnson, M.S.C., James Ouchterlony Macdonald, Thomas Boustead Nelson, Alfred Richard Cecil Selwyn, Lionel Henry Shirley, Arthur Telford Simpson, Henry Edward Thornton, and Thomas Walker.

A report was brought up from the Council stating that, under the provisions of Section IV. of the By-Laws, the following candidates had been admitted since the last announcement Students of the Institution:—John Hopwood Blake, Joseph Cash, Raymond Edmiston, Malcolm Graham, Charles Edward Jones, James Verchild Ley, Morton Kelsall Peto, William Herbert Peto, Charles Edward Robinson, Arthur Toulmin Smith, Edward Herbert Stone, and Frank Napier Thorowgood.

## INSTITUTION OF MECHANICAL ENGINEERS.

### ANNIVERSARY MEETING.

The twenty-first anniversary meeting of the members of the above institution was held at Birmingham on Thursday, the 30th of January, in the lecture-room of the Midland Institute, Sampson Lloyd, Esq, Vice President, in the chair.

Mr. W. P. Marshall having read the minutes of the previous meeting, the annual report of the council was then presented, which showed that the institution was in a highly prosperous condition, with a large increase in the number of its members. Reference was also made to the large and important meeting of the institution, which was held in Paris last summer, during the period of the International Exhibition. The annual election of officers took place, and John Penn, Esq., was elected president; after which several new members were elected.

The first paper read was by Sir William G. Armstrong "On the transmission of Power by Water pressure, with the application to Railway Goods Stations, Forge and Foundry Cranes, and Blast Furnace Hoists." In this paper a description was given of the method of transmitting the power obtained by water-pressure, by means of the accumulator, which also acts as a reservoir, always supplying an equal or nearly equal force. The accumulator permits of the engine which works the force-pumps being run more constantly, and also can be made to regulate the engine, according to the amount of water stored within it. The load generally used is such as to produce a pressure of 700lbs. per square inch, and, from the accumulator, the water is conveyed by pipes to the various points at which the power is required. The water thus conveyed takes the place of shafting, over which it possesses the great advantage of being used intermittently, and with any required variation of power. The absence of elasticity in water gives it great steadiness of motion, but at the same time necessitates the adoption of relief-valves, consisting of small clacks opening against the pressure in the supply-pipes, and yielding to the back pressure on the piston, if it exceeds the pressure in the accumulator.

In the Victoria and many other docks, water-power is used to open and shut the gates, swing bridges and sluices, and also for hauling vessels through the locks, discharging their cargoes, and lifting those cargoes into the warehouses. At the Goole Docks a very novel arrangement is at work for the purpose of shipping coals; the coal barges are floated into a cradle, and lifted up bodily a sufficient height, and then turned over; the coals being delivered into a shoot and thence into the ship's hold.

Water-pressure cranes are now in use at the Paris and Lyons railway-station in Paris, where there are also hydraulic capstans for hauling the goods-waggons into any desired position. Most of these cranes, besides lifting by water, are also turned by the same power by means of a chain passing round a horizontal wheel, which is worked by a pair of horizontal presses. The valves for lifting, and also for turning, are slide valves, worked by a hand lever. Some of the cranes have two powers, the cylinder being provided with a piston and a ram; the smaller power being obtained by admitting the water on both sides of the piston, which therefore acts only upon the ram, and the higher power is obtained by causing the water-pressure to act upon one side only of the piston. The simplest and cheapest form of crane is when the crane-post is made to serve for the cylinder, the crane chain being hauled directly into it.

Water-pressure is also employed at the writer's works, at Elswick, for working the foundry and forge cranes; the lifting-press and the pair of turning-presses being placed in a horizontal position below the floor. The lifting-chain passes over pulleys on a traversing carriage, which runs upon the top of the horizontal crane-jib, and is hauled outwards or inwards by the action of a pair of presses fitted to the pillar of the crane; by which means very heavy forgings are manipulated under the steam hammer with the greatest facility and precision.

Another application of water-pressure has been successfully adopted for working hoists for raising the material for charging blast-furnaces. In this case two cages are connected by a rope passing over a pulley so as to counterbalance one another, and are worked by a pair of presses fixed vertically to the framework of the hoist; the water-pressure being regulated by a single valve, so that while the water is admitted into one cylinder, it is likewise allowed to escape from the other. This arrangement admits of working at an increased velocity, and enables the supply to be kept up to the requirements of the present larger and higher blast furnaces.

The second paper read was "On the Allen Engine and Governor," by Mr. Charles T. Porter, of Manchester. In designing this engine, the object aimed at has been to obtain the greatest economy in working the steam expansively, by having the full pressure in the cylinder at the commencement of the stroke with a quick cut off without wire-drawing, although the slide-valve is worked with a direct continuous motion, instead of a liberating and disconnecting valve gear; also to keep an invariable exhaust with any degree of expansion. This arrangement admits of the engine being worked at the unusually high speed of piston of 600ft. to 800ft. per minute with complete steadiness, which also gives great uniformity in the driving power throughout the revolution; as the inertia at that speed compensates for the variation of pressure in the cylinder. The engine has a single horizontal steam cylinder, and the air-pump is worked direct from the piston-rod, which is prolonged through the bottom cylinder cover. There are two separate steam slide-valves, one for each port, both in equilibrium, worked by independent motions; the motion of one valve being greatly accelerated, so as to effect a quick cut-off, at the same time that the other is proportionately retarded. There are also two exhaust slide-valves which are fitted to the same valve-rod, and consequently move together. The valves are all worked by a single excentric, the strap of which has formed upon it a curved slot, corresponding to an ordinary expansion link, and from the sliding-block in this slot the two steam-valves are worked, while the exhaust-valves are fixed in the usual manner. The position of the sliding-block in the slot of the excentric is adjusted by a lever actuated by the governor, which thus regulates the speed of the engine by varying the degree of expansion instead of the usual method of working a throttle-valve in the steam-pipe. The air-pump is in the lower part of a cubical box filled with water, the valves being all on the top, so that the air entering through the inlet passes at once to the outlet valves without being mixed with the water in which the plunger is working. The valves, which are of vulcanised india-rubber, have a light spiral spring behind them, to afford the necessary quickness in shutting, as they have to open and close 200 times per minute at at the high speed at which the engine is worked. The governor is a modification of the ordinary Watt's centrifugal governor, designed for the purpose of increasing its sensitiveness and quickness of action. The balls are very much lighter, to correspond with a much higher speed of revolution, and the connection of the radius rods to the govenor spindle is made with forked ends, having considerable width in the fork, and fitting upon a pin which passes through the axis of rotation, whereby the friction at the joints that opposes the rise and fall of the balls is much reduced. The balls in rising pull up a heavy weight, which slides upon the centre spindle. It is found that the sensitiveness of this description of governor is so great that the variation in the speed of the engine is regulated to within a range of only two per cent. when under extreme variation of load; while a variation of only five per cent. would carry the governor through its entire range of action. In practice the steam-pipe valve is always set full open, and the engine runs under all circumstances with great steadiness and uniformity of motion without requiring attention. One of these engines was worked at the late Paris Exhibition at the speed of 200 revolutions per minute, or 800ft. per minute speed of piston; and other engines have been running for some time at various works in Manchester, one at the above speed and the others at 600ft. per minute.

It was announced that the annual meeting of the institution for the present year would be held at Leeds, during the time of the Art Exhibition there, in the course of the summer. The meeting then terminated.

In the evening the twenty-first anniversary of the institution was celebrated by a number of the members and their friends by a dinner.

## LONDON ASSOCIATION OF FOREMAN ENGINEERS.

The ordinary monthly meeting of members of this society took place on Saturday, the 1st ult., at their rooms, Aldermanbury, City. The sitting commenced with the reinstallation, for the tenth consecutive year, of Mr. Joseph Newton as president. That gentleman, in resuming the office, expressed his sense of the honour conferred upon him, and promised to devote his energies to the furtherance of the interests of the institution. The election of several new members—honorary and ordinary—followed. Among the former of these were Joseph Whitworth, Esq., LL.D., F.R.S., John Lea, Esq., and W. F. Stanley, Esq.; and among the latter Mr. Peter Keay, of the Royal Arsenal, Woolwich, and Mr. Joseph Stone, of Messrs. Cottam and Co.'s.

Mr. William H. Keyte next proceeded to read a paper "On the lining of large iron vessels or boilers with lead." The subject was treated in a thoroughly practical manner by the author, who detailed his own experiences in superintending works of the description in question. He had encountered many difficulties in the operation, and found that it was almost impossible to overcome them. It was found that the vessels when charged with acid and heated beyond a certain degree showed symptoms of weakness. The unequal expansion and contraction of the two metals induced a separation between them. The lining of lead, though applied in the first instance with great care, became permanently collapsed and distorted, and no means could be found for preventing that disaster. Illustrative of this fact Mr. Keyte introduced diagrams, exhibiting longitudinal and cross sections of a large boiler after being in use for a short time. The lead lining was seen to have become buckled and misshapen to an extraordinary extent, and to present rather curious phenomena. The writer of the paper then invited his fellow-members to favour the meeting with their views as to the best way of solving the problem which had so far puzzled him.

Several members responded to the appeal, and numerous sketches were made on the spot and handed round for inspection, Some of these exhibited much ingenuity, and comprised a variety of plans for jointing the lead so as to facilitate expansion and contraction. The discussion demonstrated very forcibly the usefulness of the association to both foremen and employers. It was sustained mainly by Messrs. Miles, Irvine, Fishwick, Bragg, Walker, Edmonds, Briggs, Stabler, and the president. Mr. Stabler very justly observed that in these days of gas, and acid engines it was highly desirable for engineers to study chemistry as well as steam.

In putting to the meeting the customary vote of thanks to the contributor of the paper, Mr. Newton earnestly pressed the associated foremen to follow Mr. Keyte's example, and to produce subjects for consideration in constant succession. He wished to make the society an adult college for the promotion of technical, scientific, and practical knowledge. It was gratifying to be able to state that its proceedings were regarded with interest both at home and abroad, and he had it from Mr. Mackinlay, chief engineer of the Royal Dockyard, Bombay, and who had that evening started for India, that it was in contemplation to form a similar institution in Bombay. The vote of thanks having been unanimously passed, the sitting closed.

## ROYAL GEOGRAPHICAL SOCIETY.

The sixth meeting of the present session of this society was held at Burlington House on Monday evening last, Sir R. I. Murchison, Bart., President, in the chair.

The following new Fellows were elected: The Rev. T. Coney, M.A.; Edward Cook; H. M. S. Graeme; Major E. Huuter; H. F. Makins; Capt. C. H. Riley; and A. R. C. Strode.

Captain Sherard Osborn read a paper "On Exploration in the North Polar Region. He said that he still maintained the desirability, in a national point of view, of keeping open that school of enterprise and adventure, combined with scientific research, which Arctic and Antarctic voyages have ever offered to British seamen in times of peace. For a North Polar expedition there were three routes by which the Polar area could be reached viz., by Spitzbergen, by Behring's Straits, and by Baffin's Bay: it was well known that he preferred the Baffin's Bay and Smith Sound route, because the land extended farther north in that direction; the existence of Esquimaux was additional guarantee for health and comfort, and the proximity of the Danish settlement of Uppernavik would ensure communication with England. Dr. Petermann, of Gotha, had communicated to him the pleasant news that a German expedition towards the Pole, *via* the Spitzbergen route, was determined on for 1869, and that M. Rosenthal, of Bremerhaven, had offered for the purpose two screw-steamers, the *Albert*, of 450 tons, and a smaller one named *Bionenkorb*. He (Captain Osborn) fully recognised the importance of ships being set to follow up the course of the Gulf-stream in these high northern seas between Nova Zembla and Greenland, but the result of the three Swedish expeditions since 1861 to Spitzbergen was to show the inprobability of an open sea-passage to the north of that land. Messrs. Torrell and Nordenskiöld had ascended, in July and August, mountains 3,000 feet high in the north of Spitzbergen, and had been unable to see a trace of open water to the northward. They say, moreover, that all who have had most experience of the northern seas have come to the conclusion that the Polar basin is so completely filled with ice that all attempts to force vessels to the northward have been without success. By the Smith Sound route, on the contrary, it would be possible to travel by sledge or boat along the shores of the land. The French are bent upon trying to reach the Pole, *via* Behring's Straits—M. Lambert intending to obtain by public subscriptions the means to start on this enterprise early next year,—and their attempts have the best wishes of English geographers. During last summer several American whalers had reached a high latitude in this direction, and had sailed along the tract of Polar land which had been discovered by Captain (now Rear-Admiral) Kellett, in 1849, and had been heard of by the Russian explorer Wrangell, when on the northern coast of Siberia. One of the whalers, Captain Long, of the *Nile*, sailed along it for three days, and saw a mountain, resembling an extinct volcano, which he ascertained by rough measurement to be 2,480 feet high. Captain, Bliven, of the *Nautilus*, reached as far N. as 72°, and traced lofty mountains in this new land extending to the north-west. Captain Raynor, of the *Reindeer*, determined by astronomical observations the position of a cape on the south-east, as 71° 10' N. lat., and 176° 40' W. long. Lastly Mr. Whitney, of Honolulu, had ascertained that one shipmaster had been as far north as 74°, and could see peaks and mountain ranges extending far to the north-west. During the past summer private enterprise has also been extending our knowledge of the Smith Sound route; Captain Wells, of the steam-whaler *Arctic*, of Dundee, having reached latitude 79° (near Kane's furthest point), and sighted Humboldt glacier. Dr. Hayes brought back from his voyage, in a small schooner, to Smith Sound, the interesting information that during the winter, in heavy north-easterly gales, the temperature rose with the violence of the storm, and fell immediately the gale subsided; and moreover that the Esquimaux of the east side of the Sound, said if he had gone further northward, on the west side, he would have found natives and good hunting-grounds, with "plenty of musk oxen." All travellers up Smith Sound have been stopped by water—a sea yielding animal food to support human life or contribute to the health and strength of our seamen. Much has been made of the peril incurred, much of the loss of Franklin and his 100 followers—alas; he feared, for a purpose. He remembered the sheaves of gallant men he had seen laid in their narrow graves in feverish China; he knew of the thousands thrown to the sharks of the Gulf of Guinea, in order that political capital at home might be made of such services. As to the expense, it has been grossly exaggerated. £080,000 only, out of 115 millions (less than the 164th part) voted to the navy in 1854-64, had been spent in the cause of science, and this includes the maintenance of Greenwich Observatory and surveying operations for charts in all parts of the world. All he asked now was, to explore the shores of Smith Sound; the method of doing it was explained in his paper communicated to the society three years ago. A committee of the British Association had been formed to promote such an expedition, and he asked the society to give its president and council an unanimous vote in favour of it, under government auspices and encouragement.

In the discussion which followed, the president observed that the object of the author of the paper in advocating Arctic exploration was not employment for himself, but to school our officers and seamen in the peculiarities and difficulties of such enterprises, and thus prepare them for the great Antartic expedition which must be undertaken a few years hence, to observe the transit of Venus over the sun. Nineteen-twentieths of the discoveries in the Arctic regions had been made by British seamen, and it ought to be a point of honour that England should continue the lead in this field of research. After alluding to the German and French North Polar expeditions about to be undertaken, Sir Roderick read a letter which he had received from Admiral Lutke, President of the Imperial Academy of Science of St. Petersburg, who advocated the Spitzbergen route, and corrected the erroneous notion that the Russian word "Polynia" meant an open Polar Sea—it signified simply a hole in the ice, and not necessarily a large one.

Captain Richards (Hydrographer to the Admiralty) agreed with Captain Osborn, that Smith Sound was the only safe and certain route to the Pole, but for the exploration of the Polar basin the Spitzbergen route was to be preferred. The necessity of being prepared with well-trained officers and men to observe the transit of Venus, near the South Pole, in 1882, was an important argument in favour of a North Polar expedition at the present time. Very few of our old Arctic voyagers would be qualified in seven or eight years' time to encounter an Antarctic voyage; the opportunity should therefore be seized to train younger men for the work. Captain Osborn's trip towards the North Pole would be comparatively easy; and if, after that, the route by Spitzbergen were attempted by a couple of good steamers, fitted out in England, and commanded by good men, he believed that they would come back quite prepared for the inevitable Antarctic cruise.

Commodore Davis (Member of Sir J. Ross's Antarctic Expedition) did not quite agree in the conclusion come to with respect to the impassibility of the ice-fields north of Spitzbergen, as reported by the Swedish expedition. He believed that if a couple of good steamers were boldly to take the pack in that direction, they would eventually get through; it being merely the stream of ice floating southward from the North Pole. The attempt to reach the Pole by Smith Sound would, as the Hydrographer remarked, be a first-rate education for those who were afterwards to proceed to the Antarctic lands.

Admiral Sir George Back spoke in favour of the Smith Sound route, and Admiral Ommanney in favour of that *via* Spitzbergen. Mr. Crawford also supported Captain Osborn's views. Dr. R. J. Mann pointed out the astronomical and geographical bearings of the observations of the approaching transit of Venus over the sun.

Captain Allen Young read a letter from Captain David Gray, stating that he intended to sail from Peterhead on the 25th inst. to the Arctic whale fishery, and was prepared to push his explorations, with a scientific object, as far to the north as possible during the ensuing season.

The president announced that the admiralty had rewarded Mr. Young, the leader of the Livingstone Search Expedition, by promoting him to the rank of gunner of the first class, besides giving him an appointment as Naval Chief Officer in the Coast Guard. and a present of £500. The subject for next evening's meeting (Feb. 24) was announced, an important paper by Mr. C. R. Markham, Geographer to the Abyssinian Expedition, entitled "Geographical Results of the Expedition to the end of 1867."

## THE NATIONAL BOILER INSURANCE COMPANY (LIMITED), MANCHESTER.

### THE CHIEF ENGINEER'S REPORT.

This report is divided into three portions—the first relating to defects met with in the boilers inspected; the second containing a few practical remarks on boiler construction; and the third a summary and a notice of the boiler explosions which have been reported during the past year. From the above we extract the following from the practical remarks on boiler construction :—

### Construction of Boilers.

Of the numerous varieties, none are more generally used than the Lancashire, or cylindrical two-flued, and the Cornish one-flued boilers, and where these are well constructed, properly fitted-up, and carefully attended, their performance is generally satisfactory. There are various modifications of these forms, some of which are valuable.

In designing such boilers, excessive length as compared with the diameter should be avoided. Long boilers strain considerably, and frequently give great trouble by leakage at the riveted seams. A fair proportion is when the length is about three and a half times the diameter.

The staying of the end plates, and the attachment of the flue tubes to the ends, should be so arranged that the tube may expand freely, unless there be some special arrangement in the form of the flue tubes to attain the same object.

Many boilers, otherwise well made, have given considerable trouble by leakage and fracture, owing to the severe strains of unequal expansion, to which their rigid construction exposed them. In some of the boilers inspected the ends were so heavily stayed and so rigid, that considerable leakage and occasionally fracture at the ring seams of the lower part resulted. In others the staying was so slight that the ends were bulged outwards, and serious risk of explosion thus occurred.

Flue tubes should never be stayed to the shell, but be attached at the ends only. Many boilers have given serious trouble through being thus stayed.

The shell should be made quite circular, and the longitudinal seams, which should "break joint," be so arranged that when the boiler is set, all those below the water-line may be accessible for examination in the flues, and be clear of the brick seatings. Many makers now double-rivet these seams, thus materially increasing their strength, and when the work is well performed reducing liability to leakage.

Flue tubes are now constructed in various ways, some makers preferring to use thick plates not strengthened in any way, whilst others prefer comparatively thin plates; but by flanging them at the ring seams, or by welding each ring of plates, and connecting them by solid T iron hoops, form a much stronger and more reliable flue tube. The liability to leakage, fracture, and excessive expansion is thus much reduced, as the heat is more freely transmitted through the thin plates. The cross tubes and water pockets introduced by some makers in that part of the flue tubes beyond the furnace bridge are of great value, chiefly from the manner in which they improve the efficiency of the heating surface by the diversion and breaking-up of the current of the gases; whilst they much increase the strength of the tubes to resist collapse.

All large tubes exposed to high pressure should be strengthened by some of the means described.

Where the tubes are formed with the ordinary lap-joints, the longitudinal seams should "break joint," as a tube thus made is much stronger than where those seams are "in line," and at the furnace end all longitudinal seams should be below the fire-grate level.

Multitubular boilers should, as far as practicable, be so constructed that every part of the interior may be accessible for cleaning and examination; and it would be a great improvement if those of portable and locomotive engines were so constructed that the tubes could be drawn without difficulty, so as to allow occasional inspection of the internal surface of the plates.

External flues are necessary to stationary cylindrical boilers of this class; otherwise the lower seams are strained and become leaky through excessive unequal expansion of the boiler.

Plain cylindrical externally-fired boilers, with egg or saucer-shaped ends, are preferred by some owners, chiefly on account of their simple form. Such boilers can never work so safely as a properly-constructed internally-fired boiler, as they are so liable to fracture at the seams over the furnace, through the excessive alternate expansion and contraction to which they are exposed. The application of stout longitudinal stays would add materially to the safety of such boilers.

A large number of cylindrical vertical boilers are used in various ironworks.

These boilers are generally heated from the "puddling" or similar furnaces, the heat first entering the external flues, and passing thence by an internal descending flue-tube to the chimney. They are especially liable to starting and fracture of the riveted seams opposite the furnace necks, owing to the intense heat at that point; and where the feed water deposits much sediment the solid plate is sometimes fractured.

To avoid this liability, the part referred to should be protected by a screen of brickwork, or the boiler set at a higher level, that brickwork may be so arranged as to spread the heat before it reaches the boiler.

The bottoms of these boilers are frequently quite inaccessible for examination, and serious corrosion may go on unknown to those in charge.

If the boilers were supported by brackets at the sides, or by wrought-iron plate standards riveted to the bottom, so that a thin wall of brickwork would suffice to form the flues, the condition of the plates could be occasionally ascertained without much difficulty.

It is well to have two safety valves to each boiler as a check upon the other; one of them should be a "dead-weight" valve, loaded externally, and the other a "lever weight" valve, or a "compound" valve, which would allow the steam to escape if the water were allowed to fall below the proper level.

Our inspectors very frequently meet with safety valves the levers of which are of such length that the usual working pressure for which the boiler was made would be much exceeded if the weight were fixed at the end of the lever. The weight should always be calculated and adjusted to hang at the end of the lever.

All boilers should be provided with correct pressure guages, for the guidance of the attendant.

The glass guage is undoubtedly the best and most reliable water guage, and it is a good plan to attach two guages to each boiler. Where floats are used I should advise that there be two, one of them fitted with an alarm whistle. Boilers with internal tubes should always be fitted with glass guages.

Fusible plugs should be attached to the furnace crowns of all internally-fired boilers.

The feed regulating valve, which may be constructed to act also as a back pressure valve, should always be placed at the front end of the boiler, within the reach of the attendant, and where boilers work in connection, each should have a back pressure valve attached. The feed water should be delivered a few inches below the surface of the water in the boiler and above the level of the tube crowns in a horizontal direction, or by means of a horizontal perforated pipe.

Where the feed is delivered near or at the bottom of the boiler it cools and contracts the lower plates, whilst those of upper part are heated and expanded by the steam, frequently (especially in boilers rigidly stayed) causing fracture at the ring seams at the lower part of shell. It is always preferable to heat the feed water before it is forced into the boiler.

The blow-out tap at the bottom of the boiler should be so placed that it may be examined at any time, and so that any leakage thereat would be at once noted. Valves should never be used, double-gland taps made altogether of brass are far preferable.

Stout seatings with planed joint faces suitable for each fitting should be riveted to the boiler.

All manholes should be strengthened by a faced mouthpiece, riveted to the boiler, so that the joint may easily be well made, and leakage with corrosion be avoided.

The setting of stationary boilers is too often entrusted to men quite ignorant of what is necessary for their safe and efficient working, and I have frequently had to point out serious errors in plans prepared by engineers and others, whose mistakes probably arose from a want of practical experience of the working of boilers.

When boilers are about to be set, special care should be taken to thoroughly drain the ground that no dampness may exist in the flues to cause corrosion of the plates. All the flues should be quite large enough to allow a man to pass through, so that every part may be accessible for examination.

Midfeather seatings are very objectionable, and no boiler should be so set except those of very small diameter, and in such cases thick but narrow iron plates should be placed on the top of the brickwork to protect the boiler.

Cylindrical boilers, internally fired, should be set on side walls, the boiler resting on fire-clay blocks made for the purpose, and so shaped that when built in place the bottom of the side flues may be much lower than the point where the boiler rests on the blocks.

If the blocks be properly fitted to the plates that the bearing thereon may be equalised, the total breadth of both side walls where in contact with the plates need not exceed one inch for each foot of diameter of the boiler. The top of the side flues should be level with the crown of the flue tubes.

All boilers should be roofed over to protect them from external moisture, otherwise the sides in contact with the flue brickwork will be weakened by corrosion.

Where flues are properly arranged as described, no serious corrosion could exist in the seatings, which could not be detected on a careful examination by a trained inspector.

Where the feed water contains much sediment, and no cleaning apparatus is in use, frequent internal cleaning is indispensable, or the plates may become overheated and injured whilst the efficiency of the boiler is reduced. The external flues are in many cases allowed to become almost choked before being cleaned, and the boiler plates so thickly coated with soot, that a wasteful consumption of fuel is the result. Some firms, on the other hand, clean their boilers thoroughly about once a month, and are thereby considerable gainers, as the efficiency of the heating surface is retained, whilst any defects are at once discovered and made good, which if neglected might entail expensive repairs, or even lead to serious disaster.

When boilers are being re-started after stoppage, they should be heated very gradually, so as to avoid as much as practicable the severe strains of unequal expansion, and when at work the feed supply and the firing should be as steady and regular as possible.

Frequent and extreme alterations of pressure, especially with high pressure boilers, or irregularity of any kind is most objectionable and sometimes really dangerous.

I would here caution steam users against the purchase of second-hand boilers. Many instances have come under my notice where such boilers have required very extensive alterations and repairs, costing nearly as much as new ones, to which they were, after all, much inferior. Where it is proposed to purchase old boilers, a thorough inspection should be made by some person of special experience in such matters, whose report would be a reliable guide to the purchaser.

In constructing new boilers the very best materials and workmanship should be employed. Low priced boilers made with inferior material and workmanship are unreliable; and as a defective boiler must be a source of annoyance or danger, and the consequences of explosion are frequently so terrible, it is evident that in no case is special care more necessary than in the construction and fitting up of boilers.

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## MANCHESTER ASSOCIATION FOR THE PREVENTION OF STEAM BOILER EXPLOSIONS.

The last ordinary monthly meeting of the Executive Committee of this Association was held at the office, 41, Corporation-street, Manchester, on Tuesday, January 7th, 1868, Hugh Mason, Esq., of Ashton-under-Lyne, vice-president, in the chair, when Mr. L. E. Fletcher, chief engineer, presented his report, of which the following is an abstract:—

During the past month 356 visits of inspection have been made, and 769 boilers examined, 529 externally, 13 internally, 9 in the flues, and 218 entirely, while in addition 3 have been tested by hydraulic pressure. In these boilers 206 defects have been discovered, 10 of them being dangerous.

Tabular Statement of Defects, Omissions, &c., met with in the Boilers examined from Nov. 23rd, to Dec. 31st, 1867, inclusive.

| DESCRIPTION. | Number of Cases met with. | | |
|---|---|---|---|
| | Dangerous. | Ordinary. | Total. |
| Defects in Boiler. | | | |
| Furnaces out of Shape | ... | 5 | 5 |
| Fracture | 3 | 33 | 36 |
| Blistered Plates | ... | 7 | 7 |
| Corrosion—Internal | 1 | 15 | 16 |
| Ditto External | 2 | 27 | 29 |
| Grooving—Internal | ... | 13 | 13 |
| Ditto External | 1 | 6 | 7 |
| Total Number of Defects in Boilers ... | 7 | 106 | 113 |
| Defective Fittings. | | | |
| Feed Apparatus out of order | ... | 2 | 2 |
| Water Gauges ditto | ... | 17 | 17 |
| Blow-out Apparatus ditto | ... | 5 | 5 |
| Fusible Plugs ditto | ... | ... | ... |
| Safety Valves ditto | ... | 6 | 6 |
| Pressure Gauges ditto | ... | 10 | 10 |
| Total Number of Defective Fittings ... | ... | 40 | 40 |
| Omissions. | | | |
| Boilers without Glass Water Gauges | ... | 6 | 6 |
| Ditto Safety Valves | ... | ... | ... |
| Ditto Pressure Gauges | 3 | 7 | 10 |
| Ditto Blow-out Apparatus | ... | 12 | 12 |
| Ditto Feed back pressure valves | ... | 25 | 25 |
| Total Number of Omissions | 3 | 50 | 53 |
| Cases of Over Pressure | ... | ... | ... |
| Cases of Deficiency of Water | ... | ... | ... |
| Gross Total | 10 | 196 | 206 |

Of some of the defects mentioned above a few further particulars may be given:—

*Fracture.*—A multitubular boiler, constructed of steel plates, and with a single furnace tube, was found to fracture on more than one occasion at the transverse seams of rivets at the bottom of the external shell. This boiler, which had a length of 24ft., a diameter of 5ft. 6in. in the shell, and 3ft. 5in. in the furnace tube, was worked at a pressure of about 50lbs. on the square inch, and set underground in a colliery, without any external brickwork flues. Boilers set without these flues are always found to give trouble to a greater or less extent at the bottom of the shell, from contraction, the tendency to which was augmented in the present instance by a severe draught of cold air, caused by the ventilation of the mine, which passed over the naked boiler. It is of the utmost importance that in boilers set in this way, the feed should be dispersed by means of a horizontal perforated pipe placed near to the surface of the water; but it is strongly recommended, in addition, that the hot air from the small flue tubes should be brought underneath the shell before passing away to the chimney, in order to equalise the temperature of the boiler throughout.

*External Corrosion.*—One of the cases enumerated in the preceding table was met with under the following circumstances, at a colliery, in a Cornish boiler 22ft. 6in. long, and 5ft. 6in. in diameter.

This boiler, which had not been previously examined by this association, had just been removed from one pit to another, when the inspector found it lying entirely bare at the time of his visit, and at once availed himself of the opportunity of making a thorough examination. On doing this, he found the front plate at the bottom of the boiler to be wasted away round the blow-out elbow pipe to the thickness of $\frac{1}{32}$nd of an inch, while the bottom of the shell was dangerously corroded from one end to the other where it had rested on the mid-feather wall. In the second plate from the front end, the overlap and rivet heads were found to be nearly eaten away; the third was reduced to $\frac{1}{16}$th of an inch in thickness; the fourth was as thin as a sheet of brown paper; in the fifth the rivet heads were gone; and in the sixth the thickness of metal was reduced to $\frac{1}{32}$nd of an inch; and so on, while our inspector knocked a hole through in another part. The manager of the works was quite unaware of the danger, and was about to have the boiler reset in the state our inspector found it. Had such been the case, it could not possibly have worked on for any length of time without explosion, while it is highly probable that it would have burst the first time steam had been got up in it on its new bed.

In a second case a Lancashire boiler, measuring 30ft. in length by 7ft. in diameter, having two furnaces and set upon a midfeather wall, was found to be so wasted away that the inspector knocked a hole through the plates with his hammer, and the owner at once resolved not to work the boiler on any longer, and by this time has had it cut up and removed from its place. Previous warnings had been given as to the condition of this boiler, and the guarantee withheld.

These two cases will clearly show the importance of frequent flue examinations.

*Purchase of Second-hand Boilers.*—Attention was called in last month's report to the disappointment frequently occasioned through purchasing old second-hand boilers, and another case precisely similar to the one then reported has been met with during the past month.

A steam user, having just purchased and laid down a second-hand boiler, had it examined by this association, when it became its imperative though unpleasant duty to inform the purchaser that the boiler was of a dangerous type, now discarded, and to beg him not to set it to work. The boiler was 8ft. in diameter by 30ft. in length, and had two furnace tubes, running into a single oval flue containing a number of vertical water tubes of conical shape. The arched sides of this oval tube were very weak, being struck from two centres, instead of from one, so as to form the arc of a true circle. Several explosions have arisen from this weak shape, and all boilers of this construction should be at once discarded.

It is only due to the makers of these boilers to state that they have long since ceased to construct their oval flues with these weak sides, but as a great many of these old boilers still hang about, seriously jeopardising the lives of those who work them, it is the duty of the association to warn its members of the fact, in order to prevent any more of these dangerous old castaways being re-purchased from second-hand boiler vendors unawares.

### EXPLOSIONS.

On the present occasion I have six explosions to report, by which ten persons were killed and thirteen others injured, while, in addition the particulars may be given of four other explosions of prior date, which there has not hitherto been an opportunity of doing. Not one of the boilers referred to was under the inspection of this association.

No. 20 Explosion occurred at a cotton mill, at six o'clock on the morning of Monday, September 9th. Fortunately it did not result either in loss of life or any serious damage to property.

This explosion is peculiar, and was confined entirely to the cast-iron mouthpiece rivetted round the manhole of an ordinary two-flued Lancashire boiler, 28ft. long, 7ft. 6in. in diameter, and worked up to a pressure of 30lb. on the square inch. The cast-iron mouthpiece was very weak, and at the same time very deceptive. The lower flange by which it was rivetted to the boiler was an inch and a quarter thick at the edge, and the upper one to which the cover was bolted an inch and a half, so that the casting to all appearance was a substantial one. At the same, however, it did not measure three-eighths of an inch in thickness in the cylindrical body of the casting just underneath the upper flange. Added to this there were no strengthening brackets, and the angle at the roof of the flange, instead of being rounded off with a good fillet, was left square and sharp. The casting gave way at this weak part, immediately under the flange, when the cover was blown up through the roof of the boiler-house, and fell down through that of the engine-room. Fortunately no other injury was done that to the boiler and the roofs.

The cause of this rupture was simply the very defective character of the casting, and if boiler makers will turn out treacherous castings, which at the parts in sight are an inch and a half thick, but only three-eighths in the others, the work of boiler inspection will become doubly onerous.

It may be added, that bad as the casting was, yet due caution on the paat of the attendant would have prevented the explosion, since a crack in the mouthpiece had displayed itself for some time, precisely in the position of the subsequent fracture, and one of the cover bolts had been left out in consequence.

This explosion may prove a valuable caution with regard to the manhole mouthpieces, and steam users will do well to adopt those similar to that described and illustrated in the Association's Monthly Report for October, 1866.

No. 22A Explosion took place at a colliery, at six o'clock on the afternoon of Thursday, October 31st, but fortunately, beyond the damage done to the boiler, it did not result in any injury either to persons or property.

The boiler was or the ordinary Cornish type, having a single flue tube, and being fired internally. Its length was 26ft, its diameter in the shell 5ft. 6in., and in the furnace tube 2ft. 11in., the thickness of the plates being half an inch in the flat ends, and three-eighths in the shell and furnace tube, the ends having no gusset stays, but being strengthened with a couple of longitudinal tie bolts, an inch and half in diameter. There were two open lever safety-valves, about 3½in. in diameter, loaded to a pressure of 60lbs. on the inch.

The explosion resulted from the collapse of the furnace tube, the crown of which came down throughout its entire length, with the exception of about 5ft. at the front or furnace end, rending at the same time transversely, and dividing the tube into four lengths. This deprived the end plates of their principal longitudinal tie, in consequence of which the back one was torn away from its attachment to the external shell at the ring of the angle iron, and blown backwards with the fragments of the furnace tube to distances varying from 40 to 50yds., where they were lodged in a field and quarry, while the shell of the boiler was shot forwards, sweeping down the firing shed, as well as passing through a coal wagon standing on an adjoining line of rails, and finally becoming embedded to the depth of about 5ft. in a coal heap 15yds. distant. Though the exploded boiler was an inner one of a series of four set side by side, yet, fortunately, the others were comparatively uninjured, and after the steam and feed pipes had been reconnected, and some of the brickwork repaired, they were able to resume work.

The cause of the explosion was simply the weakness of the furnace tube, which was not strengthened by encircling rings or any other means, without which, on account of its large diameter and light plate, it was quite unfit to be worked at 60lbs. which was the pressure to which the safety-valves were loaded. The flue tube could easily have been made strong enough by suitable construction.

No. 27 Explosion, by which four persons were killed, another injured, and a good deal of property destroyed, took place at a chemical works, at a quarter before twelve o'clock on the morning of Thursday, November 14th.

The boiler was of an old-fashioned type, now generally discarded, being what is termed a "Breeches boiler," having two internal furnaces connected to a single flue tube by means of an oval and tapering combustion chamber. The length of the boiler was 25ft. 3in., its diameter in the shell 7ft. 3in., in the furnaces 2ft. 9in., and in the flue tube about 2ft. 11in., while the combustion chamber was 4ft. 6in. in length, and tapered from a width of 6ft. at the front end where connected with the furnaces, down to 2ft. 11in. where connected with the flue tube. The thickness of the plates was seven-sixteenths of an inch in the external shell, about three-eighths in the furnaces, combustion chamber, and flue tube, and half an inch in the flat ends. The pressure at the time of the explosion appeared to have been about 30lbs.

The boiler gave way at the underside of the oval combustion chamber, which collapsed upwards, and then rent entirely round the circles of rivets by which it was connected to the flue tube. This threw a greatly increased strain upon the flat ends, in consequence of which the front one was wrenched off from the boiler, and blown out in a forward direction along with the furnace tubes and combustion chamber which remained attached to it, the angle iron by which the end was attached to the shell being rent at the root all the way round, while the main portion of the shell and the remainder of the internal flue tube were blown a few feet backwards.

At the coroner's inquest a very full investigation was made as to the cause of this explosion, and two competent scientific witnesses gave clear evidence on the subject. Unhappily this is not always the case; if it were, it would do much toward the prevention of steam boiler explosions. It appears from the evidence given that the boiler was at least from twelve to thirteen years old, and had recently been purchased second-hand, while it had not been set to work in its new position before the day on which it exploded; in fact, steam had but just been got up in it when it burst. The boiler had been patched in several places, and the previous owner stated that he had sold it on account of the expense it incurred for constant repairs, which led him to the conclusion that working old boilers was not economical, adding that he certainly had no idea it was fit to be worked at the time it was taken out. Under these circumstances the boiler was sold for £40, and laid down by its new purchaser to drive a high-pressure engine, when it exploded, as just stated, on the first time of getting up steam. The two scientific witnesses both agreed in the view that the collapse was not due in any way to shortness of water, but simply to the weakness of the combustion chamber; since, although it was as much as 6ft. wide at the furnace end, and flat, or nearly so, at the top and bottom, yet was not strengthened by water tubes or other stays, while the plates were reduced by corrosion in places to about a quarter of an inch in thickness, and several of the rivet heads nearly eaten away. They both considered that the boiler, in the condition it then was, was not safe at a pressure of 20lbs. on the square inch, and that it ought to have been stayed at the combustion chamber, one of them adding that the boiler should have been condemned five yeare ago, that it was only fit to be used as a water tank, and that to have set it to drive a high-pressure engine, was very discreditable and reckless. The jury returned as their verdict, "That the men in question were killed by the explosion of a steam boiler, and that there was very gross and reckless negligence in purchasing a a worn-out second-hand boiler, and not using sufficient means to ascertain its strength after having it repaired; while the jurors earnestly request the coroner to draw the attention of Her Majesty's Secretary of State to the evidence and circumstances respecting this distressing explosion, being strongly of opinion that from the frequency of such accidents some measures should be adopted by Her Majesty's Government for obtaining and having an inspection of boilers by a competent engineer or other person, as is done with respect to factories generally." The coroner expressed his approval of the verdict, considering that "the matter had become a very serious one, and that it was quite necessary that owners of boilers should be compelled to take due precautions for the safety of the public as those who sold gunpowder, for the one appeared to have become as dangerous as the other," adding that "the recommendation of the jury should find its way to the proper quarter."

A second and independent coroner's inquest was held on the death of two other poor men who suffered by the explosion, and the jury returned a verdict precisely similar in substance to the one just reported, and with the same recommendation appended with regard to Government inspection.

My own examination of the exploded boiler fully corroborated the views expressed at the inquest as to the cause of the explosion, and there can be no question that the catastrophe was due simply to the weakness of the combustion chamber, which competent inspection would at once have detected.

No. 28 Explosion, by which three persons were killed and two others injured, occurred at a paper mill, at about one o'clock in the afternoon of Thursday, November 21st.

The distance from Manchester at which this explosion occurred, combined with other claims upon my time, prevented my making a personal examination, and I have but scanty information with regard to the details of the catastrophe, though sufficient to lead to some practical conclusions.

It appears that the boiler was a small one, of Cornish construction, having a single flue running through it from end from end, in which the fire-grate was placed. The safety-valve was loaded to 44lbs. on the square inch, and the steam had just been got up to that pressure in preparation for re-starting the engine at the close of the dinner hour, when the explosion took place.

The boiler failed through the rending of the furnace tube, on the occurrence of which a torrent of steam and hot water rushed out through the furnace mouth, carrying away the fire-bars, and projecting them, with other *débris*, like grapeshot from a cannon. The stoker, with a lad of about ten years of age, and a young woman who were in the firing space at the time were all killed instantaneously, the lad being hurled across a small meadow and brook, to a distance of about 66yds.; while in addition a workman and his son employed at the paper mill, who were sitting at one side of the boiler, were severely scalded and otherwise injured.

It was stated at the inquest by the foreman of the works, who said he was an engineer and paper maker, that the boiler had been cleaned out on the previous Saturday, after which he had carefully examined it with a light and sounded it with a hammer, when he had found it all right and in good working order. On re-examining the boiler, however, since the explosion, he had discovered an old fracture about 3in. long, of which he was not previously aware, but which he concluded must have existed for some time from its black and rusty appearance, whereas the surfaces of the other rents produced by the explosion were bright and clean. This old fracture, he thought, could not have been discovered by examination before the explosion. No scientific evidence was called in, and the jury expressed themselves perfectly satisfied, stating in their verdict that "the deaths were occasioned by the accidental bursting of a boiler."

It is to be regretted that a more satisfactory investigation was not made. It is clear, however, that this explosion would not have occurred had the furnace tube been strengthened with flanged seams or encircling hoops at the ring seams of rivets, or by other approved means. No crack 3in. in length would lead to the explosion of a suitably strengthened furnace tube; while the fact that the foreman, who was responsible for the safety of the boiler, had examined and passed it as safe but a few days before it exploded, shows the importance of competent independent periodical inspection. The parties who had the management of these works evidently had no idea of what an engine of destruction they were dealing with in working on so defective a boiler.

Tabular Statement of Explosions, from November 23rd, 1867, to December 31st, 1867, inclusive.

| Progressive Number for 1867. | Date. | General Description of Boiler. | Persons Killed. | Persons Injured. | Total. |
|---|---|---|---|---|---|
| 29 | Nov. 27 | Plain Cylindrical, flat-ended. Externally-fired...... ..... | 1 | 0 | 1 |
| 30 | Dec. 23 | Single flue or Cornish. Internally-fired ......... | 6 | 4 | 10 |
| 31 | Dec. 26 | Particulars not yet fully ascertained................. | 0 | 2 | 2 |
| 32 | Dec. 28 | "Balloon" or "Haystack" Externally-fired ...... | 1 | 4 | 5 |
| 33 | Dec. 30 | Two-flue Lancashire. Internally-fired ...... | 0 | 2 | 2 |
| 34 | Dec. 31 | Plain Cylindrical, egg-ended. Externally-fired ...... | 2 | 1 | 3 |
|  |  | Total.................. | 10 | 13 | 23 |

No. 29 Explosion occurred at a colliery, at a quarter before seven o'clock, on the morning of Wednesday, Nov. 27th, and resulted in the death of one man.

The boiler was of plain cylindrical flat-ended construction, and externally fired, having a length of 25ft. 6in., and a diameter of 6ft. 3in., while the thickness of the plates was seven-sixteenths of an inch in the cylindrical portion, and half an inch in the flat ends. The usual working pressure was stated to have been from 40lbs. to 45lbs. per square inch, but the two saftety-valves with which the boiler was fitted admitted of a pressure, with the weights at the end of the levers, of about 50lbs. in one case and 60lbs. in the other.

The boiler failed at the back, the flat end plate being rent entirely round its circumference through the line of rivet holes at the angle iron attaching it to the cylindrical portion of the shell. On the occurrence of the rent the end plate was blown in a direction nearly at right angles with the original position of the boiler, and to a distance of about 60yds., where it lodged in a canal, having in its course struck the chimney stack, which prior, to the explosion, stood at the back of the boiler, but was levelled to the ground either by the force of the blow or by the rush of steam and hot water; while the remainder of the shell was blown forwards to a distance of about 50yds., where it partially lodged on the roof of a stable, having demolished a small hut or cabin, and performed a somersault on its way, while the attendant, who was blown into the air, fell to the ground a short distance from the shell of the boiler.

The cause of the explosion will be at once explained by giving a history of the treatment of the boiler, which is simply a history of bungling. The boiler had been originally one of the Cornish type, having a single flue tube running through it from end to end, and adapted to be fired internally. When, however, it was purchased second-hand and laid down at the colliery, about two years prior to the explosion, the fire-grate, instead of being placed within the flue tube as it should have been, was placed underneath the external shell; and in order to accommodate the lay of the plates, which were arranged for internal firing, the boiler was turned round end for end so as to prevent the flames meeting the edge of the plates. Thus the end plate, which had originally been at the front of the boiler, stood at the back, and the external angle iron with which it was attached to the shell projected into the course of the flame, which was the more objectionable, since the boiler was set with a single direct or "flash" flue. The boiler worked in this way for some eighteen months, but as the tube was found to give constant trouble from leakage at the ends, and also from its interfering with repairs, it was taken out altogether, and the opening in each blanked up, while at the same time the boiler was rebottomed at the part immediately over the fire. The removal of the furnace tube seriously weakened the boiler, not only by increasing the area in the flat ends on which the steam acted, so that the pressure on each amounted to nearly 100 tons, but at the same time by removing a most valuable longitudinal tie. An attempt was made to meet this by putting in additional stays, and the back end which gave way had altogether seven diagonals, two of which, however, were merely rods an inch in diameter attached by nuts; while the remaining five were made of plates about 9in. wide, three-eighths of an inch in thickness, and secured to the shell by three rivets only in each. The back end plate consisted of as many as seven pieces, while these stays were but roughly put together, and proved insufficient to withstand the strain. All of them gave way, and rent either at their attachment to the end plate or shell. It was a sad blunder to convert this boiler from an internally to an externally fired one, and also to remove the furnace tube without amply strengthening the flat end in a longitudinal direction, and this explosion is attributed to bungling boiler making.

No. 30 Explosion, which took place a few minutes after one o'clock on the afternoon of Monday, December 23rd, was of a very disastrous character, as many as six persons being killed, and four others injured, while the dye works at which it occurred were levelled to the ground.

The boiler, which was set immediately under the drying room, was of the ordinary Cornish construction, being internally fired, and containing a single furnace tube. Its length was 18ft., its diameter in the shell 6ft., and in the furnace tube about 3ft. 2in., while the thickness of the plates was three-eighths of an inch, and the blowing-off pressure about 25lbs. on the square inch.

The boiler failed at the bottom of the external shell, rending longitudinally from one end to the other, when the whole was lifted from its seat, and the entire works laid in ruins. It was to this that the loss of so many lives was due, and not to scalding, or injuries received directly from the boiler, but to the fall of the works upon the poor fellows who were crushed and buried in the ruins.

The cause of the explosion was but too apparent on examination. The boiler which was set on a midfeather wall, had been shamefully neglected; the external brickwork flues were very damp, leakage had occurred at many of the seams, the boiler had not been properly examined, and external corrosion had been allowed to go on eating into the plates till they were wasted away at the bottom of the shell to the thickness of a sheet of brown paper, almost from one end of the boiler to the other. The boiler was totally unfit for work, and it is a matter of surprise how it withstood the steam pressure at all. The explosion is a striking instance of the folly of neglecting periodical inspection.

At the coroner's inquest the jury returned a verdict of "Accidental death," adding that they considered great neglect had been displayed by the conduct of the employers, and urging the coroner to call the attention of the Home Secretary to the fact that it is considered desirable that the periodical inspection of boilers should be compulsory.

No. 32 Explosion, by which one man was killed and four others injured, occurred at a steam corn mill, at about noon on Saturday, December 28th.

The boiler, which was of the balloon or haystack class, measured about 11ft. in height by 11ft. 6in. in diameter, while the plates were three-eighths of an inch in thickness. The bottom of the boiler, immediately underneath which the fire was placed, was arched upwards, the rise, as far as could be ascertained after the explosion, having been as much as 3ft. 6in. The boiler had three internal stays, two transverse ones running across the shell, and a single vertical one, measuring an inch and an eighth square, and secured by cottars and stirrup plates to the crown of the shell and crown of the furnace. The boiler was fitted with a single safety-valve, 4in. in diameter, loaded to a pressure of about 16lbs. on the square inch.

The boiler gave way at the bottom, which was blown completely out, rending all round at the lower part of the external shell, when the main body of the boiler flew upwards, and fell at a distance of about 100yds. from its original position, passing completely through a cottage in its course, then smashing in the roof of a public-house, and finally landing on the top of a chemist's shop in one of the principal thoroughfares of the town in which the explosion occurred, while the bottom of the boiler was rent into several fragments, which were scattered in various directions, one of them being thrown on to the roof of a house some 40yds. off, from which it rebounded into the garden.

The cause of the explosion was considered at the inquest to have been shortness of water, and it is stated that the engineman had absented himself from his post for a short time, in order to call on a neighbouring boiler maker for a Christmas box, and to inform him that the boiler leaked, having left it meanwhile in charge of one of the millers, with instructions to attend to the feed, as the water in the boiler was then rather low. On the return of the fireman, it is stated that he found his instructions had been neglected, and consequently turned on the feed himself, when the explosion immediately took place. As the fireman was so seriously injured that he survived the explosion only a few minutes, nothing could be learned from him further than "it was just what he expected." It may be added that the plates on examination were not found to be wasted from corrosion, while a water-mark was discovered inside the boiler considerably below the proper level, and some felt with which the boiler had been covered was stated to have been charred and burnt almost to a cinder. There is, however, so strong a tendency to attribute every explosion to shortness of water through the neglect of the attendant, that such views must always be received with considerable caution, and having been prevented making a personal investigation, I should not feel justified in giving a decided opinion. The bottom of the boiler, with steam at 16lbs. on the square inch, would have been subjected to a pressure on its entire surface of about 100 tons, while it was stayed with but a single rod of wrought-iron, measuring an inch and one-eighth square, as already described, and which had torn through the stirrup strap connecting it to the furnace crown. Whether, therefore, the immediate cause of the explosion was shortness of water or not, there can be no doubt that this class of boiler is of very weak construction and should now be discarded; while even had shortness of water occurred, the explosion would have been prevented had the boiler been fitted with a low-water safety-valve, which would have opened and allowed the steam to escape as soon as the water fell below the desired level, thus relieving the boiler of the pressure, and at the same time sounding an alarm and calling attention to the fact of neglect.

No. 33 Explosion occurred at about six o'clock on the morning of Monday, December 30th, at a hackle and gill pin manufactory. Two persons were injured by the catastrophe, but fortunately no one was killed.

The boiler, which was of the Lancashire class, having two furnace tubes running from end to end, in which the fire-grates were placed, was set upon a midfeather, with an ordinary wheel draught, and had a length of 22ft., a diameter in the shell of 7ft. 3in., and in the flues of 2ft. 7in., while the thickness of the plates was three-eighths of an inch.

The boiler gave way at the bottom of the external shell, which was rent in the first instance from one end to the other longitudinally; and then separated from the two end plates and opened out nearly flat, while the furnace tubes with the ends remained comparatively uninjured and connected together. On the occurrence of this rent, the shell was blown into an adjoining street, and the flue tubes lifted and turned over end for end.

The cause of the explosion was apparent at a glance on an examination of the fragments. The boiler was in a shameful state of decay, the plates along the bottom having been wasted by external corrosion until reduced for a length of about 20ft., where resting on the brickwork, to the thickness of a sheet of brown paper. The explosion is simply due to gross neglect, and would certainly have been prevented by competent inspection.

It may be noted in passing that the external shell was stayed transversely with three wrought-iron rods an inch and a quarter square. These, however, do not appear to have rendered any service. They did not prevent the primary rupture, or the subsequent opening out of the shell. These transverse stays in cylindrical boilers are, however, strongly advocated by some; but since this is just a case in which, if they possessed any value, they might have proved of service, it is trusted that their failure in the present instance will lead to a conviction of their uselessness, and that no new boilers will be encumbered with them.

### Drying Cylinder Explosion and Sundry Cases of Scalding.

In addition to the particulars of the steam boiler explosions given above, it may be of service to make brief reference to a recent explosion of a drying cylinder, as well as to three cases of scalding, from which three lives were lost.

The drying cylinder exploded at half-past twelve o'clock on the afternoon of Thursday, December 18th, at a silk mill; but though several persons were standing by it at the time, yet, fortunately, no one was injured. Some 300 panes of glass, however, were either blown out or shattered by the concussion.

The drying cylinder, which was 4ft. in diameter and 3ft. 6in. long, was connected by a half-inch pipe to a boiler worked at a pressure of 28lbs. on the square inch, while it had an open drain pipe, three-quarters of an inch in diameter, to take off the water of condensation, and prevent any undue pressure within the cylinder. It rent, however, from one end to the other at a longitudinal seam, showing that there should have been a safety-valve on the inlet pipe, while, in addition, a steam pressure guage would have proved a useful guide. These are added by first-class makers. The safety-valve is essential.

It is interesting to notice the different effects of the explosion of a vessel filled with steam or hot water. The steam in the drying cylinder escaped with a single puff, but had it been full of hot water it would have been hurled from its seat, and those near it in all probability killed on the spot. The destructive agent in boiler explosions is not so much the steam contained in the boiler as the hot water.

The first case of scalding occurred on October 10th, and was due to the boiler attendant's commencing to take off the manhole cover before the steam was entirely down. He had taken out all the bolts but one, when the lid blew up, and he was thrown some distance and dreadfully scalded by the rush of steam. His eyes were torn out of their sockets; when, rendered frantic by his sufferings, he rushed blindly against a stone wall with so much violence that he fractured his skull, and died the following day.

The second case of scalding took place on November 18th, and was due to the bursting of a steam receiver, used for the purpose of heating iron plates. One man was severely injured by the flight of one of the fragments, in addition to being scalded by the steam.

The third case of scalding occurred on December 14th, in consequence of a blank flange being unscrewed from the end of a steam pipe while the steam pressure was on, under a misapprehension that the valves had been screwed down and the steam shut off. Two men were engaged in unscrewing the flange and both scalded to death.

It is extremely injudicious, as previous reports have shown, either to caulk boilers or tighten joints when the steam is up, and it is trusted the circulation of the particulars just given may serve as a useful caution.

In bringing this report to a conclusion, I am happy to be able to state that no explosion has occurred to any boiler under the charge of this association during the year 1867, now just closed; but I have recorded 36 explosions which have occurred during that period to boilers not enrolled with this association, which resulted in 59 deaths, in addition to 68 cases of personal injury. It is more than probable, however, that this is not the total number, and that several have occurred that have not come under my notice. The whole of the explosions recorded have arisen from the simplest causes, and entirely from neglect. They might all have been prevented by competent periodical inspection. It will be observed that during the past month two explosions have called forth the recommendations from coroners' juries that a representation should be made to the Home Secretary that the safety of the public demands that periodical boiler inspection should be made compulsory. This fact should not be overlooked. The adoption of Government inspection is a serious question, since it would be impossible to frame such a system without severely harassing the steam user and cramping progress. Other measures it is thought may be tried before this is adopted. Let coroners' juries when sitting on boiler explosions make a complete investigation, and when it has been found that the explosion occurred from a bad boiler, let them plainly say so. Faithful investigation and plain-speaking would do much toward the prevention of these constantly-recurring disasters. This association has pursued this course for several years, and it calls upon both coroners and jurymen, and all who may be connected with investigations upon steam boiler explosions, to afford it their assistance by doing the same. If steam users could only be induced to adopt a system of voluntary inspection, there would be no need of Government interference, and steam boiler explosions would shortly cease.

## ROYAL SCOTTISH SOCIETY OF ARTS.

### ADDRESS

By George Robertson, Esq., President, M. Inst. C.E., F.R.S.E.

Gentlemen,—I propose this evening, as my contribution to the Presidential Addresses delivered from this chair, to give the society some idea of what has recently been done in Scotland by civil engineers in the way of marine, hydraulic, and sanitary engineering. To do this with any degree of accuracy, I have had to draw largely on the courtesy of my professional brethren; and I beg to return them my best thanks for the information they have given me. The ground is to a great extent untrodden by any of your former presidents; and I hope the short notices I have to give of recent works, or works in progress, may not be unacceptable to a society which has on its roll upwards of fifty members of my own profession.

To commence with the sea, and with our immediate neighbourhood.

The east breakwater which was lately completed at Granton has a total length of 3,170ft. The outer portion, about 1,000ft. in length, was made first, the materials for it having been taken over a temporary bridge which crossed the harbour mouth. The remainder was commenced from the shore end, and joined on to the outlying portion. This breakwater shelters 53 acres from the north-east wind, making the total area of the harbour 130 acres. A timber wharf, 800 feet in length, has been erected on the west side of the harbour, in immediate connection with the Caledonian Railway, and fitted up with two twenty-ton cranes for shipping coal, and other cranes for general purposes, all worked by steam. Since the year 1835 the Duke of Buccleuch has expended an aggregate little short of half a million on this munificent private undertaking.

On the opposite side of the Ferry, the North British Railway Company have increased the accommodation for the goods traffic by throwing out a pier to the end of the first one, with a sheltered slip for their waggons to be drawn up from the ferry boat.

The same company are also making a harbour at South Queensferry, consisting of a basin 40 acres in extent, connected with 60 acres of ground for trade purposes. There are to be two piers, one for the passenger traffic across the Queen's-ferry, and the other for the coal and goods traffic. These piers are about 400 yards long, and they are laid out so as to allow engines and trains from the Queensferry Branch to approach all parts of them; the object being to enable large vessels to take in a cargo of coal in twenty-four hours. The depth along the goods pier is to be 12ft. at low water of spring tides. The quay walls of the piers are designed to give a clear berth, fitted with a steam crane to each vessel, so that it could take advantage of the great depth of water at that part of the Forth, and arrive and depart at any time of the tide.

I have on several occasions described to the society the various works which have been constructed of late years at Leith by the Commissioners for the Harbour and Docks, and will only, therefore, say that the works connected with the present extension of the docks are far advanced, and are being carried out very much in accordance with the original plan. The trade and prosperity of the port of Leith has increased greatly. The dock revenue has risen, since the opening of the Victoria Dock, with six feet more water than the old docks, from about £30,000 to upwards of £54,000 per annum. The new dock is to be fitted up with Sir William Armstrong's hydraulic machinery for opening the dock gates and lifting the shuttles of the filling culverts. The cranes and capstans round the dock will also be worked by water power. The pressure of the water is obtained, and kept up, by means of steam power applied to pumps, which force the water, at a pressure of as much as 700lbs. per square inch, through the pipes which convey it to the point of application. The superiority of this system, over steam power applied directly, lies in the concentration of the steam power into one, or more, engines erected in places out of the way of shipping or warehouses, and consequently not likely to expose them to the risk of fire, and in the greater ease with which it is managed. The value and economy of the principle consist in a large saving of manual labour, and in the rapidity with which work can be executed.

The system of hydraulic machinery round a dock has, not inaptly, been compared to the circulation of the blood; in which the steam engine represents the heart, the throbbings of which send life and energy through the arteries to the most distant extremity of the body. At Leith the simile will be farther carried out—as fresh water there is precious, a return series of pipes, or veins, will bring back the water which has done its work to the heart, to be again circulated through the system. Most of the docks on the Thames, Mersey, Tyne, Wear, and Humber in England, as well as the Welsh Docks and other places, have this hydraulic machinery; but Leith will be the first port in Scotland to make use of water power as a system.

Several large examples of Morton's patent slips for repairing vessels have lately been constructed at Leith, one for Alexandria being for vessels of 3,000 tons. Since the invention of this useful substitute for a dry dock, 56 slips have been made at Leith for this country, and 17 for foreign ports; equal to the repair of vessels of 37,750 aggregate tonnage. To avoid the necessity of enormous wheels for the gearing of the purchase in large slips, Miller's hydraulic purchase has been substituted for toothed gearing.

The harbour in process of construction at Anstruther is meant as a companion to the recently formed one at Dunbar on the opposite shore, both being intended chiefly as places of refuge for the boats engaged in the herring fishing about the entrance to the Forth. The eastern pier, which has to resist the full force of the sea, is to be about 1,200ft. in length, extending from the top of the beach into a depth of 9½ft. at low water. It is being constructed as a quay, with a protecting parapet 17ft. above high water. The faces of the wall are formed of free stone ashlar set on edge. The construction differs from that at Wick Harbour chiefly in the character of the building above low water, which is all set in Roman cement. This permits of small material being used for backing, as the whole becomes a monolithic mass in a few hours after it has been built.

At Dundee the Harbour trustees have lately increased the wet dock accommodation. The Camperdown dock has now an area of 8½ acres, with 23ft. 6in. on the cill at high water, and 7ft. at low water, of ordinary spring tides. The width of the entrance is 60ft., and it is closed by an ingenious floating caisson gate, larger than, but similar in principle to the one made by Mr. Ower for the new dock at Alloa. It is simply an iron box 62½ft. long, 30ft. high, and 11ft. wide, turning on a hinge at one corner when floated a few inches by running off some of the water inside it. Two men on each side work it with the greatest ease. The Victoria Dock has been deepened to the same depth as King William Dock, with which it may eventually be connected, should the entrance locks of that dock and of Earl Grey Dock ever be converted into dry locks. A low-water landing pier has been proposed at the entrance to the Camperdown Dock, and a new line of sea wall extending from the Stannergate on the east to the Magdalen point on the west of the harbour. This will not only lead to the reclamation of 225 acres of valuable flat ground, which Dundee much wants, but is intended to improve the depth of water at the dock and harbour entrances. These, as well as the Tay ferries, have to contend with sand banks coming down the river, which are a constant source of annoyance and expense.

The British Fishery Society are engaged in constructing an important harbour in the Bay of Wick, noted for its extensive fisheries of 1,000 boats, and also for its stormy seas. The pier will extend about 1,500ft. into the bay, and will shelter an area of 20 acres. The seas here have proved so heavy, that it has been found necessary to substitute greenheart timber, instead of pine, for the staging from which the work is built. The roadway of the quay is 30ft. in width, and is protected by a parapet on the seaward side rising 21ft. above high water. The outer walls are founded on the natural bottom, which consists of large boulders, until they reach a depth of 27ft. under low water of spring tides. Beyond this the walls are founded on a mound of rubble at a depth of about 18ft. under low water. The walls are, on the sea face from 10 to 12ft., and on the inner face about 8ft. in thickness. The interior between the outer walls is filled with large blocks.

I have not time to notice several smaller harbours and piers lately constructed on the north and west coast, but must proceed at once to the Clyde. The finest pier probably of its kind on this river is the one lately completed at Wemyss Bay. It is made of greenheart timber, and is 500ft. long, and 56ft. broad.

The new Albert Harbour at Greenock consists of 11 acres of water area, with about a mile of quayage, including 1,800ft. of river quay. The depth is 25ft. at high water, and 15ft. at low water, of springs. The sea piers, with perpendicular walls stone faced, were constructed in the water without the use of coffer-dams, by a successful combination of iron piles and granite slabs for facing, and concrete for backing, up to the level of low water. Above this they were built, in the ordinary way, of masonry.

Advantage was taken of the excavation for this basin to form a magnificent esplanade, upwards of a mile in length and 100ft. wide, to the west of Greenock; the river face being formed by a stone sea wall built to the low-water line. The steamboat quay at present in use, well known for its nasty and inconvenient approach, is to be shifted to the west end of the Albert Harbour. Both the Caledonian and Greenock and Ayrshire Railways have got powers to extend their lines and build stations on the new quay. The quay will be constructed of greenheart, concrete, and stone, and is to be ready for the opening of the Greenock and Ayrshire Railway next June.

At Port-Glasgow it is intended to make a wet dock of the present tidal harbour. The port has recently been put in direct communication with the Caledonian Railway, and a swing bridge has been thrown across the entrance of the harbour to carry the rails down to the quay.

The Windmill Croft or Kingsdon tidal basin at Glasgow is 5¼ acres in extent, with a depth of 24ft. at high water of springs. The entrance walls are of masonry upon timber-bearing piles and concrete. The entrance is 60ft. wide on the square, and is spanned by a lattice girder bridge, swung by hand power, or by hydraulic machinery worked by the pressure of the town water pipes. The wharves round the basin are of timber, and were completely finished before the greater part of the excavation was done. The water was then admitted, and the dredger set to work to take out 14ft. in depth over the whole area. An expeditious system of pile-driving has been successfully tried in this work. The piles were driven in bunches of five at once, between guide piles at regular intervals. Three fir piles were placed between two elm piles, the whole resting on one shoe of cast iron with wrought iron straps. The five piles were fastened together with wooden dowels and iron dogs, and hooped with one ring over all. The timber panel was then driven by a broad ram worked by steam power, and so successful was the system, that a bunch of five piles, each 25ft. long, has been driven in three hours. The cost of the Windmill Croft basin, including dredging, swing bridge, paving, sheds, &c., will amount to about L.115,000. Half a mile has thus been added to the quays at Glasgow, making a total quayage of three miles.

The bridge now being constructed over the Clyde by the Union Railway is on the lattice girder principle, of five water spans, each 75ft. in the clear, and two land spans of 65ft. each. The girders rest on granite columns carried upon cast-iron cylinders 8ft. 4in. in diameter, sunk to a depth of nearly 80ft. through the sand to the solid rock and clay which form the bed of the river. The Milroy excavator, by means of which the cylinders were sunk, has been perfectly successful. It consists of a bunch of eight spades, hinged to the outside of an octagonal frame 5ft. in diameter, the bottom of which they form when closed. The spades hang down, when the apparatus is lowered, as far as it will go, by tackle attached to the outside of the frame. It is pulled up again by tackle at the centre, which raises each spade from the vertical to the horizontal position, enclosing by their junction a quantity of sand. In order to ensure the excavator being both kept and forced down, while the spades are being lifted to the horizontal position, two holding down chains are fixed to opposite sides of the frame, and pass under pulleys held down at the bottom of the cylinder by long vertical timber spars. During the time I watched the excavator, the frame never failed to come up perfectly full of sand; and I was told that as much as 14ft. in depth has been taken out in three hours, the average being about 4ft. per hour. Three hours per diem was the usual time taken up in sinking the cylinders, the remainder of the day being employed in caulking, bolting together, and weighting them; but on one exceptional occasion a cylinder was sunk as much as 25ft. in one day, the total time occupied in sinking being 6¾ hours—in other work 3½ hours. The number of men employed being twelve, including the foreman. The cylinders are afterwards filled with concrete and brickwork.

The upper of the three stone bridges spanning the Clyde at Glasgow is to be removed in consequence of the improvements of the river, and replaced by a handsome structure of iron and stone, in three spans of 120ft. each.

The state of the river from the sewage pollution is now so bad that the authorities will shortly be compelled to take some active steps for its purification.

The Clyde is a remarkable example of how the improvement of a port affects its revenue. Though it does not by any means follow that deep water in a harbour will of itself alone create trade, or divert traffic from neighbouring places, already centres of business, yet it is nevertheless pretty certain, that when trade has once fixed itself to one place, increased depth of water and increased revenue are closely connected. Thus, in the Clyde in 1800, when the depth of water at Glasgow was only 3ft. at high water, the revenue was only £3,320. In 1825, when the depth had been increased to 12ft., the revenue had grown to £8,367. In 1863 there was 22ft. of water, with a revenue of £118,083; while last year the amount was £131,862, it being intended by dredging to keep up a depth of 24ft. at high water of spring tides, and 22ft. at neaps, for the whole way up to Glasgow.

Before leaving the subject of marine engineering, I would draw the attention of the society to the proposal of Mr. Thomas Stevenson, to illuminate beacons and buoys by means of electricity from the shore. I need only do this briefly, for the experiments were fully explained to us during the session. The subject appears to me to be one of great importance, as it is likely to form a new era in maritime illumination. We may hope that the time is not far distant when such a navigation as Liverpool will be as clearly defined at night as in the day by the illumination of its buoys and beacons.

It is not necessary for me to say much to the society on the importance of proper drainage and a plentiful supply of good water to every town. Our attention has often been directed to this subject, as well as to the kindred ones of the pollution of rivers and the utilization of sewage. I need only, for example, refer to the excellent papers read during the present session by Mr. Macpherson on the removal of the refuse of this city, and by Dr. Macadam on water supply. There is a general feeling throughout the length and breadth of Scotland, that bad drainage means typhus, and that bad water means cholera. Upwards of eighty towns and populous places have already adopted, in whole or in part, the General Police and Improvement Act, 1862, commonly known as Provost Lindsay's Act.

I cannot undertake to ennumerate all that has been done in the way of sanitary improvement in every town, but I hope to be able to give you sufficient to prove that that the old Scotch saying, "The clartier the cosier," is fast losing its significance; and that a very great deal has been done of late years towards rendering our cities more healthy, and better supplied with that invaluable luxury—good water.

I commence with the most important hydraulic work ever executed in Scotland—important, not only because it furnishes an abundant and pure supply of water to our most populous city, but because it foreshadows that much larger scheme which must, sooner or later, be undertaken for the supply of London.

The great Loch Katrine water-works, for the supply of the city of Glasgow, have been open now for seven years, and during last year gave an average daily supply of 21,200,200 gallons. In addition to this, 3,500,000 gallons were sent in from the Gorbals water-works, on the south side of the river Clyde, making the total daily supply to Glasgow 24,700,000. This, distributed over a population of about 500,000 persons, gives nearly 50 gallons per head per diem. Of this quantity, about 4½ gallons per head are sold by meter, of which there are upwards of 600 in use, producing a revenue of £20,000 a year.

The drainage area to the works amounts to 72 square miles, and includes Loch Katrine, Loch Achray, Loch Vennacher, and Loch Drunkie. The water of Loch Katrine has been raised 4ft. above its former summer level by a masonry dam, and it can be drawn down to 3ft. below the former summer level. This gives a control over the contents of the loch of 7ft. in depth, with a storage capacity of 910,000,000 cubic fett. The water from this loch alone is used in the supply of Glasgow, and it is very pure, containing only 2¼ grains of soluble matter per gallon, with a hardness of 0°·8 on Dr. Clark's scale, in which 1° of hardness represents 1 grain of chalk per gallon. The softness of the Loch Katrine water causes a great saving in the amount of soap used for washing in Glasgow.

Loch Vennacher and Loch Drunkie are used for compensation to the proprietors and others having an interest in the rivers Forth and Teith, and furnish a daily supply to those rivers of 40,500,000 gallons. The total storage provided by the works at the three lochs is 1,455,000,000 cubic feet, equal to a supply for 100 days of 50,000,000 gallons to the city, and 40.500,000 gallons of compensation, without taking into account the natural flow of the streams running into the loch. At the rate of consumption in January last this storage is equal to 47 days' supply.

The water is taken from Loch Katrine to the service reservoir at Mugdock, by an aqueduct 25¾ miles long, the built and tunnelled portion of which is 22 miles long, with a height and width of 8ft., and a uniform slope of 10in. per mile. The valleys of the Duchray, the Endrick, and the Blane, are crossed by cast-iron syphon pipes 48in. in diameter, of an aggregate length of 3¾ miles, and a mean fall of 1 in 1,000. Provision has been made at the bridges and other places for laying two additional lines of pipes when the consumption requires it; and one of these lines, a pipe of 36in. diameter, is being laid between the two 48in. pipes. On the line of this aqueduct there are no less than 25 important iron and stone bridges, and 80 distinct tunnels, varying in length from 1½ mile downwards, and forming a total length of 13 miles.

The Mugdock service reservoir is 8 miles from Glasgow, and has a water surface of 60 acres, with a depth of 50 feet. The surface of the water is 312 feet above the level of the sea. It contains 26 days' supply at the present rate of consumption, and repairs can thererore be made on the aqueduct without interrupting the supply to the city. The water is taken to Glasgow by two lines of 36in. pipes, with provision for additional pipes, as may be required. The sluices, self-acting throttle valves, momentum valves, any many other details of this great work, are all worthy of notice, but I cannot now do more than allude to them. The water-works were opened by the Queen on the 14th of October, 1859, and the total cost was £1,592,000.

The water is now supplied to nearly all the villages and populous places round about Glasgow, and the natural increase of the revenue is about £5,000 per annum. The water-rate paid is 1s. per pound for dwelling-houses, and 1d. per pound additional on all properties in the parliamentary limits.

Notwithstanding the great purity of the Loch Katrine water—more than nine times as pure as that supplied to London—the inhabitants of Glasgow yearly consume upwards of 1,000 tons per annum of foreign matter in the water from that lake.

The Greenock new waterworks include two reservoirs, with an aggregate capacity of 1,200,000,000 gallons. The embankments are 2,200 and 850 feet in length respectively, with a height of about 60ft. in the centre. The tunnel for conveying the water from these storage reservoirs to the point of distribution is fully 1½ miles long, and there will be filter-beds, having an area of 6,700 square yards.

The waterworks commenced at Paisley consist in the construction of a store reservoir to hold 76,000,000 cubic feet, having an area of 100 acres, a maximum depth of 35 feet, and a catchment of 1,220 acres. From thence the water will be taken by an aqueduct of 6½ miles in length to filters to be constructed above the present store reservoir at Stanley, about 2 miles from the centre of Paisley. The works are also intended to provide a supply for the towns of Johnstone and Elderslie.

The new waterworks at Port Glasgow, which were opened last month, consist of a reservoir on the Finlaystone Burn, with a filter and service tank at Park-hill. The reservoir covers of area of 26 acres, and contains 8,800,000 cubic feet of water, or more than 100 days' supply for a population of 12,000. The depth of water is 15ft., and the top water level is 346 feet above the mean level of the sea. The service tank is 256ft. above the sea, and with this pressure the highest houses in the burgh can be supplied.

The Edinburgh Water Company are engaged in collecting and leading to the farther end of the existing aqueduct at Rashie Dean, about 12 miles south-west from Edinburgh, the springs of Crosswood, the most distant of which is about six miles beyond Rashie Dean. A reservoir is also being constructed on Crosswood Burn, to afford compensation to that stream and to the river Almond for the abstraction of the spring water. The springs in question are expected to yield about 75 cubic feet per minute—say 675,000 gallons a-day; and the capacity of the reservoir is 25,000,000 of cubic feet, its area being 62 acres, and its greatest depth 38ft. The aqueduct is laid out so as to be capable of bringing in additional springs at the boundary between Mid-Lothian and Lanarkshire, but no Parliamentary powers have yet been got for taking those springs. The additional supply now being brought in, which is barely 10 per cent. on the present supply, will serve for a few years; but, with the rapidly increasing demands of this city, some much larger source of supply must soon be found.

The details of the scheme for the drainage of the Water of Leith are so well known to the inhabitants of Edinburgh, that it is not necessary for me to do more than allude to it. Except during floods, no sewage now enters the stream from Coltbridge to the sea, and it would be absolutely limpid and free from all impurities, were it not for the paper mills and other manufactories above Edinburgh.

The recent jury trial regarding the pollution of the North Esk has such an important bearing on the question of the Water of Leith purification, that it may be of some interest to the society to describe the nature of that pollotion, as well as the steps recently taken by the paper-makers for its amelioration.

The quantity of paper made at the mills on the North Esk has risen from 681,000lbs. in 1807 to 11,175,000lbs. in 1863.

Rags and rope were alone used up to 1861, when Spanish grass was introduced; and owing to the great reduction in the cost of foreign paper, following the abolition of the import duty in that year, the paper-makers gladly availed themselves of this new fibre, "Esparto," which enabled them to produce a cheaper paper than formerly, and thereby meet the competition of the foreigner.

Paper is now made from rags and Esparto, and the refuse discharged occasionally, or regularly, into the stream, according to circumstances, consists either of dry, semi-solid, or liquid impurities.

The dry refuse, either floor sweepings or dustings of rags, was, prior to 1841, thrown into the river, but since then has been collected and sold to farmers and others.

The semi-solid refuse is the sediment left after mixing dry bleaching powder, or chloride of lime, with water. Owing to the much greater quantity of chemicals necessary to bleach Esparto fibre, there has of late years been a great increase in the quantity of waste chloride of lime, and difficulty at present is found in its disposal. The paper-makers desire to keep it out of the river; and while in one or two cases the neighbouring farmers have been enterprising enough to use it as manure, yet, in the greater number of the mills, the millowners have not been able to do better than store it in heaps, where it solidifies, and becomes in course of time quite hard. It is believed to be fitted for application to clay lands or peat mosses; but the large proportion of moisture it contains, and the distance and height above the mills to which it requires to be carried for application to suitable ground, have hitherto delayed the utilisation of the waste chloride of lime. The consumption of bleaching powder on the Esk has increased from 113 tons in 1835 to 964 tons in 1863.

The liquid impurities are, however, by far the most objectionable of the refuse thrown into the river.

In the early part of this century writing paper was made from rags of so clean a character that no more soda was used than is employed in proportion by a washerwoman. But, since then, the extension of the trade, and the necessary use of rags from Russia and other countries, where the population are of very filthy habits, have obliged the paper-makers to employ rags of a much coarser and dirtier character than formerly, and thereby the great use of "soda" was begun. The quantity of soda used on the North Esk has increased from 35 tons in 1835 to 570 tons in 1856. After the introduction of Esparto fibre the soda rose to 980 tons, without any corresponding increase in the quantity of paper manufactured

It will be seen, therefore, that the exigencies of trade and the effects of legislation have caused the paper-mills, which, when first established on the Esk, were comparatively harmless, to become now an intolerable nuisance, and cause of pollution to the river to which they owe their birth.

The paper-makers have been at great expense in experiments to remedy the nuisance and in procuring the highest chemical advice; but the result can as yet hardly be called a triumph. Some of them are at present boiling down the liquors in which Esparto has been boiled, in shallow pans, or by Swan's patent process; and by incineration of the residuum in a reverberatory furnace they get back a great part of the soda. One of the manufacturers is erecting works at the sea-side, at which the Spanish grass is intended to be boiled down and washed, and afterwards sent as "half stuff" up to the works to be made into paper. This, though really begging the question altogether, is highly satisfactory for the stream. Prevention is better than cure, and there appears to be no reason why all paper-makers should not buy the Esparto grass in a boiled state, instead of each man boiling it himself, more especially as the patentees of the Esparto process are now ready to sell half stuff to those who wish it, instead of the raw fibre.

The washings from the various machines contain a good deal of fibre and colouring matter. Some of the fibre is retained by conical "save-alls," and some by subsidence in settling tanks. The best invention, however, for purifying liquor containing fibre, is Needham and Kite's filter-press; but it is both costly to buy and to work. One firm has three of them in use for the liquor from their three machines for making writing paper, and they discharge 70 gallons per minute of transparent water, which, when it entered the filter, was full of fine fibre. A great deal of the ultramarine and other colouring matter is also retained with the fibre. The liquors are driven into the filter-presses by a pump, and after being forced through two plies of strong cotton cloth, exude through hundreds of finely cut grooves in the framework of the presses.

I am glad to learn that the paper-makers on the Water of Leith are rousing themselves from their apathy, and are likely to do as much as their brethren on the North Esk. The Water of Leith does not certainly flow through the beautiful parks of spirited noblemen, but it does flow through the metropolis of Scotland, the inhabitants of which will never reap the full benefit of the money they have laid out in purifying their stream, till those who are polluting it higher up have also done their duty in arresting the sources of the contamination.

The sewerage of Portobello was completed some years ago, and nearly half the expense of the scheme was incurred in works to preserve the purity of the sea beach, by carrying the sewage in iron pipes out to low water.

The Haddington sewerage works are not yet commenced. It is proposed to utilise the sewage of this town by irrigating some adjoining land. For this purpose, the sewage will have to be pumped to a height of about 30ft., and Lord Wemyss has undertaken to pay half the estimated cost of pumping.

Jedburgh is bringing in a supply of about 60,000 gallons of water a day, by gravitation from the Blackburn springs to the highest part of the town.

Hawick lately got a supply of nearly 400,000 gallons per diem by gravitation from the River Allan.

Selkirk has a supply, if required, of above 100,000 gallons a day, from a well sunk in a haugh near the River Ettrick, pumped up, to about 300 feet above the highest part of the town, by a water power on the Ettrick. This river forms the natural outfall for the sewage of Selkirk, but it will be possible to irrigate about 25 acres of land belonging to the town with the sewage, after it is collected by the sewers now being formed. As the bed of the river is sometimes dry in summer, from the water going down the mill-lade, the new sewers will discharge into the lade itself, below the lowest point at which the water is used for manufacturing purposes.

The water for Peebles has been brought a distance of five miles in a 5in. pipe, from a stream which gives more water during dry weather than the town requires. There is, therefore, no store reservoir; but there is a small reservoir, containg about twenty days' consumption, which supplies the town while the stream is in flood. There is also ground for a filter if required.

A water work and system of sewerage is being executed at Moffat. Clay pipes are used for the sewers, and the water is brought in by iron pipes, with turned and bored joints, from some strong springs a few miles above the town.

The new water supply to the Bridge of Allan is by gravitation, principally from a burn which rises on the west of Demyat. There is a collecting and storing reservoir on the stream of 8½ acres, with an extreme depth of 20ft., capable of storing more than 19½ millions of gallons. This reservoir is 250ft. above the distributing tank, the greatest pressure from which will be 295ft. The intended supply is 25 gallons per diem to a maximum population of 4,500.

The burgh of Alloa is at present supplied with water from Gartmorn Dam, which lies two miles to the east of the town. The water is conducted to the filters in an open cut or lade, exposed to contamination from several sources. It is now to be taken in pipes, and large and efficient filters are also being made to provide for the increasing population.

The Dunfermline Town Council, having purchased the property of the Water Company, are constructing an additional store reservoir, to hold nearly 7 millions of cubic feet. As there is at present considerable waste from overflow, it is expected this will enable the works to afford a sufficient supply for a good many years. Dunfermline has lately also been drained on the small tubular pipe principle.

The burghs of Kirkcaldy and Dysart, with a population of 20,000, have power to obtain a supply of water from the Falkland hills, from a gathering ground about nine miles distant, consisting wholly of pasture land, and having an average elevation of 1,000ft. The water is to be led to a distributing reservoir near Dysart, high enough to afford every building within the district a supply under pressure of from 40 to 50 gallons per head per diem. This plan of grouping adjacent burghs or populous places for water purposes might, I think, be carried to a greater extent than has hitherto been done. Small places, by combination, might then go longer distances for really good water and a plentiful supply, than they could possibly do singly.

St. Andrews has lately been drained. The town is divided into two districts, and the sewerage of each taken in iron pipes out to low water. The water supply is also being improved.

The drainage of Dundee was begun in the year 1856, and with the exception of two outlying and thinly populated districts, the whole town has now been drained in accordance with the original plan. The town, however, is increasing so rapidly, by the addition of new streets, that the work of drainage can hardly be said to be completed. Tubular fire-clay sewers have been laid wherever tubes would suffice for the passage of the water, and egg-shaped brick sewers for the mains as they approached the outfall. There are 25 miles of tubular sewers, at an average cost per lineal yard of 13s., and 10 miles of brick sewers, averaging 33s. per lineal yard. The total cost of the drainage was about £56,000. The water used for flushing the sewers is the waste water from the various mills and factories in all parts of the town, and flushing gates are placed at numerous junctions, by means of which water can be made to flow through several series of sewers before it reaches the river. No ventilation of these sewers has been attempted, the town surveyor being of opinion that it is unnecessary where sewers are made sufficiently smooth inside and flushed with water so as to prevent all deposits. A great many of the streets in Dundee are very steep, some of them being 1 in 8; but in a few streets, where the fall is not great, and a supply of water for flushing could not be obtained, silting takes place, mostly of sand. This is cleaned out at intervals by a windlass placed over a man-way leading to the sewer, and another over the next man-way about fifty yards distant, an iron chain passing from the one windlass to the other, having scraping tools and brushes attached to it, and the sewer is easily and rapidly cleaned. In forming the sewers it was necessary to excavate 26,000 cubic yards of whinstone rock, and this was done by gunpowder, through crowded and narrow streets, without accident. Nearly all the sewage has been taken to one point in the River Tay, at a considerable distance from the town, so that at any future time it may be conveyed to the country for irrigating purposes by means of iron pipes and pumping apparatus, or be otherwise utilised.

The new works of the Dundee Water Company consist in the construction of an additional store reservoir in Crombie Den, capable of holding 32 millions of cubic feet. The area is 45 acres, and the greatest depth 55ft. The reservoir is for the purpose of enabling the Water Company to store up and use the whole yield of their gathering ground of about five square miles, whereof a large part now runs to waste. This can be but a temporary expedient, and a much larger supply must soon be procured for the town of Dundee from some more distant source.

The town of Perth is divided by the River Tay into two drainage districts—the western, or Perth proper, and the eastern, or Bridgend. The natural outlet for the sewage is the river. On each side a catch-sewer is proposed to be made along the side of the river, to receive all the sewage from the street drains, and discharge it at a remote distance below the town, keeping in view the probability of pumping it up, and applying it for irrigating the lower part of Moncrieffe Island, situated in the river a little below the town. The principal, and most densely populated, part of the western district lies low and flat. The gradients of the main drains will range from 1 in 750 to 1 in 200, at such depths as to admit of gradients for the house drains, of from 1 in 36 to 1 in 45. Abundant flushing is obtained for the whole of the main drains from mill-lades that intersect the town. Deodorising ventilators, reaching to the tops of the houses, are to be connected with every drain. As the western district is subject to floods, which have thrice during the last twenty years risen from 12in. to 24in. above the lowest parts of the streets, apparatus has been designed to prevent the sewage rising up through the gullies from the drains. This apparatus consists in a hollow india-rubber ball, hung by a chain within a water-tight chamber, so as to be entirely clear of the flow of the sewage in the gully. When acted upon by a back-flow, this ball floats into the mouth of the gully pipe, and is intended to prevent the sewage rising to the streets.

The eastern district affords for the most part facilities for step gradients in the drains.

The water supply for the western district is filtered from the river into a long drain or reservoir, in the upper end of Moncrieffe Island, and pumped up to a high level. The works were constructed many years ago. Of course, in carrying out the scheme of drainage, the purity of the filter beds is kept in view. There is always a large amount of water in the river, and a rapid current, leaning rather to the western side. The lowest summer discharge is estimated to be twelve hundred times the sewage discharge. The catch-sewer in the western district will be 5ft. diameter, of brickwork, and in consequence of its length, capable of containing, if required, the whole sewage of the town during the short time the tide lasts at Perth.

The main drains are some of them egg-shaped, from 3ft. by 2ft. to 4ft. by 2ft. 8in., and other pipes from 2ft. in diameter downwards. The scheme is at present being carried out.

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## DESCRIPTION OF A COMBINED OPTICAL SQUARE AND "LINE FINDER."

By JAMES M. BALFOUR, C.E., F.R.S.S.A., Otago.

In marine surveying especially, it is often very desirable to be able to run on a straight line between two objects, and the instrument submitted to the society is intended to facilitate this. It consists simply of two mirrors at right angles to each other. Any two objects seen in contact in the two must, if the mirrors be properly adjusted, be in line with the observer, or rather with the instrument. The third mirror has been added to enable the same instrument to be used as an optical square also. It is convenient, but not essential.

I am aware that similar instruments have been already made, but none have been constructed in so compact and convenient a form, the absence of all external machinery, which so greatly increases the field of view, being, I believe, new. I have already made and worked with a little instrument of this form, and found it to answer well; but even in this form the small field was found to be an objection, as when off the line it was difficult to pick up the second object. To overcome this objection, it occurred to me to make one of the mirrors a portion of a convex cylinder, so that the coincidence of the images at the point of intersection would still indicate a straight line; but when off the straight line, even to some distance, the second object would still be seen in some part of the curved mirror, and its position in the mirror would also show on which side of the line the observer was.

This idea appeared to deserve further investigation, and I found that the mirrors, when properly arranged, could be made very delicate measurers of angles. Thus, if the curved mirror be a portion of a cylinder subtending 15° at the axis, any point 15° on either side of the line would be visible in some part of the field; and if the curved mirror were made to slide at right angles to the plane one, it could be moved along till the contact became perfect, so that if the slide were divided an angle could be measured within these limits. As the delicacy of the scale will depend solely on the proportions of the mirror, this seems to promise great usefulness, from its being capable of a high degree of accuracy within certain limits. Such an instrument, being set to the constant angle, could be made to interpolate any number of points in a railway or other curve. The surveyor would have only to get a coincidence of the images of the poles at any point when he must be in the curve. Any possible error would be a maximum and not a cumulative error, as the original poles would be observed in all cases. Other applications of the principle will doubtless occur to others as they have to me. By proper modifications any angle within moderate and defined limits could be measured with great accuracy. Instead of a straight slide, the mirror could be made to turn on a centre, other than its centre of gravitation, with the peculiar effect that, by a proper selection of the centre, a comparatively deeply curved mirror can be made to do the work of a very flat one, and *vice versa*, so that the radius of curvature may be subordinated to convenience of manufacture. For astronomical and other delicate work, I should be inclined to take a central slice out of a convex lens of the proper curvature, and to silver it by Foucalt's process. This would insure great accuracy of curvature, and, consequently, a regular scale; while the trifling transverse curvature would not, I think, be objectionable.

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## THE MONT CENIS TUNNEL.

According to the usual monthly statement of the progress made in the Mont Cenis Tunnel, published by the Italian Government, the length of tunnelling during the month of December, 1867, was 73·25 mètres of which 30·40 mètres were on the Italian side at Bardonechi and 37·85 mètres at Modane on the French. The position of the tunnel up to the 31st of Dec. was as follows:—Total length of tunnel, 12,220·00m.; do. of boring, 7,846·65m.; leaving 4,373·35m. uncompleted.

The progress during the past year is 1,511·96m., of which 824·50m. were at Bardonechi, whilst at Modane the advancement was 687·46m. This difference may be attributed in a great measure to the extra hardness of the rock on the French side. The falling off in the advancement made during the month of Dec., as compared with the other months, is due to the suspension of the works for some days, for the purpose of verifying the levels and line by the engineers. Altogether the progress during the past year has been most satisfactory as compared with that of the previous year when the total progress at both ends amounted to only 1,024·99 mètres.

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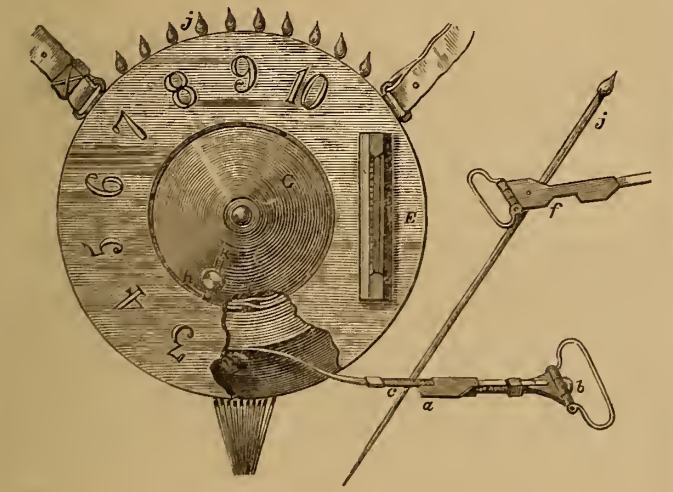
## PAINE'S STEEL MEASURING TAPES.

There are very few engineers who have been engaged in measuring land for any purpose requiring great accuracy but what have experienced the difficulty, not to say the impossibility, of doing so with the common surveyor's chain. A little wear in the links at once vitiates its accuracy; then there is the difference of length in hot and cold weather; and, again, the principle of measuring up to one side and from the other side of each pin, all combine to destroy anything like delicate accuracy. Besides the incorrectness of the chains in general use, another great objection to them is their weight, which is not only a fruitful source of error from causing them to sag, but increases the labour incurred over any particular job to an unnecessary extent. In order to overcome these objections and errors, Mr. Paine has invented an ingenious contrivance, an engraving of which is annexed, and which is intended to supersede entirely the old chain. This is a steel measuring tape fitted in a case made of light sheet brass, provided with a strap so as to be suspended at the side of the forward chain bearer; which case also carries the marking pins.

When the measure is to be used, it is entirely withdrawn and detached from the case, and the handles taken from their respective pockets in the edge of the case, are attached to the extremities, as shown in the annexed engraving. The smaller handle is attached to the front end of the measure, the shoulder, *f*, of which should exactly coincide with the first or zero mark on the measure. The rear handle is arranged to compensate for the expansion or contraction of the measure, caused by changes of temperature, which is caused by moving the scale, *c*, by means of the tangent screw, *b*, so that the end-mark, *a*, of the measure shall be exactly opposite the graduation on the scale, corresponding with the degree of temperature as indicated by the thermometer, seen on the case, at *E*. The shoulders represent the extremities of the measure; both face in the same direction, that all the contacts may be made exactly alike. The front shoulder is always made at a distance from the joint of the handle equal to some subdivision on the measure, for the purpose of measuring exactly to any upright flat surface, unless in some instances where handles are made with the measurement to commence flush with the end. The usual number of marking pins, *J. J.*, are received, each in a separate aperture, in the rim of the case, in the most convenient position for use, by the chain bearer; the absence of one will be detected at a glance. The tally record is kept by turning the knob, K, as an index, to, and securing it at, the proper figure on the front of the case. When the measure is returned to the case, this same knob is used to turn the plate or reel, *G*, on which the measure is coiled within.



The process by which the temper is reduced and the application of a zinc coating, gives great tenacity to the steel tape, and also protects it from oxidation—a very necessary property for such an instrument. The extreme lightness of this tape must also be a great convenience, besides doing away with the error caused by sagging; the weight of one chain of this tape only being about 12 ounces, although the tensile strength is upwards of 400 pounds. The method of suspending the case with the marking pins in it is ingenious, and admits of the heads of the pins being made plummet-shaped so that they may be inverted and dropped with considerable accuracy when occasion requires. This measure has been in use for a considerable time in the United States, and has been adopted by many of the leading engineers of that country.

## ROYAL NAVAL ENGINEERS.

Some years ago we called attention to the just complaints of the Royal Naval Engineers respecting their treatment by the Government. We now find that there are still left several disabilities which press most harshly upon them. Their chief engineers are not permitted to reckon for increase of full and half pay the whole of the service which had been rendered previous to attaining that rank, but only four years of that service. Now, as the average term of that service is above thirteen years, and as a very considerable portion of that time is frequently served in the capacity of senior engineer in a small vessel, and moreover as the *regulations* require that before an assistant engineer can receive his first promotion, "he must have served at sea for three complete years, and be fully competent to take charge of a watch at sea, when the steam is up;" it does seem very hard that more than nine years service should be counted by the Admiralty as nothing. The effect of the present extraordinary arrangement is, that very few chief engineers can serve sufficiently long to retire on full pay, unless they should continue to serve after they are physically incapable.

Another hardship of which the engineer officers complain is the slowness of promotion, only five officers being promoted to the rank of chief engineer during the year 1866, and twelve in 1867 from a body numbering over 500, exclusive of 1st and 2nd class assistants. The cause of such slow promotion results from the niggardly practice of the admiralty in not appointing chief engineers to all vessels in which other departmental chiefs are born, and which would appear to be right, but only to some of the larger vessels.

The engineers also complain that the old system of requiring five years service to be rendered for each increase of full and half pay is enforced in their case, though it has been altered in the case of other officers of corresponding rank to their own. They point out that in many cases very great hardships has been experienced by officers who from illness or other cause have been removed from active service at a time when a large portion of the required term of five years has been served, and who for want of the remaining portion of the term (possibly only a few weeks or even days) are deprived of a very large fraction of their income, in some cases as much as one-fourth being thus lost to the unfortunate victim of the present system.

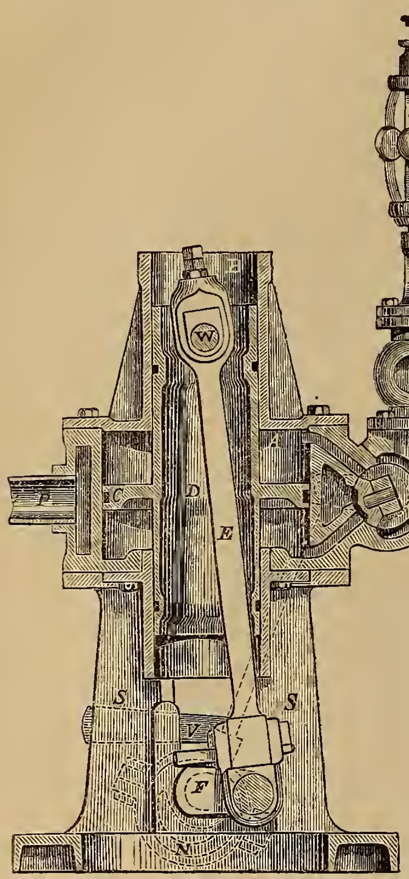
## TURRET SHIPS.

The armour-plated iron turret-ship *Monarch*, 6 guns, 5,100 tons, 1,100-horse power, building at Chatham Dock-yard, the only turret-ship under construction in either of the Royal shipbuilding yards, was commenced shortly after the keel of the *Hercules* was laid down, in the latter part of 1866. A variety of causes have, however, contributed to prevent the turret-ship being pushed forward with that rapidity which has characterised the construction of the *Hercules*, and fully 12 months more are likely to elapse before the *Monarch* will have a gun on board, or be ready to proceed on her experimental cruise. Although nominally intended to represent a powerful ship on the turret principle the "improvements" and alterations made in her design have been so many and frequent that the principal advantages of the turret principle have been entirely sacrificed to the prejudices of naval officials connected with the Admiralty. The chief distinguishing feature in the *Monarch* is the great comparative height of her free-board, which from her water-line to her upper deck is 14ft., or more than double the height of American turret-ships, as well as those building for European Powers. In the turret-ship *Captain*, building at the yard of Messrs. Laird at Birkenhead, under the sole superintendence of Capt. Coles, the free board is carried to a height of 9ft. Another important deviation from the accepted theory of a true turret-ship has been in the placing of a huge topgallant forecastle on the *Monarch's* upper deck—a strikingly novel feature, insisted upon by the Admiralty in opposition to the remonstrances of the officials connected with the department of the Controller of the Navy, to whom the designs of the *Monarch* are credited—the effect of which will be that the turret guns will only be enabled to sweep a portion of the deck, instead of having an all round fire. The turrets alone will absorb 177 tons of 10in. and 8in. armour-plating, the *maximum* thickness of 10in. plating being fixed in that part of the turrets close to the gun, and plates of 8in. in thickness in the remaining parts. The 10in. plates will be laid on a backing of teak 8in. in thickness, and the 8in. plates on a similar backing of 10in. in thickness. Behind the timber backing will come a skin of ⅝in. iron plating, fastened to 7in. girders, with an inner plating ¾in. in thickness, the total thickness of iron and wood in the turrets being 2ft. 2⅜in. Along the entire broadside of the vessel protecting the turrets will be laid armour-plating 7in. in thickness, laid in five tiers, with a single tier of plates 6in. in thickness. The total quantity of armour-plating protecting the *Monarch's* sides will be 1,380 tons, of which about two-thirds have already been bolted to her sides. From the central broadside aft the plates range from a thickness of 7in. to 4½in., with a *minimum* thickness of 3in. under the counter. Forward the plates taper from 7in. to 4in., with the exception of the third tier, in which none of the plates are less than 5in. in thickness. The armament of the *Monarch*, as at present decided upon by the Admiralty, will consist of a couple of 22-ton guns in each of the turrets, the foundations for the platforms being already laid in each turret. In addition to these, however, and as a compensation for the *Monarch* not being able to fire her turret guns directly ahead or astern, a 6½-ton gun will be placed in the bow and stern, both guns firing in a line with the vessel's keel, and each protected by armour-plating. The *Monarch* will be a full-rigged ship, her running gear being worked from the upper deck as in an ordinary vessel, the fore and aft bridge, or hurricane deck, usually seen in turret-ships not being required. The machinery is in course of manufacture by Messrs. Humphreys, Tennant, and Co., of Deptford-pier, and is of 1,100-horse power (nominal).

## ROOT'S TRUNK ENGINE.

This engine of which we give an engraving was exhibited at the late Paris Exhibition, and obtained a prize medal. It has also received a premium at the late exhibition, or—as the Americans call it—fair of the

American Institute, and seems likely to come into considerable favour in that country and possibly also in England. The chief peculiarities of this engine over the usual description of trunk engines appears to be the method of packing the trunk, and also the adoption of a longer connecting rod than usual, so as to lessen materially the side strain, while at the same time the characteristic compactness of the trunk arrangement is retained. In trunk engines, as usually built, the large stuffing boxes are a constant source of annoyance, especially if superheated or high pressure steam is used, and the trouble of keeping them steam-tight is often much increased by the side strain and consequent wear induced by a short connecting rod. In this engine, an engraving of which is annexed, it is claimed that the defects above mentioned have been entirely obviated.



The general arrangement of the engine will easily be understood from the sectional elevation, where it will be seen that the cylinder A is cast with an exhaust chamber, P running entirely around it, and thus forming a steam jacket to prevent condensation. The steam chest J and the lower cylinder cover are also cast on the cylinder. The trunk D passes entirely through the cylinder and cylinder covers, and has a pin W at the upper end of it, or at the end farthest from the crank-shaft F, to which is attached the connecting rod E, fitted with brasses in the usual manner. The trunk is kept in line while reciprocating by the upper guide B, cast upon the top cylinder cover, while the lower guide is bolted on the lower cylinder cover. The insides and ends of the cylinder and guides, and the outside of the trunk and piston being all turned and fitted up in a lathe, the piston and trunk must necessarily run true with the cylinder and guides. The piston has the usual steel packing-ring, turned slightly eccentrically and cut and fitted with a tongue. The trunk is kept steam-tight by having precisely similar packing-rings towards its upper and lower extremities; the guides being sufficiently prolonged to allow these rings to work in them during the full length of the stroke of the piston. The steam chest J is bored out and the valve face turned to fit it; the valve being worked by a pin in the valve spindle. This pin is not fixed rigidly into the valve, but permits of end play to allow for any wear of the valve face or seat. The valve spindle is worked in the usual manner by a cranked arm connected to the rod of the eccentric N. The top of the frame is bolted to the under side of the cylinder, while the bearings are formed near the bottom as shown in the engraving; the brasses being adjusted by a taper key. A cap or cover, not shown in the engraving, is sometimes fitted over the top guide B to avoid as much as possible any loss of heat by radiation from the trunk.

As this is intended to be a quick running engine, a sufficient momentum and regulating power is obtained from a comparatively small fly wheel, which still further contributes to the compactness of the engine.

It is said that a 20 horse-power engine, including fly wheel, only occupies a floor space of 36in. by 52in., and is 61in. high; while a 40 horse-power engine occupies a floor space of 60in. by 72in., and is 7ft. high.

Upon the whole this seems to be a very compact engine, having very few working parts, with a very judicious disposition of the strain; and, should the packing-rings of the trunk be found to keep tight, would give but little trouble in its management.

## THE LATE SIR DAVID BREWSTER.

Sir David Brewster, Principal of the University of Edinburgh, died at his seat Allerly, near Melrose, on Monday night, in the 87th year of his age.

David Brewster was born at Jedburg on the 11th December, 1781, his father being rector of the grammar school there. He was destined for the ministry and was accordingly sent to the university of Edinburgh, where he passed through the theological classes and took licence as a preacher, but his inclinations were too strong towards the study of science, and the observation of natural phenomena. He received the degree of M.A. in 1800 and devoted himself principally to the study of optics.

In 1807 he was made LL.D. of Aberdeen University; Oxford conferred on him the degree of D.C.L.; and Cambridge that of A.M. Next year, Dr. Brewster was elected a member of the Royal Society of Edinburgh, of which he subsequently filled the offices of Secretary, Vice-President and President—holding the latter office at his death; and in the same year he took in hand the task of editing the "Edinburgh Encyclopædia," a work to which he made a number of important and interesting scientific contributions, and which he did not complete till 1830. In 1813, under the title of a "Treatise on New Philosophical Instruments, &c.," he presented to the public some of the results of his optical researches during the preceding twelve years. In 1815, he sent to the Royal Society of London a paper "On the Polarisation of Light by Reflection;" and the Society elected him a Fellow, and voted him their Copley medal for his discoveries and researches. Next year (1816), Brewster had the honour to receive from the French Institute half of the prize of three thousand francs awarded for the two most important discoveries made in Europe in physical science during the two years preceding. In the same year, he achieved the invention which has rendered his name most popular—that of the Kaleidoscope.

In 1818 Dr. Brewster received from the Royal Society of London their Rumford gold and silver medals, for further researches on the subject of the polarisation of light; and in the latter year he associated himself with Professor Jameson, the Scottish mineralogist, in the conduct of the *Edinburgh Philosophical Journal*, of which ten volumes were published up to 1824. In that year, the collaborateurs established, in its stead, an *Edinburgh Journal of Science*, in the sixteen volumes composing the collection of which, many interesting papers of Dr. Brewster's were published. In 1825, he was elected a corresponding member of the Institute of France, which had several years before otherwise rewarded his fruitful scientific labours. The Royal Society of London again, in 1830, did Dr. Brewster honour, by the award of its royal medal for the researches and discoveries by which he had enriched and widened the field of optical science. In union with Davy, Herschel, and Babbage, he originated the idea of a British Association for the promotion of science by means of periodical congresses; and it was largely owing to his personal and literary exertions, that the first meeting of the Association was held, and held successfully, at York in 1831. The same year saw a fresh honour paid to Brewster, in the conferment of the decoration of the Guelphic Order of Hanover; and next year (1832) he was knighted by King William IV. In 1838, the Crown appointed Brewster Principal of the United Colleges of St. Salvator and St. Leonard at St. Andrews; which he held until 1859, when he was unanimously elected by the curators, Principal of the University of Edinburgh. In 1849, he received from the French Institute, on the occasion of the death of the great chemist Berzelius, the highest honour it can bestow on any one not a Frenchman, by being chosen one of its eight Foreign Associates; and in the same year he was president of the British Association. In 1851, at the Great Exhibition, Sir David exhibited his ingenious and popular adaptation of the stereoscope. To the distinctions that we have enumerated as falling to his share—and that of the corresponding-membership of the Royal Societies of St. Petersburg, Berlin, Vienna, Stockholm, Copenhagen, and several other Continental cities—the King of Prussia added (in 1847) the Order of Merit, and the Emperor Napoleon (in 1855) the cross of the Legion of Honour.

The list of Sir David Brewster's contributions to scientific and general literature is very extensive. In the Transactions of the Royal Societies of Edinburgh, London, and Dublin, and other learned bodies, many of his most valuable scientific observations and discoveries are recorded. The "Edinburgh Encyclopædia," the "Edinburgh Philosophical Journal," the "Edinburgh Journal of Science," the "Philosophical Magazine" (of which Sir David was one of the editors), the *Edinburgh* and *North British Reviews*, the Transactions of the British Association, the Library of Useful Knowledge, have all been enriched by numerous products of his pen, bearing upon almost every department of physical science. His separate works were:—"A Treatise on New Philosophical Instruments for Various Purposes in the Arts and Sciences, with Experiments on Light and Colours," 1813; "A Treatise on the Kaleidoscope," 1819; "Notes to Robison's System of Mechanical Philosophy," 1822; "Letters and Life of Euler," 1823; "Letters on Natural Magic," dedicated to Sir Walter Scott, 1824; "A Treatise on Optics," 1831; "Life of Sir Isaac Newton," 1831; "The Martyrs of Science, or Lives of Galileo, Tycho Brahe, and Kepler," 1841; "More Worlds than One, the Creed of the Philosopher and the Hope of the Christian"—an answer to Professor Whewell's "Plurality of Worlds"—1854; "Memoirs of the Life, Writings, and Discoveries of Sir Isaac Newton"—1855. He also edited a translation of Legendre's "Geometry."

## FIFTEENTH ANNIVERSARY OF THE FOUNDATION OF THE LONDON ASSOCIATION OF FOREMAN ENGINEERS.

The fifteenth anniversary of the above association was celebrated on Saturday, the 15th ult., by a banquet at the City Terminus Hotel, Cannon-street, Mr. Whitworth, L.L.D., F.R.S., in the chair. Upwards of 200 sat down to an excellent dinner, and among the guests were Major the Hon. G. F. Jocelyn, Messrs. Penn, Napier, Rennie, Humphry, Robertson, S. Smiles, E. J. Reed, Chief Constructor of the Navy, Captain M'Neile, Captain Routh, Mr. Chetwynd, of the Post-office, Mr. Worssam, Captain Shaw, London Fire Brigade, Mr. Wm. Smith, C.E., Mr. R. S. Fraser, Mr. Hendry, Mr. Cargill, C.E., &c. Mr. Joseph Newton, who has held the office of president for ten years, and to whom the society is greatly indebted for its success, occupied a seat next Mr. Whitworth. After the usual toasts had been proposed and responded to, some excellent speeches were delivered by Major Jocelyn, Mr. E. J. Reed, Mr. Joseph Newton, Mr. John Penn, Mr. Napier, Mr. George Rennie, Mr. James Roberton, Mr. S. Smiles, and others, and the proceedings terminated.

## THE SUEZ CANAL.

Sir,—In your letter addressed to me, and published in the February number of The Artizan, you take exception to some remarks in my address to the Civil and Mechanical Engineers' Society touching the works now going on at the Suez Canal.

In reply, I have to say that I believe the figures I then brought forward are undeniable. They no doubt refer to a period two years past, as I then stated, since which time I find, from Monsieur Lesseps' Report, bearing date August, 1867, which you have had the kindness to send to me, that the works have made very considerable progress, and that there is now a certainty that the canal will be "entierement terminé" in October, 1869.

You will at once perceive that it would have been hardly possible that I should have had an opportunity of making quotations from that report, published in Paris for the benefit of a meeting of shareholders in the month of August, and of introducing them into my address given here in the following October.

I heartily wish Monsieur Lesseps success in the prosecution of this great enterprise, which will, when completed, shed upon him an enduring lustre, such have been the skill and the unflagging courage which alike, through evil report and through good report, he has displayed since the digging of the first trench.

I have the honour to be, Sir,
Your very obedient servant,
B. Haughton,
President of the Civil and Mechanical Engineers' Society.

Daniel A. Lange, Esq., Director and English Representative of the Suez Canal Company, London.

[We have been requested to publish the above letter.—Ed. Artizan.]

## REVIEWS AND NOTICES OF NEW BOOKS.

*The Combined "End-on" and Broadside Principle* versus *the "Turret.* A Paper read by Capt. T. E. Symonds, R.N., at the Royal United Service Institution. Harrison and Sons, St. Martin's-lane.

In this paper Capt. Symonds very ably points out the great advantages possessed by a vessel which can fire in a line with the keel over the old system when a vessel had to be yawed round considerably before it was possible that the guns could be brought to bear upon the required object. Thus, in the case of chasing a pirate or other vessel, it often happened to be fruitless because no guns could be brought to bear in the direction of the vessel being chased, which, of course, would be in line with the keel. In his system the broadside ports are retired or recessed about two feet from the side, so that the guns may be trained to a much greater angle than is usual, and by which means the fire can be concentrated much nearer. In order to obtain a perfectly "end-on" fire, the vessel is made with an indented side, at a sufficient distance from the stem and stern to enable the vessel to carry the heavy guns steadily, the indent being of sufficient extent to form a port-hole, and the vessel forward of the fore port and astern of the after port is so built in from a sufficient depth below the port upwards as to admit of a shot being fired from this port in line with the keel. Capt. Symonds points out that the turret vessels as at present designed cannot fire nearly in line with the keel, and consequently would be useless for attacking end-on, and would therefore be placed at a disadvantage when fighting with a vessel constructed according to his designs.

*Abridgments of Specifications relating to Patents for Inventions; also the Index to Foreign Scientific Periodicals.* By Bennet Woodcroft Esq., of the Great Seal Patent Office. 1868.

The last four volumes of abridgments published by order of the Commissioners of Patents relate—1st, to Railways, from the year 1770 to 1863; 2nd, to Hydraulics, from 1617 to 1865; 3rd, to the Preparation and Combustion of Fuel, from 1620 to 1865; and, 4th, to Raising, Lowering, and Weighing—and are so admirably complete and exhaustive as to merit special notice and commendation of the compiler's labours. The first volume of the "Index to Foreign Scientific Periodicals contained in the Free Public Library of the Patent Office" was issued in numbers between June 1st, 1866, and June 28th, 1867, and contains, in addition, an "Index of Authors," and an "Index of Subjects," mentioned or quoted in the "General Index" to the contents of the foreign periodicals. These are exceedingly useful works for the inventor, patentee, and manufacturer. We must, however, postpone until a more convenient opportunity further reference to these books.

*The Year Book of Facts*, 1868, by John Timbs, F.S.A. Lockwood and Co., 7, Stationer's Hall-court, London.

This valuable annual has frequently been noticed in The Artizan, as each year a vast number of miscellaneous but interesting "facts" are chronicled in its pages, giving an account of the most important discoveries and improvements that have taken place during the preceding year. In this "Year Book" is contained descriptions of an immense number of novelties in the mechanical and useful arts, in natural philosophy, electricity, chemistry, natural history, geology, mineralogy, astronomy, &c. The work is compiled with great care and will be found valuable both for reference and instruction alike to the scientific and the general reader.

*A Magyar Mérnök-egyesület Közlönye.*

The above it may be necessary to explain is the title of a new Hungarian scientific periodical, issued by the Society of Civil Engineers of Pesth. It is published every second month and contains several very fairly executed lithographic plates; the first being a very good railway map of Hungary, showing the lines projected, in progress and completed. As comparatively few people understand the Magyar language, a glossary (Magyar and German) has been inserted in the first number in order to make the articles intelligible to a greater number of readers.

## ERRATA.

In February number, under heading "Suez Canal," p. 44, 14th line from top, read "where" instead of "when," and in the same page, 11th line from bottom, read "and *audit* has been *regularly* gone through," instead of "and *credit* had been *rapidly* gone through;" and in last line of same article for "Birmingham" read "London."

## NOTES AND NOVELTIES.

### MISCELLANEOUS.

The port of Wisbeach received, in the year 1863, 124 vessels of the aggregate burthen of 22,015 tons; 1864, 158 vessels, 28,542 tons; 1865, 217 vessels, 36,514 tons; 1866, 122 vessels, 22,973 tons; and in 1867, 133 vessels, 24,615 tons.

**Royal Albert Hall, South Kensington.**—The plans of Mr. W. W. Phipson, C.E., have been selected for the ventilation and warming of the above. The heating apparatus for the hall alone will be composed of more than 27,000ft. of 4in. hot-water pipe, arranged in coils, under the arena, galleries, and lower corridors, the fresh air from the outside being caused to circulate amongst them by means of two fans, 6ft. in diameter.

A list of casualties on the western and south-western lakes and rivers in America during the past year shows that 128 accidents to boats occurred, 82 of which resulted in the total destruction of the vessels. The loss of life was over 90, and of money 645,000 dollars.

The first selected armour-plate for the turret ship *Cerberus*, which is being built at Jarrow, for the colony of Victoria, was tried at Portsmouth in the early part of last month. Eighteen shots were fired at it in two clusters, nine shots being planted in one cluster, with the edges of the indents overlapping. The plate, which was manufactured by Messrs. Cammell and Co. (Limited), proved of very superior quality.

The number of forges and blast furnaces in the Zollverein in 1865 was 1,581, which produced 4,060,628 tons of iron, lead, zinc, &c. In this total the works devoted to the production of iron numbered 1,376, and the number of workmen employed in them was 87,097, the quantity of iron being 3,784,905 tons.

The Royal Mail steamers now stop at Jamaica instead of St. Thomas. They only just call at the latter island to drop their intercolonial mails and fill up with coal. Virgin Gorda, one of the Virgin Islands, will probably be made the rendezvous of the steamers. In the first instance the steamers were made to call at Madeira to coal up, and then to Grenada, one of the safest islands from storms and convulsion; then they were made to go to Bermuda, because the British admiral was stationed there. This was a disastrous route on account of the weather experienced on it. At length the increased demand for speed compelled the building of monster steamers to run to St. Thomas, a distance of nearly 4,000 miles, without stopping to coal.

The following figures illustrate the growth of Scotch shipping:—In 1656, the number of vessels belonging to Scotch ports was 137, measuring in the aggregate 5,736 tons, which gives an average of about 42 tons. In 1760, there were 999 vessels, of 53,913 tons in the aggregate, or an average of about 54 tons. An immense increase took place in the forty years following; and in 1800 there were 2,415 ships, carrying 171,728 tons, averaging a fraction over 71 tons, and employing 14,820 seamen. The number and size of the vessels went on increasing, and on 31st December, 1840, there were 3,479 ships of all kinds, the aggregate tonnage of which was 429,204, the average being over 123 tons, and the number of seamen 28,428. Ten years later the numbers were—Sailing ships, 3,432; aggregate tonnage, 491,395; average, 143 tons; steam ships, 169; aggregate tonnage, 30,827; average a fraction over 182 tons. During the next decade a great change took place in the size of the ships, consequent on the extension of foreign trade and the improvement of harbours and docks. The total number of sailing ships in 1860 was 3,172, being 260 fewer than in 1850; but the tonnage showed an increase of 60,817, so that while the average tonnage in 1850 was 143, in 1860 it was nearly 175. The number of steam-vessels had increased in 1860 to 314, with an aggregate tonnage of 71,597, the average being 228. On 31st December, 1866, the number of sailing vessels of and under 50 tons registered in Scotland was 1,030, with an aggregate tonnage of 31,218; above 50 tons, 1,922 vessels, with a tonnage of 610,710. The number of steam vessels of and under 50 tons was 130, with a tonnage of 3,452; above 50 tons, 340; tonnage, 136,470. The returns for last year have not yet been made up.

It is computed that the cost of distilling water at Annesley Bay is 2s. a gallon, and the daily needs of the men and animals collected there average 40,000 gallons a day. Therefore, the water supply alone of that station is costing the British taxpayers at the rate of £1,520,000 a year.

**Mineral Traffic on Railways.**—In 1862 the railways of the United Kingdom carried 63,405,864 tons of coal, coke, and minerals; in 1863, 68,043,154 tons; in 1864, 75,445,781 tons; in 1865, 77,805,786 tons; and in 1866, 85,483,444 tons, showing an increase in five years of no less than 22.077,580 tons. The revenue derived by British railways from mineral traffic stood in 1862 at £4,957,406; in 1863, at £5,419,667; in 1864, at £6,302,888; in 1865, at £6,469,502; and in 1866, at £7,074,923. The mineral traffic of the 14 leading railways of England, Wales, and Scotland was as follows in 1866:—Caledonian, 5,691,129 tons; Glasgow and South-Western, 2,755,305 tons; Great Eastern, 1,010,173 tons; Great Northern, 2,391,007 tons; Great Western, 6,012,211 tons; Lancashire and Yorkshire, 4,531,620 tons; London and North-Western, 11,331,103 tons; London and South-Western, 493,805 tons; London, Brighton, and South Coast, 629,627 tons; Manchester, Sheffield, and Lincolnshire, 2,460,866 tons; Midland, 5,983,873 tons; North-Eastern, 15,813,619 tons; North British, 4,118,943 tons; and South-Eastern, 236,992 tons. The system which enjoys the finest mineral traffic is thus the North-Eastern, which comprises the old Stockton and Darlington, West Hartlepool, and Newcastle and Carlisle Railways.

**Unwrought Steel.**—The quantity of unwrought steel exported from the United Kingdom was about maintained last year, the total to November 30th, having been 30,517 tons, as compared with 31,529 tons to the corresponding date of 1866, and 20,868 tons to the corresponding date of 1865. The slight decline observable arose in the deliveries to the United States, which only amounted in the first eleven months of 1867 to 17,778 tons, against 18,799 tons in the corresponding period of 1866, and 9,418 tons in the corresponding period of 1865. The total value of the unwrought steel exported to November 30th last year was £998,619, as compared with £1,029,907 in the corresponding period of 1866, and £686,110 in the corresponding period of 1865. The value of the unwrought steel exported in the whole of 1866 was £1,129,761; in the whole of 1865, £782,129; in the whole of 1864, £890,395; in 1863, £935,517; in 1862, £848,933; in 1861, £726,956; in 1860, £986,228; in 1859, £805,832; in 1858, £589,676; and in 1857, £748,579. The quantities of unwrought steel exported in each of the ten years were as follows:—1857, 22,374 tons; 1858, 16,378 tons; 1859, 24,744 tons; 1860, 32,173 tons; 1861, 21,810 tons; 1862, 25,779 tons; 1863, 28,687 tons; 1864, 26,834 tons; 1865, 23,877 tons; and 1866, 34,647 tons.

### NAVAL ENGINEERING.

Her Majesty's unarmoured screw steamer *Blanche*, 6 guns, 1,268 tons, with engines of 350 horse-power, built and fitted out at Chatham dockyard for a three years' commission, made her official trial of speed at her deep load draught at the measured mile, Maplin Sands. On getting under way the *Blanche* drew 16ft. 7in. aft, and 13ft. 7in. forward, which was slightly in excess of that of her sister ship, the *Danae*, when tried at the measured mile, and also rather more than her deep draught as designed, the increased displacement being due to the two additional guns composing her armament, with the necessary shot, shell, and ammunition, together with some thirty hands more than her originally-fixed complement. The weather was favourable for the trial, the wind being from the W.N.W., with a force of from two to three. After the preliminary run to prepare the furnaces and boilers, the vessel was placed on the measured mile, and six runs made at full-boiler power with the following results:—First mile—5 min. 29 sec., speed in knots per hour 10·942, steam 31lbs., vacuum 27in., revolutions of screw per minute 88; second mile—time 4 min. 1 sec., speed 14·938 knots, steam 30lbs., vacuum 27in., revolutions 88; third mile—time 5 min. 20 sec., speed 11·250 knots, steam 30lbs., vacuum 26in., revolutions 86; fourth mile, time 4 min. 2 sec., speed 14·876 knots, steam 30lbs. vacuum 26in., revolutions 87; fifth mile—time 5 min. 23 sec., speed 11·146 knots, steam 28lbs., vacuum 26in., revolutions 84; sixth mile—time 3 min. 57 sec., speed 15·190, steam 33lbs., vacuum 25, revolutions 88, giving the mean as 13·055 knots per hour, or nearly two-tenths of a knot per hour more than the speed of the *Danae*, which, when tried at a lesser draught on the 12th ult., at Stokes-bay, realized a mean speed of 12·872 knots as against 13·384 knots per hour at light draught, showing that the *Blanche* is, in comparison, a faster vessel at her deep load draught than the *Danae* at her light draught, although both vessels and machinery were constructed from the same drawings and patterns.

Under the superintendence of Captain Willes, who is in command of the steam reserve at Devonport, a trial of the iron double-screw steam corvette *Penelope*, 10, was made at the measured mile outside Plymouth breakwater on the 14th ult. The weather was fine. The *Penelope* was built at Pembroke; she burdens 3,096 tons, and has engines of 600 horse-power nominal, constructed by Messrs. Maudslay, Field, and Co., whose partner, Mr. Maudslay, jun., with Mr. Warriner, was on board. The result of six runs gave a mean speed of about 12½ knots, which was considered satisfactory. The *Penelope* is provided with two rudders, and when both screws were put in motion and both rudders turned to port or to starboard the corvette performed the circle in less time than when one screw was reversed and its rudder placed so as to aid the movement. The *Penelope* is now in Keyham steamyard, where her fittings will be completed.

### MILITARY ENGINEERING.

One of the old 32-pounder cast-iron ordnance guns, of which a vast number have encumbered the gun park at Woolwich for some years, and some of which have been handed over to Major Palliser for conversion to 64-pounders bored out and strengthened on his principle, has been in course of trial at the Woolwich butt. The gun has fired 100 experimental charges per day, and has already gone through the 1,500th round, without showing the smallest sign of weakness. It is intended to apply the *maximum* test of 2,000 proof rounds. As much depends on the success of the new system of using up the useless stock of old guns, the trials are witnessed with considerable interest.

### LAUNCHES.

**Launch of the Hercules.**—On Monday, the 10th ult., one of the most powerfully armed and one of the most strongly built ships ever sent afloat was turned into the Thames from Chatham Dockyard. In spite of all the expedition that has been used upon her, she has just been twenty months building, and another year will certainly elapse before she is fitted with her engines and ready for sea. Much time of course was occupied in designing her before she was begun, so that even using the utmost haste it takes *four* years to design, build, and fit out one ironclad. The dimensions of the *Hercules* are—length between the perpendiculars 325ft., giving a length over all of 337ft.; her extreme breadth is 59ft. Her draught is 22ft. 10in. forward, and 26ft. 10in. aft., and her burden 5,226 tons. Her displacement when undocked was just 5,225 tons, so that she came to within a fraction of an inch of her calculated immersion. Her displacement when fitted for sea will be 8,530 tons. The screw engines, by Penn and Sons, will be 1,200 horse-power nominal, but capable of working up to 7,200 horse-power, and are expected to drive the ship at a rate of not less than 14 knots an hour. The capacity of the cylinders is unusually large, they are jacketted all over, and the covers are cast hollow for the reception of steam. Small side valves are fitted on the top of the cylinders intended to admit steam and start the engines, whether the valves are closed or open. They can be easily worked by one man, and the engines may thus be kept slowly turning while the main links are in mid-gear. The condensers are cylinders 11ft. 4in. in diameter. The condenser tubes are of copper ⅝in. in diameter, and the aggregate length is not less than 12 miles. The condensing water is driven through these tubes by two Appold centrifugal pumps, drawing either from the bilge or the sea, and each discharging 60 tons of water per minute. These pumps are worked by a pair of auxiliary engines of 40 horse-power. The ship has two boiler rooms, each containing four boilers. The superheaters are so arranged that the ventilation of the stokehole will be kept as complete as possible. The weight of the crank shaft is 34 tons 16 cwt.; of the screw shaft, 24 tons; of the cylinders (each), 32 tons 17 cwt.; of screw propeller, 23 tons 10 cwt. The screw is not fitted with lifting gear, but it can be disconnected from the engine. The diameter of the cylinders is 127in.; of trunks, 47in.; of cylinders (effective), 118in.; length of stroke, 4ft. 6in.; number of revolutions (estimated), 65; speed of piston, 585ft.; diameter of screw propeller, 23ft. 6in.; number of blades, 2; number of boilers, 8; number of furnaces, 40; size of fire-grates, 2ft. 10in. by 8ft.; number of tubes, 3,600; length of tubes, 7ft.; diameter of tubes, 3in. The total weight of machinery, boiler, water, and spare gear will not exceed 1,090 tons, or rather less than 3 cwt. per indicated horse-power. Her main deck battery amidships consists of eight 18-ton rifled guns, each throwing what is called a 500-pound shot or shell. Forward on the main deck she is to have one 300-pounder, firing thruogh two ports as a bow chaser, and another of the same kind for the stern. On the upper deck there are to be four 6½ ton guns, or 150-pounders—only 14 guns in all.

The *Magpie*, first-class screw gun-vessel was launched on the 12th ult. from No. 2 building-slip of Portsmouth Dockyard. The *Magpie* is one of eleven vessels, all alike in dimensions, construction, and propelling power, and now completing in their build and outfit in the several Government dockyards. They are built of wood, carry no armour-plating, and average 665 tons measurement. Their other dimensions are:—Length between perpendiculars, 170ft.; extreme breadth, 29ft.; depth in hold, 12ft. 5in. Their propelling power consists each of a pair of three-bladed twin screws, driven by two sets of engines having a combined nominal power of 160-horse. The engines for the *Magpie* have been manufactured for the Admiralty by Messrs. Summers and Day, of Southampton. The accommodation for the officers and crew on board these vessels is ample, and the ventilation is also very good. As regards speed, they will average upwards of 11·5 knots under full steam. They are altogether very fit for the purpose for which they are supposed to be intended—the suppression of piracy in the Chinese and Japanese Seas; but for fighting purposes in any other part of the world they would be absolutely useless. As the cost of these eleven vessels must amount to £400,000, it becomes a question whether this large sum of money might not have been expended with truer economy in producing small ironclads.

The hydraulic propelled gun-vessel *Waterwitch*, Commander P. Sharp, having been completed in alterations and repairs at Portsmouth, has been put through trials of her machinery and speed prior to sailing on a competitive channel cruise with the twin screw gun-vessel *Viper*. On the 12th ult. the ship made her trial of speed over the measured mile in Stoke's Bay, her draught of water being 11ft. 2in. forward, and 11ft. 9in. aft, or a mean draught of 11ft. 5½in. The mean of six runs over the mile with full boiler power gave the ship a speed of 8·880 knots per hour, with an indicated power by the engines of 785 horse. Four runs with half-boiler power gave the ship a speed of seven knots per hour, with an indicated power by the engines of 370 horse.

The *Bullfinch*, first-class twin screw gun-vessel, built under the shed of No. 2 Dock of Sheerness Dockyard, was floated into the basin on the 14th ult. The ship is sister ship to the *Magpie*, noticed above. She is built of wood, but is strengthened between decks with iron beams, and has been constructed from the designs of Mr. E. J. Reed, Chief Constructor of the Navy. The engines are to be made by Messrs. Rennie and Co., and will be of 160-horse power, nominal, driving two propellers of the Mangin pattern. She will carry three guns—one 6½-ton, and two 40-pounder guns, all made so as to act as broadside guns. At the time of christening the ship drew forward 4ft. 8½in., and aft 6ft. 10in. of water. The following are her dimensions:—Length between perpendiculars, 170ft.: length of keel for tonnage, 151ft 7¾in.; breadth, extreme, 29ft. 0½in.: breadth for tonnage, 28ft. 8in.; breadth, moulded, 28ft. 2in.; depth of hold, 12ft. 5in.; burden in tons, 664 11-94.

## SHIPBUILDING.

An Admiralty order, received at Chatham Dockyard, directs preparations to be forthwith made for the construction at that establishment of another powerful armour-clad war ship of the *Hercules* class, in the large dock from which the *Hercules* was recently floated out. The instructions accompanying the order state that the new vessel will be in all respects the same as the *Hercules* below the water-line, and that the ironwork for the keel of the new ship is to be immediately commenced.

Messrs. Laws, Clough, and Co., of North Shields, have a large screw steamer building at Messrs. Schlesingen and Davis's yard at Sunderland. Messrs. Backhouse and Dixon, of Middlesbro', launched, on the 8th ult., the *Fulmar*, a steamer of about 1,000 tons, built for Messrs. Harris and Co., of that town. The engines have been supplied by Messrs. Blair and Co., of Stockton. Messrs. Backhouse and Dixon have another steamship of about 2,000 tons on the stocks.

Messrs. Napier and Sons are building, at their Govan yard, a steam ram for the Dutch Government. of about 3,000 tons; and also a turret ship, of about 2,000 tons, for the same government.

Steam Shipbuilding on the Clyde.—It is understood that Messrs. Scott and Co., of Greenock, have contracted with Messrs. Monies, Munro, and Co., to build for them a screw steamer of about 500 tons. The Glasgow and Londonderry Steampacket Company has purchased the paddle steamer *Bridgewater* from the Dublin and Liverpool Steam Navigation Company. The *Bridgewater* was built by Messrs. Caird and Co., Greenock, for Messrs. Burns' Glasgow and Belfast line of steamers; but she afterwards became a blockade runner under the name of the *Old Dominion*. On the conclusion of the American war she was purchased by the Dublin and Liverpool Company, and now she has once more changed owners.

It is understood that Messrs. Randolph, Elder, and Co. have concluded a contract to build two screws, each of 2,500 tons and 500 horse-power, for the direct Pacific trade from Liverpool to Valparaiso. The Liverpool, New York, and Philadelphia Steamship Company has completed a contract with Messrs. Tod and M'Gregor, of Glasgow, for a new steamer for the Transatlantic mail service. The length of this steamer will be 345ft., and her burden will about 2,600 tons, she is to be called the *City of Brooklyn*. Messrs. Macnab and Co. have launched a paddle steamer of 280 tons, named the *Walney*, built for the Furness Railway Company. The *Walney* will be supplied by her builders with disconnecting engines of about 100 horse-power.

## TELEGRAPHIC ENGINEERING.

It is proposed to lay a submarine cable between the Tyne and the coast of Denmark and thence to Copenhagen. Should the project be carried out the United Kingdom Telegraph Company will work the line. The distance is about 1,000 miles.

## RAILWAYS.

There are at present in India 3,657 miles of railway completed; the total number for which sanction has been obtained being 5,641. These 3,657 miles are worked by 8,000 Europeans and East Indians, and 50,000 natives. The rolling stock consists of 795 locomotives, 1,834 passenger carriages, and 17,446 trucks and wagons. The expenditure of capital amounted to £67,932,530 up to April 1st, 1867.

The number of locomotives added during six years (1860-66) inclusive, to the rolling stock of the railways in England, Wales, Scotland, and Ireland amounted to 1969.

## ACCIDENTS.

Seven Years' Railway Accidents.—In the seven years (1860-66) there were 297 passengers killed in railway accidents in the United Kingdom—169 of them from causes beyond their own control, and 128 through their own misconduct or want of caution. In the same seven years 4,515 passengers were injured—4,468 of them from causes beyond their own control, and 47 through their own misconduct or want of caution. The year 1866, for which the statistics have just been issued, was a favourable year. There were 274,293,668 passengers, besides 110,228 holders of season and periodical tickets. 15 passengers were killed, and 540 injured from causes beyond their own control; and 16 passengers were killed and 7 injured owing to their own misconduct or want of caution. In the seven years there were 1,477,649,511 ordinary passengers, and 504,893 holders of season and periodical tickets, making together 1,478,154,404 travellers by railroad in the United Kingdom. The result of the railway accidents of the seven years was that one passenger in 8,716,475 was killed, and one in 330,831 was injured, from causes beyond their own control, and one passenger in 11,548,081 was killed, and one in 31,450,093 injured owing, according to the company's returns, to the misconduct or want of caution of these passengers. This statement is to a certain extent more unfavourable than the facts, for as it is not known how many times the season and periodical ticket-holders travelled they are counted only once. If we suppose that they travelled one hundred times apiece upon an average the foregoing statement of ratios would be above 3 per cent. too high. For instance, the passengers killed from causes beyond their own control would be only one in 9,042,241. In the seven years, the number of ordinary passengers increased from 163,435,678 in 1860, to 274,293,668 in 1866, and the number of season and periodical ticket-holders from 47,894 to 110,227, the latter class of travellers increasing the fastest. The length of line open increased from 10,433 miles at the end of 1860, to 13,854 at the end of 1866, the number of passengers increasing a great deal faster in proportion than the number of miles.

## DOCKS, HARBOURS, BRIDGES.

Mr. Lyster, engineer of the Mersey Docks and Harbour Board, has submitted a report to the Works Committee, from which it appears that the amount required to complete the works in progress and contemplated is £700,694.

At the Victoria Docks 1,055 vessels, of an aggregate tonnage of 712,380 tons have been docked by the hydraulic lift during the past seven years.

Russia.—A bridge has been erected across the Boug, on the Balter and Olviopol, railway, which is 800ft. in length, the total weight being 1,610 tons.

## MINES, METALLURGY, &c.

The following is a return of the exports of coal shipped at the South Wales ports during the month of January last, and the corresponding month of 1867:—Cardiff, 162,361 tons; Newport, 32,356 tons; Swansea, 43,118 tons; and Llanelly, 7924 tons, in 1868, against:—Cardiff, 145,062 tons; Newport, 27,015 tons; Swansea, 37,470 tons; and Llanelly, 9,792 tons in 1867.

## LATEST PRICES IN THE LONDON METAL MARKET.

| | From | | | To | | |
|---|---|---|---|---|---|---|
| | £ | s. | d. | £ | s. | d. |
| **COPPER.** | | | | | | |
| Best selected, per ton | 75 | 0 | 0 | 76 | 0 | 0 |
| Tough cake and tile do. | 74 | 0 | 0 | 75 | 0 | 0 |
| Sheathing and sheets do. | 77 | 10 | 0 | 79 | ,, | ,, |
| Bolts do. | 83 | 0 | 0 | ,, | ,, | ,, |
| Bottoms do. | 86 | 0 | 0 | 88 | 0 | 0 |
| Old (exchange) do. | 66 | 0 | 0 | 67 | 0 | 0 |
| Burra Burra do. | 83 | 0 | 0 | 83 | 10 | 0 |
| Wire, per lb. | 0 | 1 | 0 | ,, | 1 | 0½ |
| Tubes do. | 0 | 0 | 11½ | 0 | 1 | 0 |
| **BRASS.** | | | | | | |
| Sheets, per lb. | 0 | 0 | 9 | 0 | 0 | 10 |
| Wire do. | 0 | 0 | 8½ | 0 | 0 | 9½ |
| Tubes do. | 0 | 0 | 10½ | 0 | 0 | 11 |
| Yellow metal sheath do. | 0 | 0 | 7¼ | ,, | ,, | |
| Sheets do. | 0 | 0 | 6¾ | ,, | ,, | ,, |
| **SPELTER.** | | | | | | |
| Foreign on the spot, per ton | 20 | 2 | 6 | ,, | ,, | ,, |
| Do. to arrive | 20 | 2 | 6 | ,, | ,, | ,, |
| **ZINC.** | | | | | | |
| In sheets, per ton | 26 | 0 | 0 | 27 | 0 | 0 |
| **TIN.** | | | | | | |
| English blocks, per ton | 96 | 0 | 0 | ,, | ,, | ,, |
| Do. bars (in barrels) do. | 97 | 0 | 0 | ,, | ,, | ,, |
| Do. refined do. | 99 | 0 | 0 | ,, | ,, | ,, |
| Banca do. | 92 | 0 | 0 | ,, | ,, | ,, |
| Straits do. | 89 | 10 | 0 | ,, | ,, | ,, |
| **TIN PLATES.*** | | | | | | |
| IC. charcoal, 1st quality, per box | 1 | 6 | 0 | 1 | 8 | 0 |
| IX. do. 1st quality do. | 1 | 12 | 0 | 1 | 14 | 0 |
| IC. do. 2nd quality do. | 1 | 4 | 0 | 1 | 6 | 0 |
| IX. do. 2nd quality do. | 1 | 10 | 0 | 1 | 12 | 0 |
| IC. Coke do. | 1 | 1 | 6 | 1 | 2 | 6 |
| IX. do. do | 1 | 7 | 6 | 1 | 8 | 6 |
| Canada plates, per ton | 13 | 10 | 0 | ,, | ,, | ,, |
| Do. at works do. | 12 | 10 | 0 | ,, | ,, | ,, |
| **IRON.** | | | | | | |
| Bars, Welsh, in London, per ton | 6 | 5 | 0 | ,, | ,, | ,, |
| Do. to arrive do. | 6 | 5 | 0 | ,, | ,, | ,, |
| Nail rods do. | 6 | 15 | 0 | 7 | 0 | 0 |
| Stafford in London do. | 7 | 7 | 6 | 8 | 10 | 0 |
| Bars do. do. | 7 | 7 | 6 | 9 | 10 | 0 |
| Hoops do. do. | 8 | 7 | 6 | 9 | 12 | 6 |
| Sheets, single, do. | 9 | 2 | 6 | 10 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 5 | 7 | 6 | 5 | 10 | 0 |
| Do. merch. Tyne or Tees do. | 6 | 10 | 0 | ,, | ,, | ,, |
| Do. railway, in Wales, do. | 5 | 5 | 0 | 5 | 10 | 0 |
| Do. Swedish in London do. | 10 | 5 | 0 | 10 | 10 | 0 |
| To arrive do. | 10 | 5 | 0 | 10 | 10 | 0 |
| Pig No. 1 in Clyde do. | 2 | 12 | 6 | 2 | 17 | 9 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | ,, | ,, | ,, |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 7 | 0 | 0 | 7 | 10 | 0 |
| **STEEL.** | | | | | | |
| Swedish in kegs (rolled), per ton | 14 | 5 | 0 | ,, | ,, | ,, |
| Do. (hammered) do. | 15 | 5 | 0 | 15 | 10 | 0 |
| Do. in faggots do. | 16 | 0 | 0 | ,, | ,, | ,, |
| English spring do. | 17 | 0 | 0 | 23 | 0 | 0 |
| Quicksilver, per bottle | 6 | 17 | 0 | ,, | ,, | ,, |
| **LEAD.** | | | | | | |
| English pig, common, per ton | 19 | 0 | 0 | 19 | 5 | 0 |
| Ditto. L.B. do. | 19 | 10 | 0 | ,, | ,, | ,, |
| Do. W.B. do. | 21 | 10 | 0 | ,, | ,, | ,, |
| Do. sheet, do. | 20 | 0 | 0 | 20 | 5 | 0 |
| Do. red lead do. | 20 | 15 | 0 | ,, | ,, | ,, |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 10 | 0 | 23 | 0 | 0 |
| Spanish do. | 18 | 10 | 0 | 18 | 15 | 0 |

* At the works 1s. to 1s. 6d. per box less.

## 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 JANUARY 18th, 1868.

180 H. A. Bonneville—Ribbon looms
181 H. A. Bouneville—Ribbon looms
182 A. Bochkoltz—Self-acting valves
183 B. J. Heywood—Pencil cases
184 J. Davidson—Bullets
185 W. E. Newton—Pottery kilns
186 J. Carr—Meat and other biscuits
187 G. S. Fisher—Links or couplings for harness
188 F. J. Baynes—Kitchen ranges
189 D. Timmins—Motive-power engines
190 G. Gopsill—Sleeve links

### DATED JANUARY 20th, 1868.

191 J. Davies—Machinery for shaping malleable materials, &c.
192 T. G. F. Dolby—Valve for supplying fresh air into feeding bottles
193 W. Firth—Application of vulcanised or unvulcanised india rubber in construction of pumps
194 M. Robinson—Expanding and contracting combs or reeds
195 R. Carling—Lubricating the interior frictional surfaces of steam cylinders
196 J. Woolley—Signalling in railway trains
197 W. R. Lake—Wood rings or washers
198 W. R. Lake—Pegging soles of boots
199 A. M. Clark—Steam boilers
200 J. H. Johnson—Ships for containing and transporting oils, &c.
201 J. Parsons—Breech loading firearms
202 A. V. Newton—Sewing machines

### DATED JANUARY 21st, 1868.

203 E. Thomas—Miners' safety lamps
204 J. F. Spencer—Steam boilers
205 J. F. Spencer—Valves of steam engines
206 C. W. Brown—Truncheons
207 J. L. Davies—Securing corks or stoppers
208 C. R. Havell—Water-heating apparatus
209 W. Dickins—Boots and shoes
210 L. N. Le Gras—Churns
211 T. V. Lee—Charcoal from peat, &c.
212 W. J. Coleman—Beer and wine finings
213 J. J. Long—Machinery used in the manufacture of matches
214 J. H. Johnson—Apparatus for indicating the relative positions of certain of the heavenly bodies
215 J. H. Johnson—Furnaces
216 W. Davis—Fastenings of paper bags, &c.
217 W. E. Newton—Rotary, steam, and other engines
218 H. Brinsmead—Thrashing machines
219 G. T. Bousfield—Liberating the colouring matter of madder, &c.
220 A. B. Brown—Valves of engines

### DATED JANUARY 22nd, 1868.

221 F. L. H. Danchell—Drying peat
222 J. Dixon—Floating bath
223 P. Harrower and J. C. Stuart—Spray producer
224 C. R. Broadbent—Shoes
225 C. E. Brouman—Colouring matter
226 W. Thompson and T. Statber—Mills
227 C. E. Brooman—Extracting colouring matter from madder
228 S. Bennett—Drying grain
229 E. Tomlinson—Ornamenting, printing, &c., articles from wood
230 R. Needham—Valves of steam engines
231 T. Gonne—An improved canteen
232 C. S. Barker—Organs
233 T. W. Gray—Lightning conductors
234 W. Dennis—Letter boxes
235 T. Cook—Machinery for uniting together materials employed in the manufacture of boots, &c.

### DATED JANUARY 23rd, 1868.

236 T. Rowley—Soles and heels of boots
237 W. Oram—Heating buildings
238 D. Y. Stewart—Cast iron pipes
239 H. Hodge—Gas stoves
240 G. Kirk—Self-acting mules and billies
241 J. C. Saunders—Door, shutter, and bell knobs
242 W. Bottomley—Milling machinery
243 J. Goulding—Looms
244 H. J. Dickinson—Billiard tables, &c.
245 H. M. Ragland—Tanning hides
246 G. Allibon—Steam boilers
247 S. Price—Mode for turning on and off gas, also applicable to other fluids
248 M. Tildesley—Furnaces
249 C. Garcin and A. Garcin—Sewing machines
250 G. Severn—Excluding air from casks

### DATED JANUARY 24th, 1868.

251 W. J. Jennings—Permanent way of railways
252 J. Storer and D. Storer—Vessels or canisters
253 A. Small—Apparatus for removing excrements
254 E. W. De Russett—Waterclosets
255 A. M. Clark—Improvements in apparatus for lubricating parts of machinery
256 C. Woodroffe—Travelling post-offices, &c.
257 T. L. G. Bell—Preparing oxide of iron for purifying gas

### DATED JANUARY 25th, 1868.

258 K. J. Winslow—Rotary motion to axles
259 J. Mason—Fuel
260 J. M. Lewis—Securing watches
261 C. W. Dixon—Rotating slide valves
262 J. Boyd and T. A. Boyd—Winding machines
263 C. Kilburn—Life and swimming belts
264 C. E. Brooman—Firearms
265 C. Ritchie—Utilising heat
266 T. Robinson—Fortifications
267 R. G. Wells and D. Jones—Optical illusions
268 E. J. W. Parnacott—Elastic rollers
269 A. C. M. Prince—Bell pull
270 A. Macdougall—Burning, calcising, or roasting sulphur
271 J. H. Johnson—Melting and heating metals
272 F. Wirth—Heating water, &c.

### DATED JANUARY 27th, 1868.

273 J. Rowley—Ornamenting candles
274 A. Middlemist—Apparatus for increasing, regulating, and controlling the heat and draught in stoves
275 A. H. Thurgar—Corks of bottles
276 J. J. Hicks—Backs for hand mirrors
277 T. Dickinson—Drawing off water
278 G. Kellogg—Hats, bonnets, &c.
279 W. E. Rendle—Protecting fruit trees, &c.
280 W. E. Newton—Machinery for grinding and polishing concave surfaces
281 W. E. Newton—Hat bodies
282 W. Ellis—Circular or rotary machine
283 F. N. Clerk—Washers
284 J. Roberts—Joining metallic pipes

### DATED JANUARY 28th, 1868.

285 W. Tranter—Firearms and cartridges
286 E. Egersdorff—Boot heels
287 H. A. Bonneville—Preserving eggs
288 H. A. Bonneville—Ribbon looms
289 W. A. Gibbs—Drying wheat
290 W. H. Crispin—Biscuits
291 C. E. Brooman—Candles
292 G. N. Sanders—Regulating and increasing light in burners for gas
293 T. Hydes—Facilitating the transit and application of caloric, &c.
294 A. Pickering—Embossing lozenges
295 T. Corbett—Cleaning grain
296 W. R. Lake—Pavement
297 J. Pearson—Refining oils
298 J. Brown—Cutting wood, &c.
299 R. J. Moser—Bellows
300 A. C. Pillner—Motive power
301 J. H. Johnson—Lithographic printing machines
302 J. D. Brunton—Cutting stone
303 W. H. Richardson and W. Beardmore—Manufacture of iron
304 W. March—Lasts for boots

### DATED JANUARY 29th, 1868.

305 C. A. McCurd—Sewing machines
306 R. Wilson—Joints for conveying liquids through pipes
307 W. Snell—Steam fireproof safes
308 W. Snell—Fireproof powder magazine
309 S. B. Ardrey and S. Beckett—Velocipedes
310 W. Tasker—Opening and cleaning cotton
311 D. Law and J. Wbarrie—Cast iron pipes
312 G. Thornton—Straw elevator
313 W. Guise—Scouring needles
314 O. Riley—Threshing machine frame
315 S. M. Martin and S. A. Varley—Electrical train intercommunication
316 W. E. Newton—Self-acting brakes
317 W. E. Newton—Breech-loading firearms
318 J. H. Johnson—Disintegrating, scouring, and cleansing raw wool
319 W. R. Lake—Furnaces

### DATED JANUARY 30th, 1868.

350 B. Dobson, W. Slater, and R. Halliwell—Machines for spinning
321 J. Radcliffe—Improvements in the manufacture of puddled iron and steel, &c.
322 J. Grimes—Soles and heels of boots
323 H. Aland—Blowing fans
324 M. A. Hamilton—Cutting bread
325 W. Hartnell and S. Guthrie—Improvements in or applicable to steam or other motive power
326 E. T. Mainwaring—Improved bale tie
327 T. Rowan—Removing impurities from iron
328 B. Hayne—Beer engine pipes
329 W. E. Newton—Sun blinds
330 W. Bull—Vacuum and pressure case moulds
331 K. H. Roeckner—Paper machine
332 J. Thompson—Feeding bottles
333 A. M. Clark—Adjustable wrenches

### DATED JANUARY 31st, 1868.

334 C. H. Adames—Metal buckets
335 E. Fleet—Aerated liquids
336 J. Walker—Machinery for turning
337 J. H. Johnson—Steam engines
338 E. Andrews—Trousers
339 H. A. Bonneville—Advertising vehicles
340 H. Chapman—Bolts, nuts, &c.
341 J. Mitchell—Marking or cutting woven fabrics into lengths
342 E. Bolton—Gunpowder
343 G. L. Scott—Steering ships
344 S. E. Howell—Suspension bridges
345 J. Livesey—Substitute for glass
346 J. Frame—Transmitting motive power
347 A. M. Clark—Steam engines
348 G. Clark—Fire escapes

### DATED FEBRUARY 1st, 1868.

349 G. Moulton—Engraving machines
350 J. V. Jones and G. J. Williams—Metallic tubes
351 R. C. Smith—Sinks
362 H. Aitken—Treating iron ores
553 A. Clark and A. van Winkle—Aerated waters
354 A. M. Clark—Utilising and increasing the lighting power of gases
355 D. Murray—Coverings for the head
356 J. Jameson—Postage and other stamps

### DATED FEBRUARY 3rd, 1868.

357 C. E. Brooman—Valves
358 B. Ford—Hot-air stoves
359 J. Tolson—Fetting or cleaning the cards of scribbling or carding engines
360 J. Weems and W. Weems—Heating grain
361 M. A. Wilson—Mattrasses
362 J. Combe—Hackling and scutching flax
363 J. M. Domenech and F. P. Jonte—Photographic apparatus
364 J. H. Johnson—Treatment of bones
365 J. West—An improved method of and composition for preventing scale in boilers
366 C. Richardson—Looms
367 W. R. Lake—Leggings
368 H. B. Wright—Sweeping chimneys
369 J. Offord—Carriages
370 W. Wallis—Stands or supports for lasts

### DATED FEBRUARY 4th, 1868.

371 J. H. Johnson—Compressed wood
372 R. A. Jones—Warming apparatus
373 E. Greiner—Machinery for cutting discs of india rubber
374 J. Lewis—Movable fire bars
375 L. Deseus—Miners' lamps
376 J. Dewar—Animal substances for use as food
377 R. Morton—Refrigerators or apparatus for cooling liquids
378 E. A. Morgan—Apparatus for spinning or twisting
379 T. Scott—Kilns, &c.
380 T. Cook—Raising or forcing liquids from casks, &c.
381 A. C. Sterry—Locomotive engines and carriages
382 T. Scott and R. Mowat—Lamps
383 P. Graham—Corks or stoppers
384 J. Webster—Preventing incrustation in steam boilers, &c.
385 W. E. Newton—Improvements applicable to steam boilers
386 J. Pettman—Percussion fuses

### DATED FEBRUARY 5th, 1868.

387 T. W. Walker—Manufacture of bricks, &c.
388 R. D. McKellen—Manufacture of cotton and other balls
389 S. G. Taylor—Spindles
390 R. J. Jones—Clog soles, &c.
391 F. Ardrache—Apparatus for winding flat cords, &c.
392 M. P. W. Boulton—Propulsion and aerial locomotion, &c.
393 H. Burning—Burning combustible liquids
394 W. E. Newton—Mowing machines
395 W. E. Newton—Buttons
396 H. Moore—Furniture expanders
397 J. A. Jones—Production of iron and steel
398 J. Hay—Roughing horses

### DATED FEBRUARY 6th, 1868.

399 C. W. Guttridge—Cutting soap
400 G. Roper—Screw propeller
401 A. E. Borgeu—Matches
402 W. J. M. Rankine—Condensing steam
403 H. Brindle—Shuttles
404 J. Honeyman—Trapping and ventilating drain pipes
405 W. E. Newton—Steam gauges
406 J. C. Cole—Drill braces
407 J. T. White—Fire lighters
408 G. F. Bradbury and T. Chadwick—Sewing machines
409 B. M. Oakeshott—Vapour bath
410 C. Brokell—Measuring fluids
411 W. Tongue—Machinery for straightening and preparing fibrous materials
412 P. E. Masey—Aerial locomotion
413 H. W. Hart—Envelopes

### DATED FEBRUARY 7th, 1867.

414 C. Longbottom and C. H. Longbottom—Machinery for spinning
415 J. O'Donnell and T. Arkill—Raising and lowering venetian blinds
416 S. Read—Finishing paper
417 J. Cash and J. Cash—Manufacture of looped and textile fabrics
418 A. B. Ibbotson—Steel spring railway fastenings
419 W. Hann—Safety lamps
420 G. Tucker—Rain-water pipes
421 W. Drake—Cutting wood, &c.
422 W. R. Lake—Locks

### DATED FEBRUARY 8th, 1867.

423 J. B. Wilson—Compressing steel, &c.
424 C. Harford—Scaffolding
425 A. McKnight—Powder or composition for cleaning and polishing articles made of steel, &c.
426 T. Walker—Constructing sewers
427 P. Rothwell—Regulating valve
428 A. Philipp—Cigar, ash, and light holder, and whist marker
429 J. Nixon—Braces
430 J. Howard and E. T. Bousfield—Steam boilers
431 W. Richardson—Combs to be used in carding engines, &c.
432 W. Cowan—Gas meters
433 J. Key and E. Hoskins—Metallic bedsteads
434 H. Woodward—Knife cleaner
435 W. Brooke—Healds for weaving
436 J. A. Nicholson—Waterclosets
437 J. E. Billups—Separating powders
438 W. T. Sugg—Valves
439 W. B. Marston—Lamps
440 N. C. Szerelmey—Rendering paper fabrics waterproof
441 N. C. Szerelmy—Preserving wood
442 W. R. Lake—Split spikes
443 W. R. Lake—Railway switches

### DATED FEBRUARY 10th, 1868.

444 W. B. Adams—Heating and welding metals in various forms
445 W. Burgoyne—Letter holders
446 W. R. Lake—Machine for scouring and cleaning grain
447 F. Barnes—Communicating motion to signals on railways
448 G. Jessop and B. Senior—Preparing wool
449 C. E. Brooman—Combined pen and ink holders
450 A. M. Clark—Breech-loading ordnance
451 H. C. Tucker—Shearing sheep
442 H. Schlotter—Raising water
453 J. Tansley—Apparatus for working the rollers of blinds

### DATED FEBRUARY 11th, 1868.

454 H. A. Dobson—Carriage spring
455 T. J. Clanchy—Matches
456 T. Smith—Engine counters
457 C. M. Holland—Permanent way of railways and tramways
458 J. W. Melling—Cutting coal
459 C. Verhulst and L. Verhulst—Fireplaces
460 J. R. Stoney—Consumption of smoke, &c.
461 W. Pickard—Woollen condensing machinery
462 H. T. Humphreys—Decarburisation of molten iron, &c.
463 G. Seamer—Silk fancy weavings
464 F. Schafer—Testing eggs
465 A. Binn—Generating gas, &c.
466 J. S. Williamson—Drying machinery
467 W. E. Newton—Apparatus for saving life
468 W. T. Woolley—Locks for purses
469 J. Wenden—Ornamenting glass
470 S. C. Lister—Looms

### DATED FEBRUARY 12th, 1868.

471 H. C. Barron—Reciprocating pumps
472 J. Smith—Boiling animal and vegetable substances, &c.
473 A. F. Bayford—Watering plants
474 J. Thornton and F. W. Voss—Weighing apparatus
475 R. Young—Training, levelling, and dressing millstones
476 R. C. Ross—Cutting paper
477 W. G. Hudson—Revolving stands
478 S. B. Tocker—Cartridge boxes
479 W. Wortton—Envelopes
480 H. B. Candy—Acetic acid
481 J. G. Willans—Iron and steel
482 J. Towle—Sewers and drains

### DATED FEBRUARY 13th, 1868.

483 S. Seville—Balling yarns
484 W. G. H. Taunton—Pumps
485 R. George—Gas stoves
486 F. Grenier—Kneading apparatus
487 W. E. Deverna—Fastener applicable as a substitute for buckles
488 J. Wood—Indicating the position of railway points
489 C. Blyth—Measuring and cutting cloth
490 F. Tolhausen—Brushmaking
491 W. Woodfield—Making up packets of needles
492 G. Roberts—Candles
493 W. R. Lake—Extracting and condensing the volatile portions of ores
494 W. R. Lake—Whip holder

### DATED FEBRUARY 14th, 1868.

495 D. Elland—Passengers travelling in railway carriages signalling driver and guard
496 H. A. Bonneville—Aniline colours
497 H. A. Bonneville—Lamps
498 A. Lemasson—Dials
499 J. Steele—Conveying and treating animal charcoal and sugar
500 J. P. Lack—Albums
501 W. E. Gedge—Separating animal from vegetable substances in textile fabrics
502 G. A. F. Eichbaum—Apparatus for indicating the amount of money received by omnibus conductors
503 G. V. Wisedill—Rings for keys

### DATED FEBRUARY 15th, 1868.

504 J. A. Hogg—Gas burners
505 J. S. Raworth—Connecting and disconnecting revolving cylindrical surfaces
506 R. Martin—Treating and deodorising oils
507 R. H. Rimes—Boots and shoes
508 D. Whittaker—Looms
509 W. Easterbrook—Railway points
510 W. J. Bennett and J. Jobson—Sewage
511 E. Cottam—Breech-loading firearms
512 B. Farmer—Crushing stone, &c.
513 A. M. Clark—Felted fabrics
514 J. Barlow—Carriages
515 L. Mummenhoff—Building blocks
516 J. Leetch—Signals

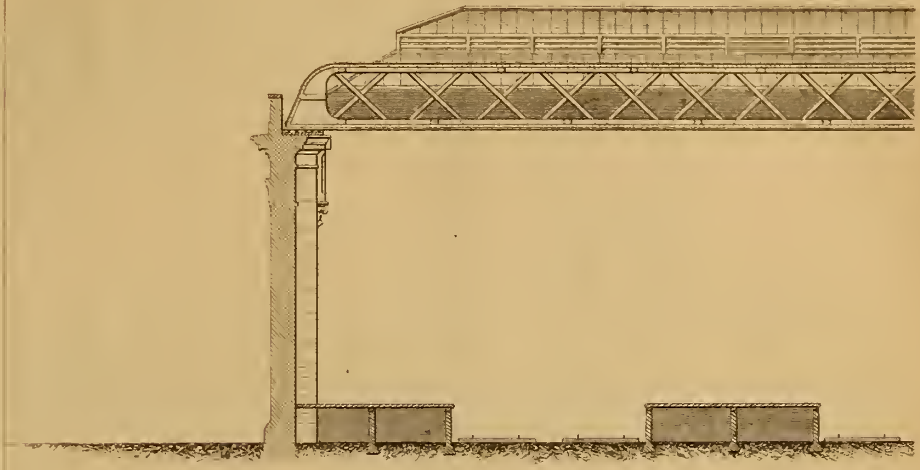
### DATED FEBRUARY 17th, 1868.

517 J. Clark—Tobacco box and cutting machine
518 W. H. Tasker—Machinery for spinning
519 A. H. Brandon—Firearms
520 J. P. Worrall—Imitating skins
521 W. H. Wilkinson—Type composition
522 W. Lincoln—Lamp burner
523 J. G. Taylor—Puzzles
524 F. Chevassu—An improved shirt
525 J. Walker—Tiles

### DATED FEBRUARY 18th, 1867.

526 A. M. Dufilhol—Shoeing horses
527 J. Cronier—Rotary heel
528 W. R. Lake—Kilns
529 L. Woolbeim—Apparatus for barometrical and thermometrical purposes
530 R. Butterworth—Looms
531 R. Baguley—Shuttles
532 J. Hinks and J. Hinks—Portable stoves
533 A. M. Clark—Vegetable extract
634 C. E. Brooman—Firearms
535 W. Perkins and G. G. Tandy—Insulating electric conductors
536 W. E. Newton—Artificial teeth
537 J. Thompson and J. Thompson—Fastening railway rails
538 A. M. Keighley—Signals for railway carriages:

# LONDON BRIDGE TE



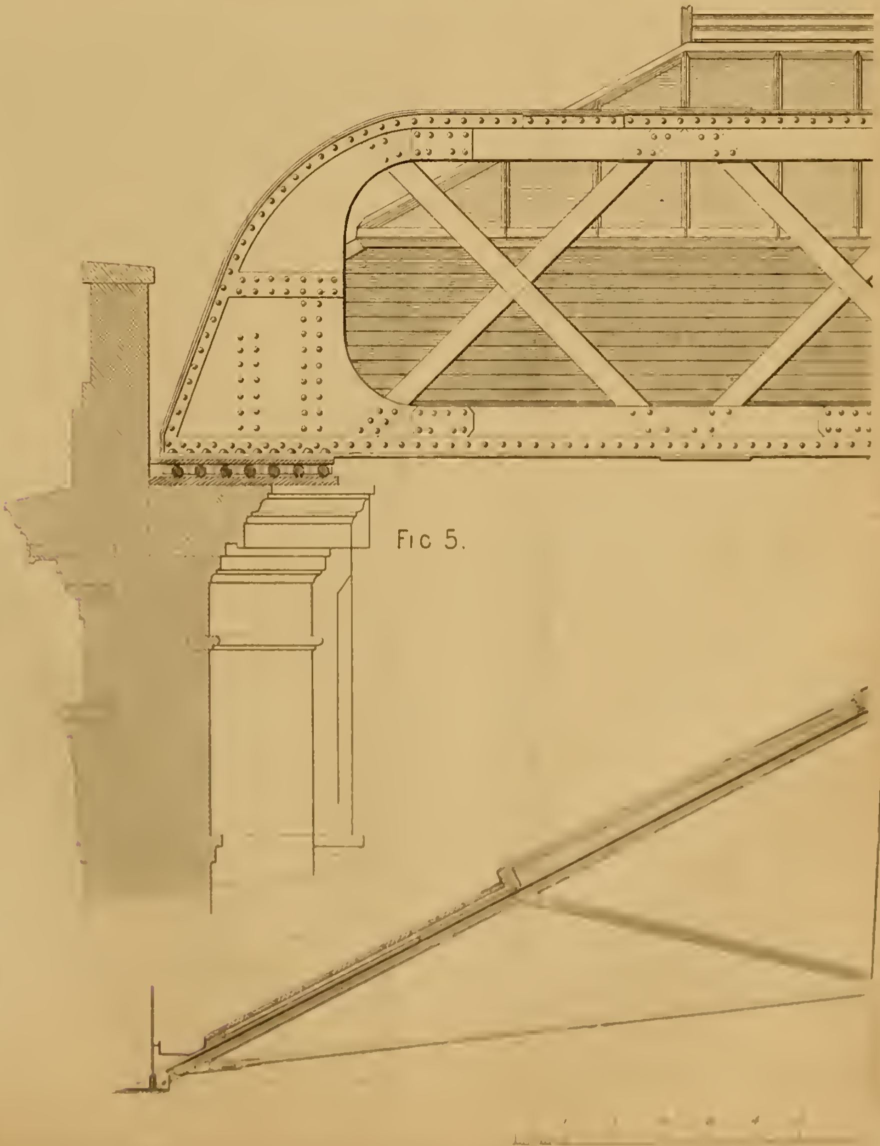


Fig 5.

# LONDON BRIDGE TERMINUS OF THE LONDON, BRIGHTON, & S.C. RAILWAY.

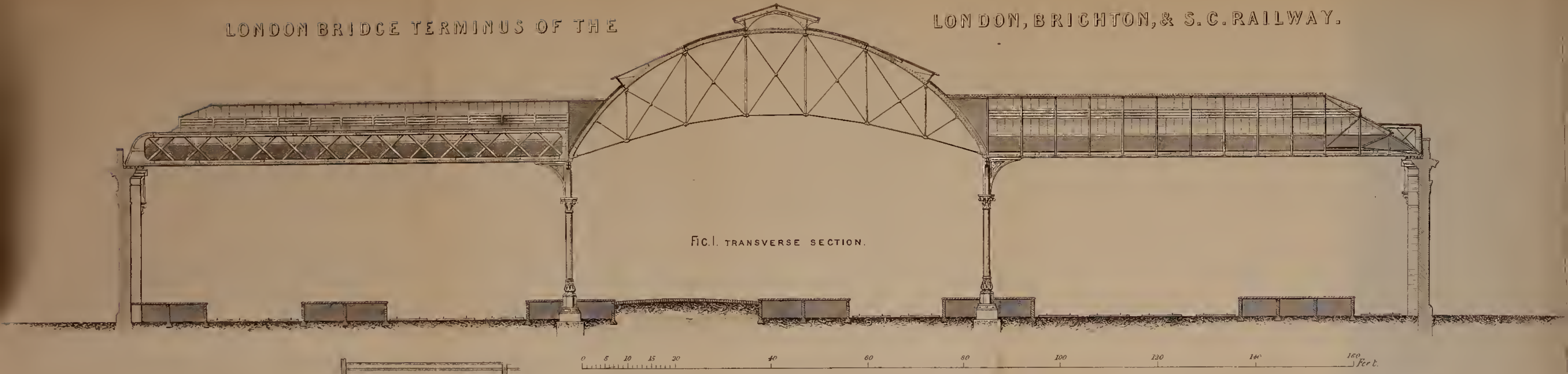


FIG. I. TRANSVERSE SECTION.

Scale to Fig. 1.

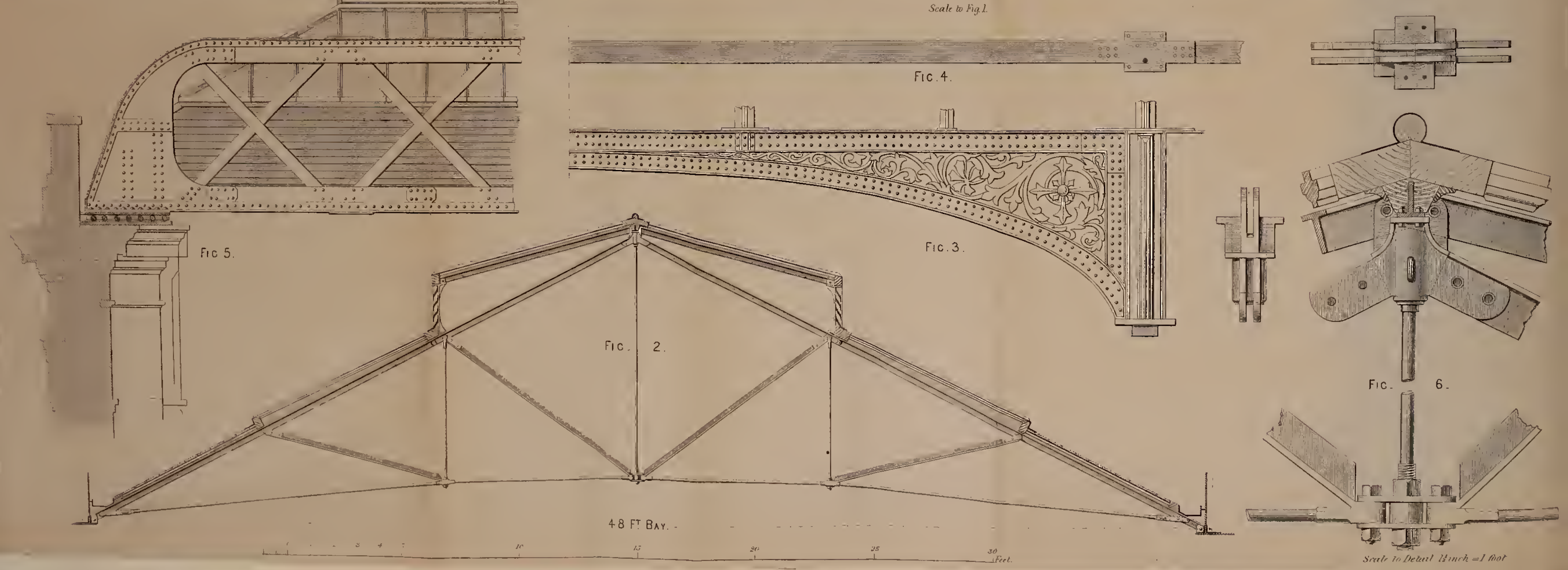


FIG. 4.

FIG. 3.

FIG. 5.

FIG. 2.

48 FT BAY.

FIG. 6.

Scale to Detail 1½ inch = 1 foot

RMI N, BRIGHTON, & S.C. RAILWAY.

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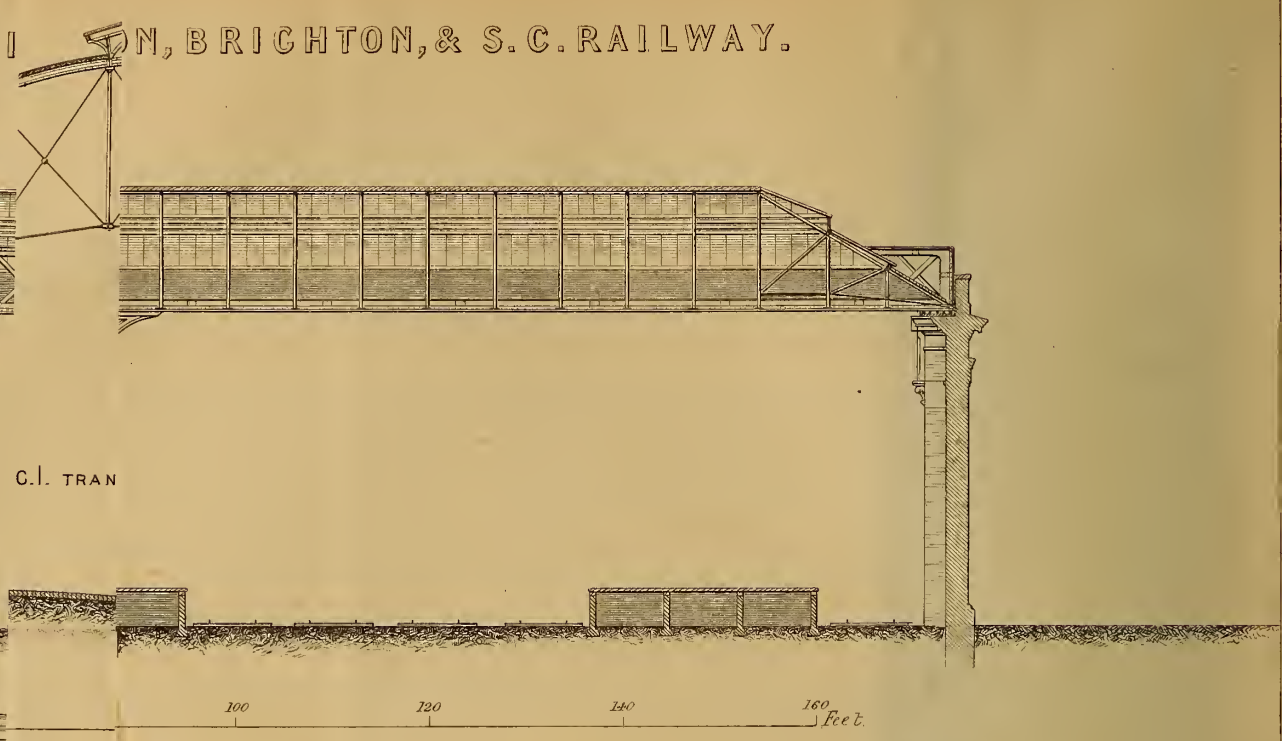
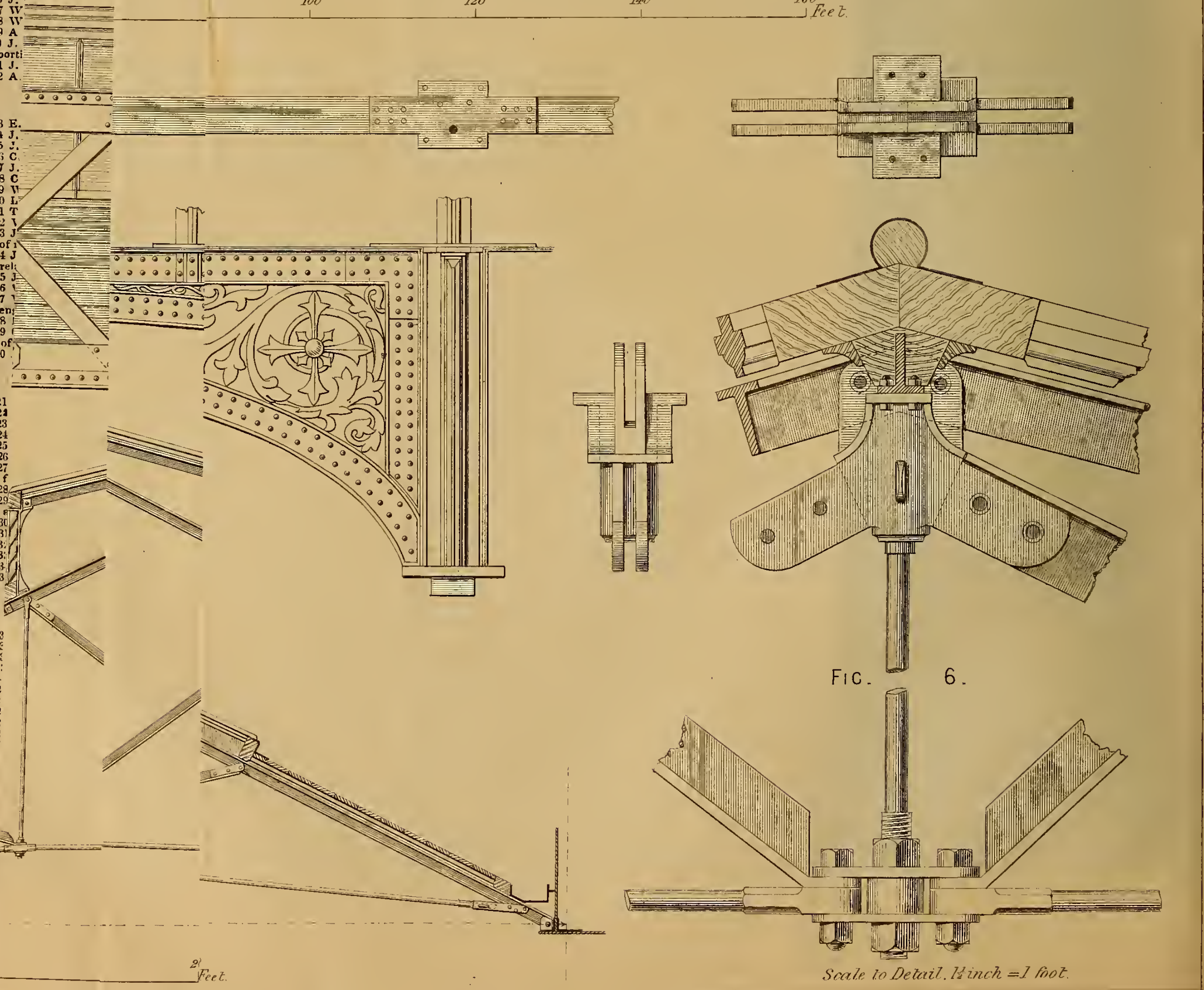
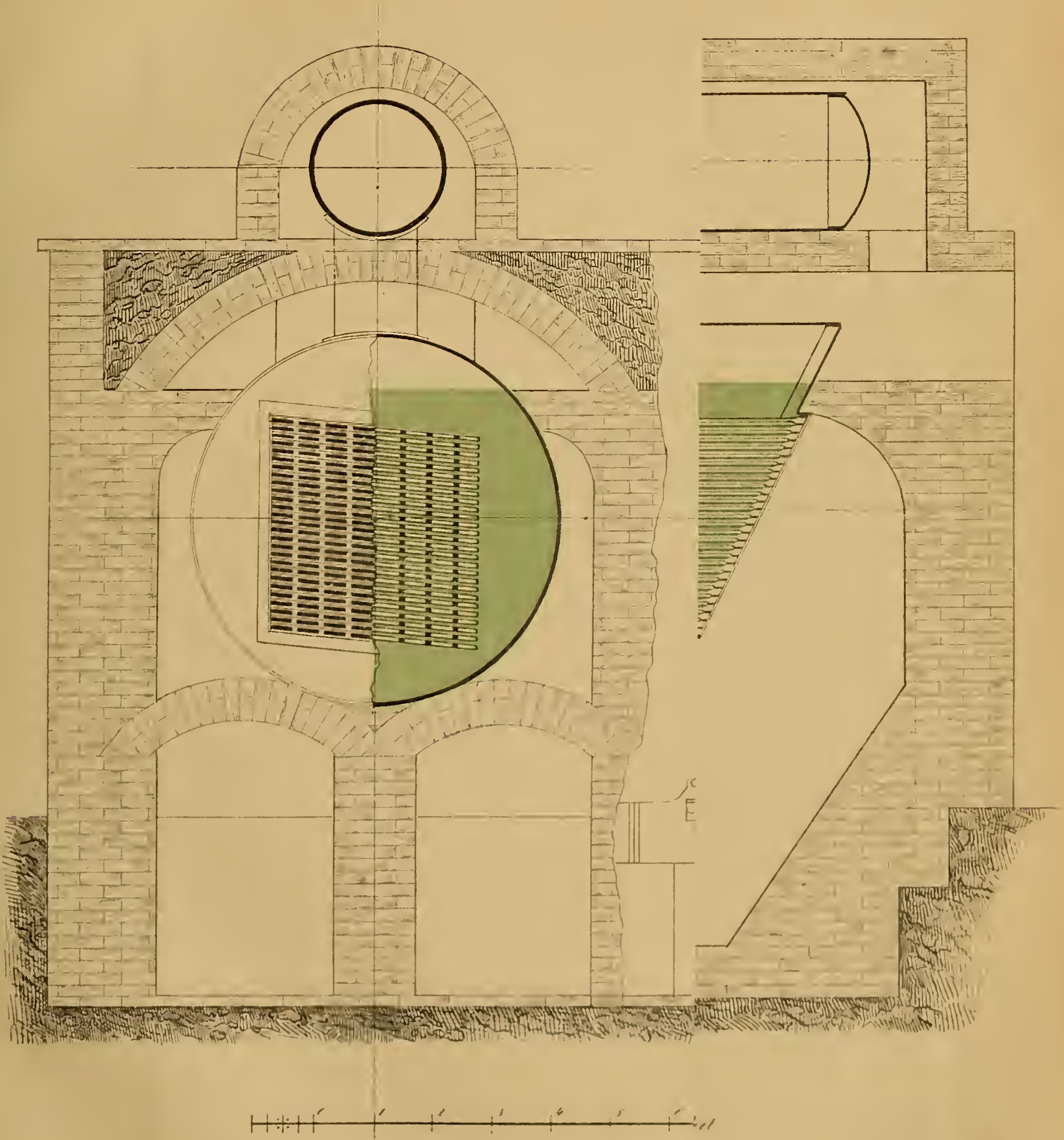




*Scale to Detail. 1½ inch = 1 foot.*

Plate 22



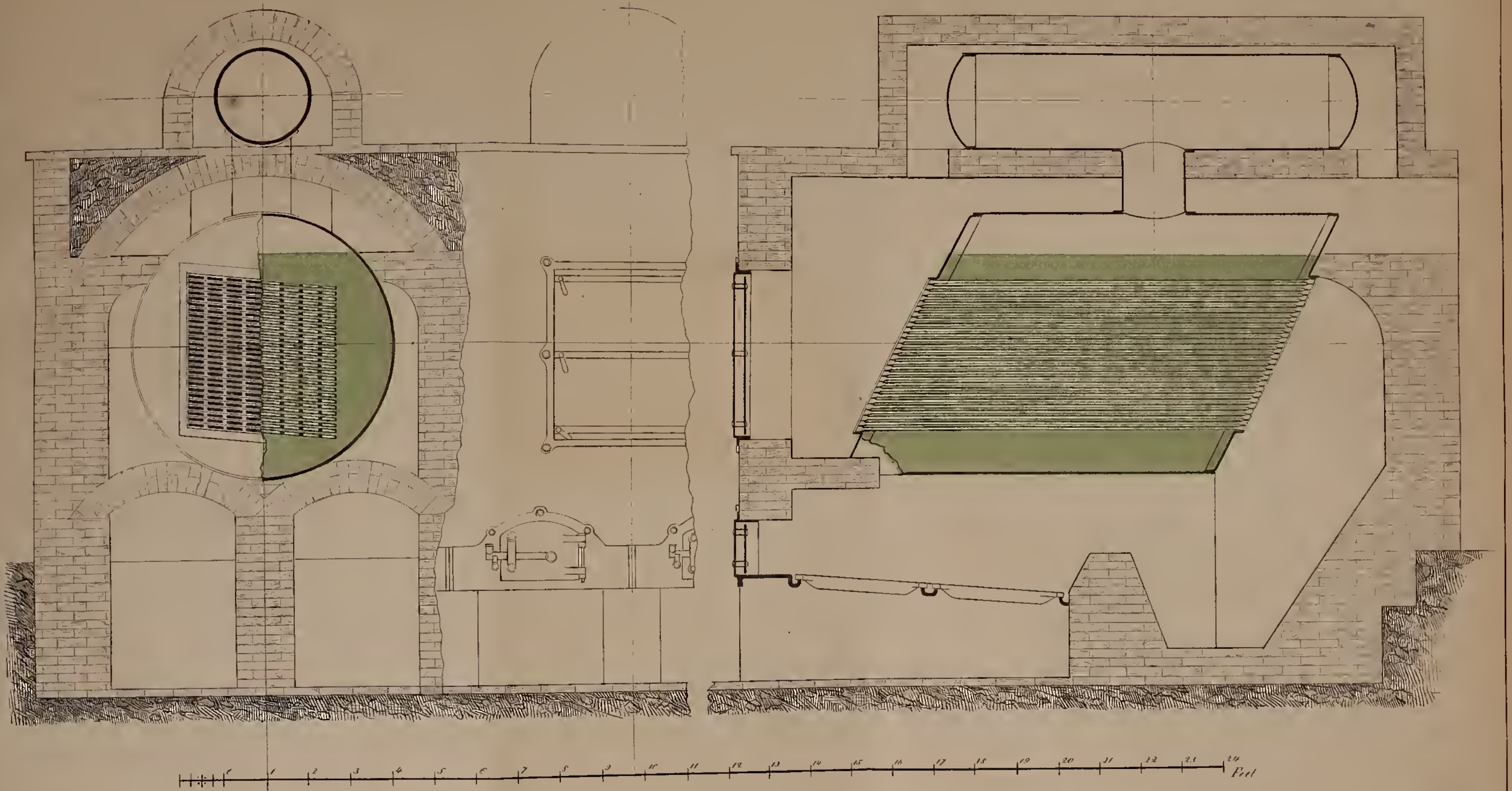
W. Smith C. Edinr

# Th. Holt's Patent

*as applied to*

# Stationary Boilers

*2 Boilers 9. feet long* { *present system* = 640 } *sq: feet hea*
{ *Holt's* = 3000 } *ting surface*



*Smith C E [illegible]*

Feet.

# THE ARTIZAN.

No. 4.—Vol. II.—Fourth Series.—Vol. XXVI. From the Commencement.

1st. APRIL, 1868.

## ROOF OF THE LONDON, BRIGHTON, AND SOUTH COAST RAILWAY STATION AT LONDON BRIDGE.

*(Illustrated by Plate 328.)*

In The Artizan of last month an engraving of the general elevation and plan was given of the above station, accompanied by a description of the various points of interest connected therewith. In order to illustrate that description more clearly, we give this month another engraving comprising an enlarged transverse section of the entire roof, also a section of one of the 48ft. bays, together with various other details. Fig. 1 is a transverse section through the roof of the station; Fig. 2 a section of the roof of a 48ft. bay; Fig. 3 a half elevation of one of the ornamental girders of the 48ft. bays; Fig. 4 a plan of do.; Fig. 5 an enlarged view of the end of one of the girders carrying the 48ft. bays; and Fig. 6 details of the king-head, &c., of the 48ft. bays. It will be seen that the design of the ornamental girder (Fig. 3) is very light and elegant, and in fact the whole of the ornamental work exhibits great excellence of design.

## HOLT'S PATENT AS APPLIED TO STATIONARY BOILERS.

The principle and the construction of this boiler has already been explained in The Artizan of last January, only in that case it was in reference to a boiler for marine purposes. In plate 329 is illustrated a very compact arrangement of this system for land boilers, where there is shown two cylindrical boilers 9ft. long, and 6ft. in diameter. The steam-chest of each boiler is a cylindrical vessel the same length as the boiler, and connected to it by a leg in the usual manner. This steam-chest is also enclosed in brickwork, and a portion of the heated products after passing through the sheet surfaces of the boiler, is made to traverse the flue in which it is placed in order to superheat, or at least to dry, the steam. These boilers are calculated to be of fifty horse power each, and certainly occupy very little space in proportion to their power. The sheet surfaces and flues can be very easily cleaned; while, as was before remarked in the description of the marine boiler upon the same principle, the economical evaporative power in boilers upon this system is very great. The construction of these boilers is very easy, the stays being plain flat bars running the whole length of the sheet surfaces and simply laid at any required distance apart. These stays can of course be at any time varied in their distance apart by increasing or diminishing their number.

## RAILWAYS AND THEIR MANAGEMENT.

Since the present financial crisis in railway affairs commenced, the attention of engineers, railway managers and all persons interested either officially or financially has been concentrated upon the question as to how to work railways more economically. In many cases this question has been forced upon railway managers in the most unpleasant form, viz., how to rescue the line from insolvency, while even in the best railways the case is only altered to the problem as to how to pay a fair dividend with the capital account closed. The subject is no doubt a most difficult one, partly perhaps because the interests of railway companies and their customers are supposed to be antagonistic. This view we are aware has often been combated, but still there is no doubt that the idea is very general. The public consider that economy in railway management means longer intervals between the starting of the trains and want of accommodation in every respect. The idea is evidently shared also by the board of management of many of our lines, and consequently is by no means unfounded. Still, it is very doubtful whether this is the correct view, as the lessening the number of trains upon any line would not only diminish the traffic for the time, but would materially hinder the increase of population and consequent development of traffic along that line. Another and, as it appears, a sounder method of accomplishing the object in view has been proposed, which consists in reducing, as far as possible, the vast disproportion between the paying and unpaying loads in each train; or in other words to carry an equal number of passengers as at present, with a much lighter train, and consequently with a greatly diminished wear and tear.

From a paper read by R. F. Fairlie, Esq., C.E., before the Society of Arts upon this subject, we extract the following:—

"The method of conducting passenger traffic yielding so little per train per mile, is of such importance, and the discrepancy between remunerative and unremunerative weights hauled, is so irrational and glaring, that it deserves to be considered a little more in detail. Quoting from the London and North-Western Railway balance-sheet, it appears that the gross produce of 9,613,195 passengers is £1,280,507, or under 2s. 8d. per passenger. Taking the average rate for each at 1½d. per mile, this gives 21 miles as the distance travelled by each, whilst the gross earnings per mile of passenger trains are about 5s., which, at a like rate of 1½d per mile, shows that the average number of passengers per train per mile is 40; allowing for a considerable amount of luggage to each passenger, this number could not be estimated at more than four tons. Now four tons is neither more nor less than about one-twelfth of the weight of the locomotive engine and tender (the tender alone being about five times weight), and taking the passenger trains at say 50 tons, the paying load will bear not more than one-twenty-fourth part of the gross weight of each train. It is evident, therefore, that the paying is altogether out of proportion to the unpaying load, although it is admitted that on railways such as the London and North-Western, from the circumstances of the great length and numerous unprofitable branches, there must always exist a much larger proportion of dead to paying weight than is the case with lines with no such encumbrances. Now there is no reason whatever why the present disproportion should exist, or anything like it.

"This is no new subject with men who have given their serious and unprejudiced attention to it. I find that in 1849, Professor Gordon, an engineer of considerable eminence, expressed, in a very able pamphlet called 'Railway Economy,' similar views to those which I have advanced. In page 4, he says—'The existing railway machinery will be found to be monstrously disproportionate to the useful effect produced in four-fifths of the number of times that the machine is put in action. And to this waste of power may be most justly attributed much of the present embarrassment of railway companies.'

"The judicious despatch of trains, and the proportion of paying to unpaying loads, are two of the most important subjects connected with railway management. These, however, could be grappled with at any time by a really competent man, so as to enormously increase the net result even with existing stock; but there are the difficulties which always surround independent departmental control, exhibiting on all occasions a strange unwillingness to adopt any change which shall interfere with their preconceived opinions, or occasion trouble or thought in departing from a system which one is tempted to think has its own personal peculiar advantages. It seems never to have occurred to these gentlemen that in the discharge of their important duties, involving every consideration they can bring to them, in the interest of their employers, what a close relation there is between the question of the dead weight necessary to the efficiency of the traffic and the dividends to those who have entrusted them with their important functions.

"The Metropolitan Railway is, without exception, one of the greatest engineering triumphs of the age, being one of the cases where cost, it would seem, has been of secondary consideration; but, certainly, its management cannot be commended, and time will not permit of dealing with the general question. The magnitude of the traffic is evinced by the fact that during the half-year ending December, 1867, nearly twelve millions of passengers were carried over the line by 348 trains on week-days and 212 on Sundays, averaging only 328 trains per day throughout the year. The distance run by each of these trains is understood to be $4\frac{1}{4}$ miles, consequently the train miles per day are over 1,396. By dividing the actual number of passengers, 11,916,924, carried for the half-year, by the number of days in the same period, we obtain 65,298 passengers carried per day, which, in 328 trains, is 198 passengers per train. This number of passengers per train for the entire distance run—say $4\frac{1}{4}$ miles—would give an average of less than 47 passengers per mile. This, however, is not the case, because the gross earnings per train mile being under 9s. 4d., the amount chargeable per passenger per mile would require to be about $2\frac{4}{10}$d. This would be above the average rate charged. It is, however, impossible to find out from the companies' balance-sheet what the real average is. To arrive at something like an average, I take 100 passengers, 50 single and 50 return journeys, from Moorgate-street to all stations, and divide these into 20 first-class, 30 second-class, and 50 third-class, which will give the average rate per passenger at 2·02d., and this divided into 9s. 4d. gives a little over 55 passengers per train per mile. The trains on this line are mostly composed of five carriages, weighing 42 tons, together 122 tons. Thus we have 122 tons of train weight to carry an average of 55 passengers, which at 14 to the ton is under 4 tons, being only one ton of paying load to 30 tons of dead weight. Some objection may be taken to this mode of dealing with figures. It will be said the average number of passengers given to each mile cannot be considered as the exact number travelling that distance. This is no doubt so, but it cannot materially affect the question, for if the whole average of 198 passengers travelled $1\frac{1}{4}$ mile there would be none the remaining 3 miles; the only difference in the proportion of paying to unpaying load which could arise from this would be a slight increase of the former to the latter for $1\frac{1}{4}$ mile only, while for the 3 miles it would be wholly dead load. To prove the correctness of this calculation, we have only to assume what many might be disposed to imagine, that 198 passengers instead of 55 are carried per train per mile, the result would give 101,293,854 instead of nearly 24,000,000 now carried.

"Nothing could be more appropriately said at this moment than the following quotation from Professor Gordon's pamphlet, written twenty years ago. At page 24 he says:—'These figures indicate the small portion of the mechanism of the railway system of transport that is actually brought into requisition even on the most frequented lines. Thousands, nay, millions of miles, are run by locomotives and carriages on the present system, whilst they are performing an amount of transport of passengers preposterously disproportioned to the power and capacity of the trains employed for effecting it.'

"Contrast this condition of things on the Metropolitan Railway with our ordinary omnibus traffic. We find that the omnibus which has to travel over an infinitely worse road than any line, weighs somewhere about one ton, whilst it carries 28 passengers or two tons, thus giving a proportion of two tons of paying to one ton of unpaying load; but as we have included the weight of the horse, *i.e.*, the locomotive engine in the calculation on the metropolitan working, it is but fair to include the horses which haul the omnibus. Two horses with every equipment cannot weigh a ton, consequently, at the very outside, the proportion is one to one, or one ton of paying load to one ton of material employed to convey it. These are very suggestive facts; they have surprised me; and that this line has earned any dividend at all under these circumstances proves its enormous productive capability. Beyond the question of proportion of effective to non-effective duty, let us consider how it all bears on the maintenance of the railway stock and road, and how they are affected thereby. I have already given the weights of the locomotives and carriages, the former at 42 and the latter at 16 tons each.

"The carriages have very long wheel bases, consequently they offer great resistance to the tractive force of the engine, besides being very injurious to the rails rounning the curves.

"The engines have 32 tons on 4 wheels, or 16 tons per pair. We have only to imagine this enormous weight ploughing along at 30 miles an hour to form some idea of the destructive effect, not only to the rails, but to the substructure and the machines, the effect being destructive alike to all. No wonder that the line has, as is stated, been relaid in many places three times with steel rails since it opened five years ago. Not content with this rate of destruction to road and stock, the Metropolitan Company are now receiving, or about to receive, locomotive engines of a still more destructive character to work the St. John's-wood branch, weighing 45 tons on 6 wheels, with a wheel base of 14 feet. The only approach to a saving feature in the 42 ton engines—viz., carrying the leading end of the engine on a bissel truck with four wheels—is in these new engines omitted. The bissel arrangement does to some extent reduce the enormous friction of the engines on rounding the curves, notwithstanding which the grating and grinding noise of the wheels can be heard at a considerable distance. The spirit of rivalry between armour plates and guns is reproduced in steel rails and locomotive engines, with this difference, that the armour plates can be made to withstand the power of the heaviest guns, whilst steel rails cannot withstand the battering of these 45-ton steam hammer locomotive engines.

## CAST-STEEL BOILERS.

An important series of experiments has been recently made at the rolling mills of Messrs. Funk & Elbers, of Hagan, Prussia, for the purpose of ascertaining the respective evaporating power of the new compared with the old style of boiler.

The two boilers experimented with were each five feet in diameter, and thirty-four feet long, constructed to stand five atmospheres pressure. One was made of wrought iron, and the other of soft cast steel. The thickness of the sides in the cylindrical portions of the iron boiler was 0·50 of an inch, and of the cast steel boiler 0·33 of an inch. Each boiler had a heating surface of 293 square feet, and twelve square feet of grate surface. Both were new, and had never been before heated. They were set alike in brickwork, and entirely separated by masonry; the gaseous products of combustion passed through a single flue underneath each boiler, and passed directly into the same chimney. At first both boilers were filled, and fires were kept under them for several days in order to dry the brickwork, after which the fires were extinguished and the boilers emptied and cleaned. Each boiler then received exactly 712 cubic feet of water at 95° Fah. temperature; the man-holes were closed, and the water was heated to the boiling point; again the fires were put out, and all the ashes and coals taken away. From this point the boilers were fired afresh, and fed with weighed fuel; the man-holes, hitherto kept closed, were now opened to let the steam escape; and the firing was so well regulated, by means of dampers, that the velocity of the escaping steam—measured by List's Velocimeter—was the same in each boiler. The temperature of the gases from the fire was measured, at a point six feet from the rear end of each boiler, by Gauntlett's Pyrometer, and found to vary from 644° to 734° Fahr.

After consuming on each grate 3,150 pounds of coal of the same quality, the cinders of which were burned over and over again, the fires were put out, and the man-holes closed. On the following day the remaining water of the boilers, showing a temperature of 95°, was let out through the emptying tube, situated at the lowest part of the boiler, and measured by means of a hydrometer adapted to the tube. The iron boiler showed 387 cubic feet, and the steel boiler 331 cubic feet of the remaining feed water. Therefore the water evaporated in the iron boiler was $712-387=325$ cubic feet, or 20,065 pounds; and that evaporated in the steel boiler was $712-331=381$ cubic feet, or 23,523 pounds. Hence the evaporating capacity was proved to be 17·20 per cent in favour of the steel boiler. One pound of coal evaporated in the iron boiler 6·350 pounds of water, and the steel boiler 7·467 pounds of water at 212° Fah.

At the next trial the whole operation was performed in the same manner, only the velocity of the escaping steam was less. It resulted in showing 19·62 per cent. in favour of the steel boiler. One pound of coal evaporated in the iron boiler 5·809 pounds, and in the steel boiler 7·008 pounds of water..

These two experiments were verified in the following manner: To an equal quantity of feed water in each boiler an equal volume of a strong solution of salt was added. After stirring the water for some time, by means of long poles, and boiling it with closed man-holes, samples were taken out for future analysis. In completing this experiment in which equal quantities of fuel and water were used, further samples were taken out. The analysis of the samples by Dr. List, of Hagan, showed that in the iron boiler one quart of water contained before evaporation 4·629 grammes of chloride of sodium, and after, 5·985; in the steel boiler one quart contained 4·371 grammes before, and 7·385 grammes of salt after evaporation, the iron boiler lost 33·76 quarts, and the steel boiler 40·81 quarts of water, showing 20·85 per cent. in favour of the latter. The average percentage of these three experiments is 19·24 per cent. in favour of the steel boiler, which it will be noted had a shell 33 per cent thinner than that of the wrought-iron boiler.

## THE THAMES EMBANKMENT.

This month the Metropolitan Board of Works will probably issue a report declaring that the Thames Embankment, so far as it has been contracted for is completed. Any one, however, who should take this statement literally, would be lamentably deceived.

The Thames Embankment, one of the greatest works of modern times, and which will eventually make one of the finest quays that any capital in

Europe possesses, will still remain a "no thoroughfare" after this announcement, and it will be well if the public, after three or even four years, come into the use of their property.

One sees with amazement the extent, the solidity, and almost magnificence with which the works, so far as they have gone, have been completed, and one sees also with a sort of blank dismay the sudden stoppage, which for about 900ft., renders all else nugatory. From Westminster-bridge up to the gasworks, beyond the Temple-gardens, all is finished, but from this point the contract which is to complete the whole work has not even been let. At present the Thames Embankment ends literally in the river near Blackfriars—a mere strip of the most costly roadway in the world without approach or egress to it. The low-level sewer is complete from Tower-hill to the pumping station at Abbey Mills, and from Westminster as far as the embankment has gone. But, in consequence of the embankment not being completed, or the new street begun, the whole of the low level drainage scheme of the north side of the City is virtually rendered nugatory by the delay and non-completion of the short length between Blackfriars and Tower-hill. According to present appearances it is not probable that, for want of approaches and for want of its continuation, it can be used for three years to come, and, unless some pressure of opinion is brought to bear upon its non-completion, it may even be much longer.

In the opinion of engineers, both English and foreign, there has seldom been so colossal a work in granite put together with the same completeness. It literally fits with the neatness of cabinet-work, and some of the landing-stages and piers will remain as standards of what such works should be. Some idea may be formed of the magnitude and importance of the undertaking when we say that a river wall in granite, 8ft. in thickness, has been built so as to dam out nearly 30 acres of the river; that this wall is nearly 7,000ft. long; that it averages more than 40ft. high, and its foundations go from 16ft. to 30ft. below the bed of the river. In the formation of this wall and the auxiliary works of drainage, subways, and filling in with earth behind it there have been used nearly 700,000 cubic feet of granite, about 30,000,000 bricks, over 300,000 bushels of cement, nearly 1,000,000 cubic feet of concrete, 125,000 cubic yards of earth have had to be dug out, and no less than 1,200,000 cubic yards of earth filled in. Such stupendous quantities of material expended over so short a space of ground have never been heard of till now, and would, if so employed, have been equal to building half-a-dozen structures like the great Pyramid.

The end of the embankment next to Westminster-bridge, and for a long way past Whitehall, is finished, with the exception of the roadway, which it is useless to complete, as at some indefinite time, the Metropolitan Railway will cut it all up again to make their tunnel. But, as a steamboat pier for arrival and departure, the public will have the use of it very shortly, and the unsightly mass of piles which now constitute the steamboat pier will disfigure the river no more. A noble flight of stone steps, 40ft. wide, will give entrance from Westminster-bridge to this portion of the great "no thoroughfare." As far as it has yet been constructed, there are six piers along the face of the embankment,—one at Westminster, for steamboats; one at York-gate, for the landing of small boats; one at Hungerford, extending on each side of the piers of the present bridge, for steamers; one at the Adelphi, for small boats; one at Waterloo, for steamboats; and one at Temple-gardens, also for steamers. As a matter of course, however, small boats will be at liberty to use these landing-places, but York-gate and the Adelphi are built especially for their accommodation. York-gate will be one of the prettiest stations on the bank, but the landing-place at Temple-gardens will be of its kind unsurpassed. The great frontage of this pier—nearly 600ft.,—the width of its stone stairways, the solidity and height of its abutments or terminals, and, above all, the carved granite arch which will give access to it from the land, will make this station one of the most conspicuous ornaments of the river The arch which leads to it is a triumph of granite work. All the piers and landing-places are of different designs, though they mostly all keep the same type of massive and enduring architecture, as befits a great work designed to last for centuries to come.

Near Hungerford-bridge about 600ft. of the caissons have still to be removed, and at the end next the Temple-gardens some of the coffer-dam inside which that portion of the wall was built has to come away. All the walls inside these parts, however, have been finished to above high-water mark, and it is simply a matter of detail to fix the superstructure and coping. In the short length where coffer-dams were used, or, indeed, along any part of the works where piling was employed, the piles have never been drawn. The elm piles have therefore been sawn off at a little below the river's bed, and still left so as to give the river wall when built the same support which they gave when building. In the iron caissons also the same prudent rule has been followed, only the upper parts of the caissons having been removed the rest still remains as firm as the first day they were forced in to keep the water out. The support which these all give to the strength of the main wall is, of course, immense.

Much difficulty was experienced in getting a good foundation near Hungerford-bridge, where the soil was marshy and unsound, and it was not till it had been dug away to the depth of more than 30ft. that the clay was reached at last. During these works the excavations were continued 8ft. below the stonework of the foundations of one of the Hungerford piers,—that is to say, 8ft. of the piles on which the stonework rests were laid bare. The piling, however, was found to be absolutely perfect, and as soon as the excavations were completed all round the pier was filled in with concrete. In the same way the piling below one of the piers of Waterloo-bridge was laid bare for a depth of 4ft., and found to be as complete as the day it was driven into the soil. One small piece of piling has, in fact, been taken out as a specimen, and from its appearance it seems difficult to believe that it has been long cut from the tree, much less been in mud and water for nearly fifty years.

It is to be hoped that all the steamboat piers will be opened as soon as possible, with something like a decent approach. The narrow, tortuous boarded alleys leading to the Hungerford and Temple piers, with their numerous steep inclines or flights of steps are a perfect disgrace. Great numbers of people have given up travelling by the steamboats rather than encounter these long passages, which thereby inflict serious injury upon the steamboat companies.

## TRIAL TRIP OF H.M.S. "BLANCHE."

The screw corvette (unarmoured, wooden), *Blanche*, 6 guns, 1,268 tons, 350-horse power, Captain J. E. Montgomerie, was put through her trial of speed at her deepest load draught over the Stokes Bay course, under the superintendence of Captain W. C. Chamberlain, commanding H.M.S. *Asia* and the steam reserves at Portsmouth.

On weighing her anchor from Spithead to enter upon her trial, the *Blanche* drew 13ft. 4in. of water forward, and 16ft. 8in. aft. All the yards were aloft on the three masts of the ship to royals, and all sails were bent. 270 tons of coal were on board, all other stores were complete to six months, and the ship was in all respects ready to proceed to sea from the trial ground. In accordance with Admiralty regulations, the machinery of the ship was, during the time of the trial, in charge of Messrs. Ravenhill and Hodgson, who were both present, under the conditions imposed by the Admiralty circular. The ship's engines are of 350-horse power (nominal), fitted with surface condensers and superheating apparatus, and precisely similar in their general arrangements to those supplied by the same makers to the *Nymphe*, *Daphne*, and other vessels of the same class. The cylinders have a diameter of 63½in., with a length of stroke of 33in. They drive a "Mangin" screw of 14ft. 7in. diameter, having a pitch, leading, of 15ft. 7in., and following of 17ft; a mean length of 12in., and an immersion of the upper edges of 7in. The weather was very favourable for the trial, the wind being from about N.W , and the water quite smooth over the mile.

The *Blanche* entered upon her first mile by running to the westward over the first of the east-going tide. The general results, as will be demonstrated by the subjoined figures, proved to be most satisfactory. Measured mile, full boiler power, six runs; speed of ship each run, in knots, 13·383, 13·953, 13·235, 14·062, 13·187, and 14.118; revolutions of the engines per mile, 394, 382, 402, 377, 403, and 379; revolutions of the engines per minute, 87·88, 88·83, 88·68, 88·37, 88·57, and 89·17; mean steam pressure in boilers, 33lb.; in engine-room, 30lb.; mean vacuum, 27in.; mean speed of the ship under full boiler power, 13·631 knots per hour. Half boiler-power, four runs; speed of ship under each run, in knots, 11·111, 12.996, 10·435, and 12.903: mean speed of the ship under half boiler, 11.788 knots per hour. With full boiler-power, the ship completed a circle to starboard in 3 min. 57 sec., and to port in 3 min. 48 sec., four men being at the wheel, and the vessel steering with unusual ease and quickness. Under half boiler-power, a circle was made to port in 4 min. 33 sec., and to starboard in 4 min. 8 sec. The action of the "Mangin" screw, driven with full power, was accompanied by the heavy thumping action upon the stern of the ship immediately over the screw at each revolution, that was so marked a feature in the vibratory action attending the working of this screw in the experimental trials made with it in competition with other screws in the trials made some five or six years since with the *Shannon* frigate.

## RAILWAYS IN SCOTLAND.

(Extracted from the *Weekly Scotsman*).

The latest official returns relating to railways refer to the state of matters as existing on 31st December, 1866. At that date, there were in Scotland forty eight railways, the aggregate length of which was 2,244 miles. The authorised capital was £50,104,794 by shares, and £17,024,623 by loans—total, £67,129,417. The amount paid up on shares and on debenture loans outstanding at the date of the return was £53,078,798. Of the forty-eight railways, all, except three, are either leased or worked by one or other of the following companies:—Caledonian, Glasgow and South-Western, Great North of Scotland, Highland, North British, of each of which we shall give a brief account in alphabetical order.

The Caledonian Railway was projected about the year 1840; but the bill for its formation was severely contested during several sessions, and did not receive the Royal assent until 31st July, 1845. The original line was 137¼ miles in length, and comprised a great fork from Edinburgh to Carnwath, a great fork from the north side of Glasgow to Carnwath, a branch from the Glasgow fork at Motherwell to the south side of Glasgow, with a subordinate branch to Hamilton, a branch from the same fork in the vicinity of Gartsherrie to the Scottish Central Railway near Castlecary, and a main trunk extending from Carnwarth to Carlisle. The act of incorporation authorised the company to raise £2,100,000, in shares of £50 each, and to borrow a sum of £700,000. The estimated cost of the railway was £2,100,000. The Scottish Central, Scottish Midland, Scottish North-Eastern, and several other railways have been amalgamated with the Caledonian. The company further hold in lease the Alyth and the Arbroath and Forfar Railways; while the Busby, Crieff and Methven Junction, Greenock and Wemyss Bay, Montrose and Bervie, and Portpatrick Railways are worked by them. The total length is 673 miles. The authorised capital of the conjoint railways at 31st December, 1866, was £17,429,181 by shares, and £5,826,357 by loans—total, £23,255,538. The amount paid up on shares and on debenture loans outstanding at 31st January, 1867, was £20,315,652. In 1866, the receipts from all sources of traffic amounted to £1,784,717, of which sum £638,376 was derived from passengers, and £1,146,341 from goods and live stock. The number of passengers, not including 7,724 holders of season and periodical tickets, was 9,127,203, carried in 113,512 trains, which travelled in the aggregate 2,699,330 miles. 900,000 head of live stock, 5,691,129 tons of minerals, and 1,830,759 tons of general merchandise were carried in 136,841 trains, which travelled 3,976,179 miles. The traffic was carried on by means of 479 locomotives, 1,068 passenger-carriages and luggage-vans, and 13,505 goods and other waggons.

In 1850, a number of lines in the south-west of Scotland were amalgamated under the title of the Glasgow and South-Western Railway. The main line extends from Glasgow by way of Paisley, Kilmarnock, and Dumfries, to a junction with the Caledonian Railway near Gretna. There are besides a number of branches. The total length is 254 miles, and the authorised capital £8,015,100, of which £6,234,600 may be raised by shares and £1,780,500 by loans. At 31st January, 1867, £6,287,311 had been paid up on shares and on debenture loans. The receipts from all sources of traffic in 1866 were £570,805, of which sum £189,040 was from passengers, and £381,765 from goods and live stock. The number of passengers, exclusive of 780 season-ticketholders, was 2,862,928, carried in 40,283 trains, which travelled in the aggregate 1,099,237 miles. 2,755,305 tons of minerals and 426,131 tons of general merchandise were carried in 75,395 trains, which traversed 1,855,085 miles. The traffic was carried on by 152 locomotives, 401 passenger carriages and vans, and 56,691 goods and other waggons.

As originally authorised by Parliament in 1846, the Great North of Scotland Railway was to embrace a line from Aberdeen to Inverness, with branches to Banff, Portsoy, and Burghead, the total length being 138¼ miles. It was to have formed one undertaking, with a line from Aberdeen into Forfarshire, which had been sanctioned in the preceding year. From various causes, however, the scheme was not carried out in its integrity—indeed, only a small portion of this line was constructed under the original proprietary; but lines which were formed as separate undertakings in the district have been amalgamated with it, and the Great North of Scotland is now a much more extensive concern than its original promoters contemplated. The more important railways that have been amalgamated with the Great North are the Banffshire, Strathspey, Formartin and Buchan, and Deeside. The total length is 289 miles, of which 284 miles have only a single line of rails. The authorised capital of the conjoint railways is £3,080,393 by shares and £1,003,019 by loans—total, £4,083,412. At 31st January, 1867, there has been paid up on shares and on debenture loans outstanding £3,638,778. The receipts from all sources of traffic in 1866 were £172,339; of which sum £87,342 was from passengers, and £84,997 from goods and live stock. The number of passengers, exclusive of 4,536 season-ticket holders, was 1,736,246, carried by 31,246 trains, which travelled in the aggregate 624,124 miles. 207,893 tons of minerals and 313,345 tons of general merchandise were carried in 10,382 trains, which traversed 261,643 miles. The rolling stock consisted of 54 locomotives, 200 passenger carriages and vans, and 1,453 goods and other waggons.

The Highland Railway comprises several undertakings, which by gradual amalgamation became in 1865 one united system under the present title. The first portion of this important system was a line from Inverness to Nairn, which was opened in November, 1855. This was followed by the Inverness and Aberdeen Junction, which extended from Nairn to Keith—the northern terminus of the Great North of Scotland Railway—and was opened throughout in August, 1858 The Inverness and Nairn was amalgamated with this line in 1861. In the following year, the Inverness and Ross-shire Railway was opened from Inverness to Dingwall, and in 1863 from Dingwall to Invergordon. The Ross-shire line was amalgamated with the Inverness and Aberdeen Junction in 1862, and the next year an extension from Invergordon to Bonar Bridge was commenced. This, with a branch to Burghead, which was opened at the end of 1862, completed the system of the Inverness and Aberdeen Junction Company. In 1863 the direct Inverness and Perth Junction Railway was opened. It consisted of a line from Forres to Dunkeld, where it joined the Perth and Dunkeld Railway. The latter was amalgamated with the Inverness and Perth line the same year. A branch to Aberfeldy was made in 1864, which completed the line of the Inverness and Perth Company. The Inverness and Aberdeen Junction Company worked the Inverness and Perth line, and by the Amalgamation Act of 1865 these two undertakings became the Highland Railway. The total length of the system is 246 miles, 239 of which are single. The Findhorn Railway, a short line of 3¼ miles, is worked by the Highland Company. The authorised capital of the conjunct railways at December 31st, 1866, was £2,338,000 by shares, and £703,880 by loans—total, £3,041,880. The amount paid up on shares and debenture loans at that date was £2,285,012, The receipts from all sources of traffic in 1866 were £190,193, of which sum £108,219 was from passengers, and £81,974 from goods and live stock. The number of passengers, exclusive of 923 season-ticket holders, was 946,461, who were conveyed in 15,059 trains, which travelled in the aggregate 522,592 miles, 102,496 tons of minerals and 146,131 tons of general merchandise were carried in 3,875 trains, which travelled in the aggregate 364,599 miles. The rolling stock consisted of 55 locomotives, 176 passenger carriages, 1,169 waggons, &c.

The North British Railway is the longest in Scotland—measuring over all 735 miles. It extends from Perth and Dundee on the north, to Carlisle, Silloth, and Newcastle on the south, and passes across the country from Helensburgh to Berwick, sending out numerous branches and loops in its course. The railway originally consisted of a line from Edinburgh to Berwick, measuring fifty-eight miles. with a branch to Haddington four miles in length. The Edinburgh and Dalkeith Railway was purchased by the company in 1845, adapted to locomotive traffic, and connected with the main line. A company had been formed, and powers obtained for the construction of a railway from Edinburgh to Hawick; and in 1845 the powers of this company were purchased by the North British, who next year got a bill passed to enable them to send out branches from their main line to Tranent, Cockenzie, North Berwick, and Dunse; and from their Hawick line branches to Selkirk, Kelso, and Jedburgh. The main line was opened on the 18th June, 1846. Further powers were obtained in the following year, and by that time the company had either constructed or held authority for a total length of 163 miles of railway. Branches to Musselburgh and Peebles were the next works undertaken. The latter of these was opened in June, 1855. Since that time numerous additions have been made by new works and amalgamations, and at present the company hold in lease the Carlisle and Silloth Bay, Edinburgh and Bathgate, Peebles and Port-Carlisle Railways, while they work the Berwickshire Devon Valley, Glasgow and Milngavie Junction, Leslie, and St. Andrews Railways. The authorised capital of the entire system at 31st December, 1866, was £16,687,620 by shares, and £6,266,467 by loans—total, £22,954,087. At 31st January, 1867, there had been paid up on shares and on debenture loans £19,178,407. The receipts from all sources in 1866 were £1,374,702, of which sum £651,185 was from passengers, and £813,517 from goods and live stock. The number of passengers, exclusive of 6,401 season-ticket holders, was 8,196,291, carried in 158,117 trains, which travelled in the aggregate 2,577,614 miles. 4,118,943 tons of minerals, and 1,539,506 tons of general merchandise, were carried in 181,839 trains, which traversed 3,571,335 miles. The rolling stock was;—Locomotives, 367; passenger-carriages and vans, 1,261; waggons, 16,277; other vehicles, 159.

The only railways not belonging to or worked by the five companies above mentioned are the Forth and Clyde Junction (thirty miles); the Leven and East of Fife (nineteen miles); and the Drumpeller Railway, which belongs to the Forth and Clyde Navigation Company (two miles). The capital of the Forth and Clyde Junction is £192,000 by shares, and £64,000 by loan—total £256,000. The total paid up on shares and debentures at 31st December, 1866, was £250,051. The receipts from all sources were £17,168, of which sum £5,381 was from passengers, and £11,787 from goods and live stock. The number of passengers, exclusive of 72 season-ticket holders,, was 92,243, carried in 1,387 trains, which travelled in the aggregate 41,612 miles. 60,000 tons of minerals, and 32,241 tons of general merchandise, were carried in 1,092 trains, which traversed 32,752 miles. The rolling stock consisted of four locomotives, fourteen passenger carriages and vans, and 289 waggons. The capital of the Leven and East of Fife Railway is £130,000 by shares, and £43,300 by loans—total, £173,300. The paid-up shares and debentures on loans were £136,170. The receipts from all sources were £15,030, of which sum £6,592 was from passengers and £8,438 from goods and live stock. The number of passengers, exclusive of 131 holders of season-tickets, was 121,027, carried in 2,584 trains, which travelled in the aggregate 54,507 miles. The number of goods trains is not stated, but 19,687 tons of minerals, and 48,429 tons of general merchandise were carried. The rolling stock consisted of three locomotives, seven passenger carriages, and 168 waggons and vans. The Dumpreller Railway, which carries no passengers, conveyed 239,867 tons of coal, the revenue from which was £2,177.

It will be seen from the above figures that the number of passengers who travelled on the railways of Scotland in 1866 was 23,082,369; exclusive of 20,567 season-ticket holders. The other traffic comprised 345,430 cattle, 1,788,321 sheep, and 82,230 pigs; 13,195,851 tons of coal and other minerals; 4.336,512 tons of general merchandise. 771,613 trains of all kinds were run, and the aggregate distance traversed was 17,680,579 miles. The receipts from passenger traffic amounted to £1,596,135, and from goods and live stock, £2,530,996—total, £4,127,131. Under the head of working expenditure, we get the following facts:—The maintenance of way and works of the Scotch railways in 1866 cost £387,425; locomotive power, £587,195; repairs and renewals of carriages and waggons, £142,280; traffic charges (coaches and merchandise), £519,053; rates and taxes, £71,872; Government duty, £33,911; compensation for personal injury, &c., £16,989! compensation for damages and loss of goods, £19,829; legal and parliamentary expenses, £34,038; miscellaneous expenses, £200,494—making a total working expenditure of £2,013,087, representing an increase of £234,754 as compared with the preceding year. The proportion per cent. of expenditure to total receipts was 49. There is some difficulty in ascertaining the number of persons employed about railways; but from a careful calculation, we conclude that at the present time not fewer than 30,000 persons are so employed in Scotland.

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## HER MAJESTY'S SHIP "MINOTAUR."

On the 14th ult. the *Minotaur*, 34, screw (armoured, iron) frigate, 1,350-horse power, Captain James G. Goodenough, made a trial of her speed, under full boiler power only, over the measured mile in Stokes Bay, near Portsmouth. It was directed by the Admiralty, when the ship was recently in dock finishing her refit for the year, that the pitch of the screw should be coarsened. In the present trials, therefore, the coarseness of the pitch of the screw has been increased by 3ft. 4in., its blades having previously been set at 22ft. 2in. They have now been set and remain at 25ft. 6in. The diameter of the screw is 24ft. 6in., its length of blade 22¼in., and the immersion of the upper edge on Saturday 22in. The ship draws 25ft. 10in. of water forward and 26ft. 10in. aft. She is, of course, as one of the Channel Squadron, in seagoing condition in all respects, with six months' general stores on board, complete in her officers, crew, armament, &c, and she had 700 tons of coal on board, but this included 60 tons of the Navigation Steam coal for use on the measured mile. The ship made the customary number of six consecutive runs over the measured mile, the speed attained in each being 14·815, 13·900, 15·126, 13·433, 15·584, and 13·091 knots. These results gave her a mean speed on the measured mile of 14·411 knots per hour, obtained with an indicated power of the engines of 6,706 horse.

On the 18th ult. she left Spithead soon after 9 a.m. for a six hours' continuous steaming trial outside the Isle of Wight, and, after cutting her anchor, she steamed out to the S.E., to get up steam and the number of the revolutions of the engines in preparation for the start. There was a light breeze from about E.S.E., and a perfectly smooth sea.

At 10h. 21m. 20s. the signal was given by Captain Chamberlain, the officer commanding the Portsmouth Steam Reserve, and in charge of the ship during the trial, that the ship would then commence her trial. She had then the Warner Light-vessel close abreast of her starboard gangway, and the engines were making 55·5 revolutions. The time was taken and continued to be so taken at the various points in the course by a Benson chronograph. The engines had made, previous to the start, 2,024 revolutions. At 10h. 32m. the Nab Light (distance run, three miles) was passed on the starboard hand, and the course of the ship altered thence to outside the Princessa shoal. At 10h. 46m. the frigate passed the shoal, with the black buoy with "Sharpus" on Bembridge Point (distance run, six miles), and at 11h. 13m. 30s. she had passed Dunnose, and was in 30 fathoms soundings on the chart off Bonchurch, and in line with the Pulpit rock. At 11h. 35m. she steamed past the Stone Light Tower of St. Catherine's, leaving the Cliffs of Black-gang. She shaped her course for St. Alban's Head. The distance by the chart between the Warder Lightship and St. Catherine's Point is 19 miles, as the ship's course had been laid down for her, and this had been run over by the ship in 1h. 13m. 40s. The tide was running to the westward, and therefore with the ship from the Nab Lightship, and would slacken about half an hour after noon. At 33 minutes past noon Chale Bay had been crossed over its extreme outer limits, and Hurst Castle and Light Towers opened to view from the ship's deck clear of the Needles Rocks and Light Tower, while Bolland Point, Durlstone, and St. Alban's Head rose rapidly, and closed with the ship on her starboard bow. Fairly in the Channel, the sea was far too smooth and the wind to light to give the frigate any movement excepting a scarcely perceptible motion of her bow and stern as she slightly rose and fell to the gentle tidal swell. Exceptionally fine as the weather was, a thin mist hung over the land, and it was not until the frigate neared St. Alban's Head that Portland could be seen through it. The engines of the ship kept up their speed, and at 1.30 precisely the helm was put hard over to port, and the vessel swung round on her return course, the point of St. Alban's Head being a mile and a quarter under her lee, and the distance between the starting-point, the Warner Light, 47 miles, having been run by the ship in 3h. 8m. 40s.

In about ten minutes after putting her helm over to starboard on the weather side of St. Alban's Head, the *Minotaur* was on her way back to Spithead, and steaming direct for Rocken End Race, off St. Catherine's. What trial coal had been put on board was now burnt, and as the ship neared the Isle of Wight again the ordinary coal of her bunkers was feeding the fires, and the certain consequence followed—the steam lost in pressure on the pistons, the engines in the number of their revolutions, and the ship in her speed. The high hopes of an astonishingly favourable result held by many in the early part of the day began slightly to fade; but still the mean result of the trial was certain to be highly satisfactory, and at the same time to approximate very closely to the figures laid down by those best qualified to form an estimate of the *maximum* capabilities of both the ship and her machinery. St. Catherine's Light was passed at 3h. 23m. p.m., Ventnor Bay at 3h. 39m., and Dunnose at 3h. 45m. The Nab Light-vessel was passed at 4h. 23m. 30s., and, as the six hours' steaming was now more than done, the trial of the maintenance of the ship's steaming powers was brought to a close. The distance run by the ship was 91 miles, and time occupied in doing it 6h. 2m. 10s. Leisurely steaming in from the Nab Light towards Spithead, the frigate's anchor was again dropped at the anchorage, and the most successful day's work on trial she has yet made brought to a highly satisfactory conclusion.

The following tabular return shows the exact performance of the engines, and appended is a summary of all the trials the ship has yet made under Admiralty or Steam Reserve supervision.

Ninety-five tons of coals were burnt from the time of the ship starting from Spithead until her return.

No hot bearing or difficulty of the slightest kind occurred, and no engines could have given greater satisfaction by their working from the start to the close of the trial. Mr. H. Anderson represented the makers, Messrs. John Penn and Son:—

| Time. | | Steam pressure, Engine-room. | Steam pressure, Stokehole. | Vacuum. | | Engine Revolutions by Watch. | Engine Revolutions each half-hour. | Engine Revolutions. |
|---|---|---|---|---|---|---|---|---|
| | | | | Forward Engine. | Aft. | | | |
| h. | m. | lb. | lb. | | | | | |
| 10 | 20 | 23 | 25 | 26·5 | 26·5 | 55·5 | | |
| 10 | 50 | 23 | 25 | 26·5 | 26·5 | 55·5 | 1,652 | 1,652 |
| 11 | 20 | 23·5 | 25 | 26·5 | 26·5 | 56 | 1,681 | 3,333 |
| 11 | 50 | 22 | 24·5 | 26·75 | 26·75 | 55·5 | 1,664 | 4,997 |
| 12 | 20 | 22 | 24·5 | 26·75 | 26·75 | 55·5 | 1,662 | 6,659 |
| 12 | 50 | 22·5 | 22 | 26·5 | 26·5 | 55·5 | 1,661 | 8,320 |
| 1 | 20 | 21·5 | 24 | 26·5 | 26·5 | 55·5 | 1,672 | 9,992 |

The ship here reversed her course off St. Alban's Head, and the revolutions of the engines were in consequence lessened considerably until a straight course was made, on return, for the point off St. Catherine's, Isle of Wight. The figures taken during the time occupied by the ship in her return to Spithead are as follows:—

| Time. | | Steam pressure, Engine-room. | Steam pressure, Stokehole. | Vacuum. | | Engine Revolutions by Watch. | Engine Revolutions, each half-hour. | Engine' Revolutions. |
|---|---|---|---|---|---|---|---|---|
| | | | | Forward Engine. | Aft. | | | |
| h. | m. | lb. | lb. | | | | | Total. |
| 2 | 5 | 20·25 | 22 | 26·5 | 26·5 | 55·25 | 1,659 | 12,458 |
| 2 | 35 | 20·75 | 23 | 26·5 | 26·5 | 55·5 | 1,651 | 14,109 |
| 3 | 5 | 21·75 | 24 | 26·5 | 26·5 | 56 | 1,670 | 15,779 |
| 3 | 35 | 18·5 | 21 | 27·5 | 27·25 | 53·5 | 1,620 | 17,399 |

The total number of the revolutions made by the engines during the 6 hours 2 minutes and 30 seconds—19,905.

Nominal horse-power, 1,350.

| Where tried ... ... | Stokes Bay | Stokes Bay. | Stokes Bay. | 6 hours' run |
|---|---|---|---|---|
| When tried ... ... | April 23, '67. | May 10, 1867. | Mar. 14, 1868 | Mar. 17, 1868 |
| Draught of water:— | | | | |
| Fore ... ... ... | 25·8 | 25·8 | 25·8 | 26ft. |
| Aft ... ... ... | 26·8 | 26·10 | 26·10 | 26ft. 10in. |
| Mean... ... ... | 26·2 | 26·3 | 26·3 | To be worked out. |
| Indicated horse power | 6,400 | 6,952 | 6,700 | |
| Speed of ship in knots | 13·18 | 14·327 | 14·411 | |
| „ screw ... | 13·35 | 13·43 | 13·81 | |
| Slip of screw per cent. | 1·25 | 6·6 neg. | 4·34 neg. | |
| Co-efficient ... ... | 464 | 556 | 579 | |
| Diameter of screw ... | 24 | 24 | 24 | 24ft. |
| Pitch ... ... ... | 23·4 | 22·2 | 25ft. | 25ft. |
| Revolutions ... ... | 57½ | 61½ | 55·9 | — |
| Pressure on safety valve | 25 | 25 | 25 | 25 |
| Vacuum ... ... | 25½ | 24½ | 26½ | 26 |
| No. of runs taken ... | 2 | 6 | 6 | 6 hours. |
| Force of wind ... ... | 6 | 2 | 3 | 2 |
| Sea ... ... ... | Slight swell. | Smooth. | ... | Smooth. |

The *Minotaur* and her machinery is in admirable condition. A very ingeniously applied mechanical engine counter, with second hands timepiece attached (designed by Mr. George Murdoch, the inspector of machinery afloat at Portsmouth), is fitted on board. It is worked from a toothed collar round the screw shafting by bevelled wheels and rods. The timepiece enables the officer of the watch to set the ship at any rate of speed by a given number of revolutions of the engines from a tabular form drawn up from the results of the ship's known rate of speed and trials over the measured mile.

## PROJECTED RAILWAYS AND WORKS IN THE CITY.

Mr. Haywood, the engineer and surveyor to the Commissioners of Sewers, has presented a report to them descriptive of certain railways and works, seven in number, which have been projected in or which affect the City.

The first of these is the Eastern Metropolitan Railway, the object of which is the formation of an underground railway, commencing in the City by a junction with the Metropolitan Railway in Aldgate High-street, east of St. Botolph's Church. From that point it is to be carried along the Whitechapel High-street and the Mile End-road to a junction with the Great Eastern Railway at Bow. The entire line is to be subterranean, and is to follow the line of some of the principal streets. The public way of the City which will be affected is the line of Aldgate High-street, between Suncourt and the City boundary, and a small area of private property will be taken for the purpose of a station. The total area scheduled within the City, including the public way, is about three-quarters of an acre, of which the area of private property is about one-sixth of an acre. The public way is to be restored to its original level and condition when the works are completed. By exchange stations at Bow and at Aldgate High-street passengers will be carried from the west to the extreme east of London without leaving the railway system, if the proposed line be carried out.

The next is the Islington Railway, which is a novel project in its way. It contemplates the formation of a railroad between Little Moorfields and Islington, at a point near the Agricultural Hall, on one continuous viaduct, and with a narrow gauge. The line is to start from Little Moorfields, between Union-street and Tenter-street, and crossing Tenter-street, White-street, and Reynold's-court, at which point it leaves the City; it will cross Chiswell-street and many streets on the west side of Bunhill-row, Bath-street, and Shepherdess-walk, passing over the City Canal near to Wenlock-basin, and over James-street, William-street, and Essex-street, through property on the northern side of St. Peter's-street, and terminating in Essex-road, near Islington-green. The line is to be on a viaduct, starting at a level of 30ft. above the pavement in Little Moorfields. The viaduct, of wrought and cast iron, will be made and fitted together at the factory before it is brought to the ground, and will, it is said, be constructed much more speedily than any other class of viaduct. Owing to the height at which it will be carried, the narrowness of the gauge, which is to be only 3ft., and the mode of construction generally, the promoters believe the cost will be small when compared with that of other viaduct lines, and, therefore, that unusually small fares may be charged to passengers, with considerable profit to the shareholders. The line appears to Mr. Haywood to have been constructed to secure the traffic, which it is anticipated would go from Islington to the City by the projected new line of thoroughfare from Upper-street, Islington, to Fore-street.

The third project is one for making a junction railway between the Metropolitan Railway at Smithfield Market, and the London, Chatham, and Dover Railway at Snow-hill. The junction with the Metropolitan Railway will begin at the meat market, be carried beneath a new street now being formed from Farringdon-road to the western side of the market, and thence by a curve under St. John's-court to a junction with the London, Chatham, and Dover Railway at Snow-hill. The line will be entirely subterranean. The total area scheduled within the City is upwards of two acres, of which about nine perches are public way, and of the property scheduled the largest portion either already belongs to the corporation in respect of the markets improvements, or to the London, Chatham, and Dover Railway. The public ways will be restored to their original state when the railway work is completed. The bill for this line of railway also seeks power to extend the time for the purchase of lands in the parish of St. Giles Without, Cripplegate, for which an act was passed in 1865. The powers granted by that act expire this year, and it is sought to extend that time to 1870.

The fourth project contemplates the formation of a subway, beginning at Tower-hill, a little to the north of Lower Thames-street and the Tower Dock, crossing beneath the river, and terminating on the sourthern side, near Pickle Herring Stairs, St. Olave, Southwark. The surface of the rails of this subway in the centre of the river will be upwards of 60ft below high water mark, and the depth of the shaft on the City side 60ft. below the surface of Lower Thames-street. The subway will be about 8ft. in diametor. The subway will pass beneath Tower-hill close to Lower Thames-street, and beneath the sewers, which receive the drainage of the western side of Tower-hill, and discharge into the river near to the Tower Dock. The subway will be of cast iron, and is intended to convey passengers by an omnibus, which will be lifted in the shafts to the surface of the pavement on either side of the river, and which, when fitted, will be lowered to the level of the subway. The omnibus will carry twelve persons, and will be moved partly by gravitation and partly by other means. It will run backward and forward all day. The journey through the subway will be short, and the fares are to be very low. Mr. Haywwood is of opinion that although there can be no doubt of the utility of any safe, quick, and cheap means of crossing the river at this spot, what is imperatively demanded is a new bridge across the river, with suitable approaches on either side. If that were constructed, there would be no necessity for this subway. The Great Eastern Railway Company, in the year 1865, obtained power to take certain property in the City, beginning on the northern side of Liverpool-street, and thence to the City boundary, forming a terminus in Liverpool-street. This power will expire in the course of the present year, and by a bill now before Parliament it is sought to extend it to 1871.

The last project to which Mr. Haywood refers is that promoted by the Corporation of London for supplying the citizens with gas of an increased illuminating power, greater purity, and at a lower price than is already supplied. In respect of illuminating power, the gas is to produce from an Argand burner, consuming 5ft. of gas per hour, a light equal to that of eighteen sperm candles of six to the pound, each burning at the rate of 120 grains per hour, whereas the illuminating power of the gas now supplied to the citizens is, according to the Metropolis Gas Act of 1860' only equal to twelve sperm candles. As to purity, not more than twenty grains of sulphur in any form are to be contained in 100 cubic feet of gas. With regard to price, not more than 3s. 6d. is to be charged by the corporation for 1,000 cubic feet of gas, whereas the price of gas of inferior illuminating power is now 4s. per 1,000 cubic feet. The measure defines more clearly the mode of ascertaining the illuminating power and purity of the gas; points not well determined by the Metropolis Gas Act of 1860. The corporation will take powers to supply meters under certain conditions to all consumers, without charge. The site of the proposed gasworks is on the northern banks of the Thames, at North Woolwich, to the east of Silvertown, whence the leading mains are to be brought by the principal roads to the City, which they may enter both at Aldgate, High-street, and the Minories. Powers are also sought to lay down gas mains and pipes throughout the City, and generally to carry on the usual operations of Gas companies, and such as may be needful for the economical supply of gas to the citizens.

## INSTITUTION OF CIVIL ENGINEERS.

### ON THE SUPPORTING POWER OF PILES; AND ON THE PNEUMATIC PROCESS FOR DRIVING IRON COLUMNS, AS PRACTISED IN AMERICA.

By Mr. W. J. McAlpine, M. Inst. C.E. (of New York).

The first part of this communication related principally to the experience gained in driving six thousand five hundred and thirty-nine piles, an average depth of 32ft., for the foundation of the Government Graving Dock at Brooklyn, N.Y., when the support was mainly derived from the adhesion of the material into which the piles were driven, and slightly from their sectional area. The piles were in rows 2½ft. apart, and at transverse distances of 3ft., all from centre to centre; intermediate piles of tough second-growth oak being frequently employed. The main piles were chiefly round spruce spars, very straight, from 25ft. to 45ft. long, and not less than 7in. in diameter at the smaller end, and on an average 14in. in diameter at the larger end. From a record kept during the progress of the work, it was ascertained that it took two and one-third blows to drive each foot of pile, and that the distance moved uniformly diminished from the first to the last blow, ranging from 8in. at the beginning to no movement at the end, the average distance moved by the last five blows being 1in. A considerable number of the piles were driven by a Nasmyth steam piling machine, with a ram of 3 tons, and a stroke, or fall, of 3ft., and making from sixty to eighty strokes per minute. The other machines were generally operated by steam power, giving an average of a blow per minute; but occasionally the hammers were hoisted by manual and horse power. The rams in the latter machines were of cast-iron, swelled out at the bottom to concentrate the weight at that point, and weighed about 2,200lbs. each, though some were used of 1,500lbs.; the fall being 30ft. It was observed that the heaviest ram, when striking blows of the same effect as lighter ones, did the least injury either to the head of the pile or to the protecting iron ring, and this injury was still less with the Nasmyth hammer. It was also found that no advantage was gained by the fall of the ram being more than 40ft., as the friction on the ways then prevented any increased velocity to the ram when falling from a greater height. With the Nasmyth hammer, piles were driven 35ft. in seven minutes, while with the other machines similar piles required one hour, or more, to drive them the same distance.

Experiments were made at different times to ascertain the weight which the piles would sustain. For this purpose a long lever of oak timber was employed, with which a number of the foundation and coffer dam piles of nearly the same size, and driven under exactly similar conditions, were withdrawn. It was thus ascertained that a weight of 125 tons was required to move a pile, driven 33ft. into the earth, to the point of ultimate resistance, with a ram weighing 1 ton, and falling 30ft. at the last blow. These trial piles averaged 12in. in diameter in the middle. From a number of other experiments, it was believed that the extreme supporting power of the pile, due to its frictional surface, was 100 tons, or 1 ton per superficial foot of the area of its circumference. From an analysis of the experiments, the following general laws seemed to have prevailed in these cases:—1st. That the effect of lengthening the fall of the ram was to increase the sustaining power of the pile in the ratio of the square root of the fall. 2nd. That by adding to the weight of the ram, the sustaining power of the pile was increased by 0.7 to 0.9 of the amount due to the ratio of the augmented weight of the ram. 3rd. That a pile driven by a ram weighing 1 ton, and falling 30ft., would sustain an extreme weight of 100 tons. The formula based upon these data, as applicable to rams weighing from 1,000lbs. to 3,000lbs., falling from 20ft. to 30ft., was $X = 80 (W + 0.228 \sqrt{F} - 1)$, in which X was the supporting power of a pile driven by the ram W., falling a distance F; X and W being in tons, and F in feet. The author was of opinion that, under the most favourable circumstances, the pile should not be loaded with more than one-third of the result given by this formula; and when there was any danger of a future disturbance of the material around the pile, or when there was any vibration in the structure which might be communicated to the piles, the load imposed should not exceed one-tenth.

The bearing support due to the sectional area of the pile had not been considered in the preceding inquiry; but numerous experiments had been made, which gave results of from 5 tons to 10 tons per square foot.

The island occupied by the city of New York was separated from the mainland by a navigable tidal estuary, called the Harlem River, and this was spanned by several bridges. In reconstructing the bridge forming the continuation of the Third Avenue, it was decided to make a pivot draw in the centre; and, with a view of creating the least possible obstruction to the current, the draw pier was composed of one central and ten circumscribing iron columns, each 6ft. in diameter and 50ft. in height, the water in the middle of the river being 20ft. deep. Careful experiments upon the supporting power derived from the frictional surface of these columns, when sunk from 20ft. to 30ft. in moderately fine material, had led the author to adopt a co-efficient of half a ton per superficial foot of the exterior surface. These piles were sunk by the pneumatic process (both plenum and vacuum), and the method of sinking them was next described in minute detail, as well as the apparatus and means taken to ascertain their sustaining power. Although the lateral support, as determined by the experiments, in addition to that which would be derived from a base of 6ft. in diameter, showed that it would be ample for that place; yet, in view of subsequent operations, the importance of devising a method of increasing even the large base due to size of the column offered advantages too great to be neglected, and various methods of accomplishing this result were proposed. The one adopted was as follows:—It had already been decided to fill the columns with concrete, and it was naturally suggested to extend this masonry below the bottom as deep as men could work in the water, and also to undermine the adjacent earth, as far as practicable, and to extend the concrete into the space. This was done in sections of about 2ft. in width, and when the ring had been completed, it was found that the column was virtually extended, and that the water would readily sink under pressure to a level with the bottom of the concrete, so that the sand within it was easily removed, and the space filled with concrete to a depth generally of 4ft., or more. Contrary to statements occasionally made, it was found that the cement set with far greater rapidity under pneumatic pressure than in the ordinary atmosphere.

The experience gained, and the reflections resulting from the operations at the Harlem Bridge proved, among other things, the rapidity, facility, and economy of driving iron columns of large size, under favourable circumstances. The extracts from the author's journal showed, that the last columns were driven from 16ft. to 20ft. in from three to six days, in sand and porous material, free from obstructions. The economy of this work was indicated by the small force employed at Harlem, which was twelve men, all told, including the engine drivers, stevedores, and foreman. Their aggregate wages, and the expense of fuel, did not exceed £6 per day. The cost of the plant was under £1,500. The metal in the column, if but $1\frac{1}{4}$in. thick, which was quite sufficient, would have been in New York £13 per lineal foot of the column. It was remarked that at Harlem the officers and workmen experienced neither temporary nor permanent ill-effects from a pressure of two-and-a-half atmospheres. It was believed that cylinder piles might be driven to great depths, through extraordinary obstacles, such as rocks, logs, and sunken vessels, without serious loss of time, or at much cost; and that they would penetrate quicksand, which was so troublesome by all other methods, with unusual facility. Again the columns might be regulated in their descent, and be suddenly arrested at any precise point, at the will of the director, by means of a pneumatic reservoir. Thus, the descent was commenced at first slowly, the velocity gradually increasing until the movement became dangerous, when it was instantly stopped. In some cases the piles could be driven by the vacuum process alone, in all cases by the plenum, and sometimes both might be employed with advantage; and the driving could be further aided by the use of mechanical pressure or weight. The support which such columns derived from their external frictional surface in ordinary earth was, as previously stated, at least equal to half a ton per square foot, but in the finest earth it would amount to 3 tons. The support from the area of the bottom in shallow depths was from 5 tons to 10 tons per square foot; and at the great depth these columns would be ordinarily sunk, it must be considerably more.

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## ON THE MANUFACTURE AND WEAR OF RAILS.

By Mr. C. P. Sandberg, Assoc. Inst., C.E.

This communication was divided into three parts. First, as to the best method of manufacturing rails out of common iron, and as to the time they would last. Secondly, as to the disposal of the iron rails when they were worn out. And thirdly, as to whether iron or steel, or a combination of the two materials, was the most economical to use for rails.

The mode of manufacturing iron rails for Sweden, as carried out in South Wales between the years 1856 and 1860 was described; and it was stated that, with a view of ascertaining the best method, it was decided to submit a number of sample rails, made from five different kinds of "piles," to actual practical trials. These experimental rails were laid down at the Camden Town Station, by permission of the London and North Western Railway Company; and the following table showed the number of tons passed over each description of rail before it was crushed, and also before the rails were taken up:—

| Mark of Rail. | Crushed.<br>Tons. | Worn Out.<br>Tons. |
|---|---|---|
| T | 3,680,000 | 5,060,000 |
| Y | 4,140,000 | 5,290,000 |
| H | 3,220,000 | 5,060,000 |
| E | 6,900,000 | 8,970,000 |
| N | 3,220,000 | 5,520,000 |

A table, calculated from the above, showed how long the rails would last, supposing them to be passed over by three thousand trains yearly, each train being composed of an engine weighing 30 tons, and of twenty waggons of 10 tons each, or a gross load of 230 tons. From these tables it was ascertained that the five different descriptions of rails were on the average crushed in six years, and worn out in nine years. The conclusion was thus arrived at, that hammering after the first welding heat, for this particular kind of iron, did not improve the endurance of the rails, but that the simplest mode of manufacture had also the material advantage of being the best. These trials at the same time established the fact, that it was not the wear or the diminished sectional area caused by abrasion which produced the unsatisfactory results in the endurance of iron rails, but the lamination caused by imperfect welding. This explained the great difference between the wear of rails made in exactly the same way, the welding in the one case being perfect, whilst in the other it had been very imperfect.

These experiments also confirmed the rule laid down in Mr. R. Price Williams's paper, "On the Maintenance of Permanent Way," viz., that the endurance of rails might be measured by the product of the speed and of the passing weight. Trial rails, of the same kind of manufacture as those marked E in the previous table, but of a heavier section, laid on the Great Northern Railway, might thus be said to have borne 276 million tons at a speed of one mile per hour. The endurance of the rails tried at Camden Town, under unusual conditions, where the wear was occasioned principally by the frequent use of the breaks and by continual shunting, was much less, and might be represented by 120 millions at a speed of one mile per hour. These experiments seemed to indicate that 220 million tons might be carried over rails, of the section and make referred to, at a speed of one mile per hour; so that any railway company, knowing the load which yearly passed over their line and the speed, might by multiplying the one into the other, and dividing this product by 220, ascertain the life of iron rails in years.

The conclusions the author had arrived at were, that no rule could be laid down for the manufacture of rails that would apply to every manufacturing district; but that in the case of Welsh iron, to which he had more particularly referred, it had been proved that the best method of manufacturing the rail was that now most commonly practised, viz., rolling the iron into bars, piling these, and repeated rolling to the finished rail, without hammering. The author assumed that the prejudicial result from hammering was owing to the large amount of sulphur in the Welsh iron. Where the iron contained more phosphorus, and less sulphur, as, for instance, in the Cleveland, Belgian, and French iron districts, hammering had proved beneficial, and rails had been made from puddled bars, without the intermediate process of piling—this being, in fact, the method generally adopted in those places, and being found to answer best.

As to the disposal of the rails when worn out, and as to the possibility of re-rolling old rails with advantage by companies far removed from the seat of manufacture, such as the British Colonies, the countries round the Mediterranean or the Baltic, the author thought that for railways near the seat of rail manufacture, the best way would be to continue to sell the old rails to the rail mills. For other countries, situated like Sweden, for instance, it became important to ascertain whether it would not be more advantageous to re-roll them. On this subject precise and detailed calculations were entered into, which led the author to think, that the manufacture might be carried on in that country with advantage, using Swedish Bessemer steel for the head, No. 2 iron for the foot or flange, and old iron rails for the remainder of the pile.

In the third division of the paper, as to the best and most economical material to be employed for rails, the following calculations were made:—Assuming that, under a very heavy traffic, common iron rails would last five years, steel-top rails fifteen years, and solid steel rails thirty years, and that iron rails would cost £7 per ton, steel-top rails £10 per ton, and solid steel rails £15 per ton, and that the old steel-top and iron rails were valued at £4 per ton, and the old solid steel rails at £8 per ton, then, with a rail section of 84lbs, per yard, 250 tons of rail would be required for one English mile of double line, and the cost of laying the rails might be estimated at £1 per ton. On these assumptions the author has calculated the following

ANNUITY TABLE, No. 1.

Interest calculated in each case at 5 per cent.

| PRICES. | Per Ton. | When Iron Rails last. | ANNUITY WOULD BE FOR Iron Rails. | Steel Top Rails. | Solid Steel Rails. |
|---|---|---|---|---|---|
| Iron Rails ... ... ... | £7 | | | | |
| Steel Top do. ... ... ... | 10 | Years. | £ | £ | £ |
| Solid Steel do. ... ... | 15 | 2 | 587 | 395 | 325 |
| | | 3 | 417 | 307 | 271 |
| CREDIT FOR | | 4 | 332 | 247 | 245 |
| | Per Ton. | 5 | 280 | 218 | 230 |
| Old Iron Rails... ... ... | £4 | 10 | 179 | 163 | 205 |
| „ Steel Top do. ... ... | 4 | 15 | 134 | 148 | 201 |
| „ Solid Steel do. ... ... | 8 | 20 | 130 | 140 | 200 |

This table might be thus explained, as to iron rails lasting five years:—

| | £ | s. | d. |
|---|---|---|---|
| 250 tons, at £7 per ton ... ... ... ... ... | 1,750 | 0 | 0 |
| Cost of laying down ... ... ... ... ... ... | 250 | 0 | 0 |
| | £2,000 | 0 | 0 |
| Which sum, at the end of five years, at 5 per cent. compound interest, became ... ... ... ... ... | 2,552 | 0 | 0 |
| The difference between this sum (viz., £2,552) and the value of the old rails (250 tons, at £4 per ton=£1,000) was ... ... ... ... ... ... ... | 1,552 | 0 | 0 |
| The annuity required to recoup this latter sum in five years was ... ... ... ... ... ... ... | £280 | 0 | 0 |

It might be objected that the prices quoted for solid steel rails were too high. Rails of this kind had been sold in some places as low as £12 per ton, but for the best quality the present price was £15 per ton, and it was only from these that the experience had been gained, as to their enduring six times as long as iron rails. However, Table No. 2 had been calculated for the different kinds and periods at the following prices, viz., iron rails at £6, steel-top rails at £9, and solid steel rails at £12 per ton, crediting the old iron and steel-top rails at £3 per ton, and the old solid steel rails at £5 per ton.

ANNUITY TABLE, No. 2.

| PRICES. | Per Ton. | When Iron Rails last. | ANNUITY WOULD BE FOR Iron Rails. | Steel Top Rails | Solid Steel Rails. |
|---|---|---|---|---|---|
| Iron Rails ... ... ... | £6 | | | | |
| Steel Top do. ... ... ... | 9 | Years. | £ | £ | £ |
| Solid Steel do. ... ... | 12 | 2 | 574 | 382 | 288 |
| | | 3 | 404 | 283 | 233 |
| CREDIT FOR | | 4 | 319 | 234 | 230 |
| | Per Ton. | 5 | 268 | 206 | 174 |
| Old Iron Rails... ... ... | £3 | 10 | 166 | 149 | 168 |
| „ Steel Top do. ... ... | 3 | 15 | 133 | 136 | 163 |
| „ Solid Steel do.... ... | 5 | 20 | 117 | 126 | 150 |

This table showed that in all cases solid steel rails were not the cheapest. The amount of traffic must, therefore, decide which material it was the most economical to use for the maintenance of the permanent way. For all railways where ordinary iron rails were worn out in five years, or in a shorter time, solid steel rails were the most economical, at the prices quoted in Table 1. Where ordinary iron rails lasted over five and up to ten years, steel top rails would be the cheapest; iron rails in these cases being clearly proved to be the most expensive, although the cheapest where they lasted from fifteen to twenty years.

The preceding tables referred to rails of the Vignoles section. Table No. 3 had been made up for the ordinary double-headed rail, for one English mile of double line, according to the prices stated, the considerations being the same as in Table No. 2, excepting that the chairs had been taken into account. Allowance had been made for 140 tons of new chairs per mile at £5 per ton, credit being given for the value of the old chairs at £2 10s. per ton. It might be observed, that steel-headed rails were here estimated to last four times, and solid steel rails eight times, as long as ordinary rails—that was making allowance for the use of both faces.

ANNUITY TABLE, No. 3.

| PRICES. | Per Ton. | When Iron rails last. | ANNUITY WOULD BE FOR Iron Rails | Steel Top Rails. | Solid Steel Rails. |
|---|---|---|---|---|---|
| Iron Rails ... ... ... | £6 | | | | |
| Steel Top do. ... ... | 9 | Years. | £ | £ | £ |
| Solid Steel do. ... ... | 12 | 2 | 780 | 379 | 296 |
| Chairs (140 tous pr mile) | 5 | 3 | 551 | 291 | 249 |
| CREDIT FOR | | 4 | 436 | 244 | 228 |
| | Per Ton. | 5 | 366 | 223 | 217 |
| Old Iron Rails ... ... | £3 | 10 | 229 | 177 | 199 |
| „ Steel Top do. ... ... | 3 | 15 | 183 | 166 | |
| „ Solid Steel do. ... | 5 | 20 | 163 | 162 | |
| „ Chairs ... ... ... | 2 10 | | | | |

Table No. 3 indicated that the iron rails were in no instance the cheapest; but, on the contrary, that when iron rails lasted only five years, solid steel rails had the advantage, and where iron rails had a longer duration, then that steel-headed rails were the most economical.

Another fact had still to be taken into consideration, the safety of the three different materials, in regard to high speeds, severe climate, &c. A report recently published by Professor Styffe, the Director of the Government School of Mines at Stockholm, showed the extent to which the tenacity and elongation of various materials were influenced by the amount of carbon they contained. From the tables which accompanied the report, it appeared that the hardest material had the greatest absolute strength, both before and after permanent set had taken place, but it had the least ductility; on the other hand, a softer material had the greatest tenacity or elongation, the Bessemer material giving the same results as that prepared from the same pig iron by puddling, refining, or the cast-steel process. In a diagram illustrating these results, the per centage of carbon and of phosphorus was stated in nearly all cases. The limit for the amount of carbon seemed to be for the Bessemer material 1·2 to 1·5 per cent. With a larger amount the absolute strength, as well as the tenacity, had been found to decrease. When the amount of carbon did not exceed 0·4 per cent., and the material was not worked at too low a heat, the elongation seemed to be 16 per cent., or the same as for puddled iron from the same pig iron; and, as such Bessemer material was not only much stronger, it deserved a decided preference for all railway purposes. The few cases of the failure of rails by breaking might be accounted for as the result of too hard a material, not perfectly manufactured, having been made at an early period of the introduction of the process. The experience which had now been gained should certainly prevent any recurrence of this.

It must, however, be observed that the raw material used in both cases was charcoal pig iron, of a superior quality compared with that used in England for making Bessemer rails, which might be seen from analyses made by two eminent chemists of both countries, which were given. These analyses showed that the great difference between the two was the excess of silicon in the English, and of manganese in the Swedish pig iron; thus explaining why the one gave a better product than the other, although worked entirely without the addition of spiegel-eisen. If there were only 0·6 per cent. of carbon in the solid steel, and 0.3 per cent. in the steel for the steel head, the safety ought to be the same for all the three kinds, and this would not influence the former calculations as to which was the best and most economical material for rails.

Having watched the development of the Bessemer process in England, as well as on the Continent, it seemed to the author that by that process a good and pure raw material had the same advantage over an inferior one as in all other processes, and that a superior product could not be obtained from an inferior raw material by that process any more than by any other. In having mentioned Swedish material, as an example, it must not be supposed that it was wished to advocate the use of Swedish iron in this country, but simply to draw attention to the better material, as equally good charcoal iron could be supplied from Canada and India—both English colonies. It might also be remarked that the author's endeavour had been to arrive at the truth irrespective of prejudice, and that he had no wish to be deemed an advocate for one kind of rail more than for any other.

At the meeting of this society, on the 3rd inst., Mr. Charles Hutton Gregory, President, in the chair, sixteen candidates were balloted for, and duly elected, including, as members, Mr. William Douglass, Trinity Works, Penzance; Lieut.-Col. John Pitt Kennedy, Consulting Engineer to the Bombay, Baroda, and Central India Railway Company; Mr. Richard Laybourne, late Locomotive Superintendent of the Monmouthshire Railway; Mr. William Henry Edward Napier, late a Resident Engineer on the Berlin-Gorlitzer and East Prussian Railways; and Mr. Josiah Timmis Smith, Engineer of the Hæmatite Steel and Iron Works, Barrow-in-Furness; and as associates, Mr. James Binfield Bird, Cowes; Mr. William Gammon, Lambeth; Mr. Thomas Bland Garland, Valparaiso; Mr. William Hunt, Westminster; Mr. James Trubshaw Johnson, Lichfield; Lieut.-Col. William Lawtie Morrison, R.E., Surveyor-General of the Mauritius; Mr. Patrick Ogilvie, Hambledon; Mr. Robert Sabine, Westminster; Mr. James Shaw, Leadenhall-street; Mr. Samuel Swarbrick, General Manager of the Great Eastern Railway Company; and Mr. Albert Vickers, Inverness-terrace.

It was also announced that the Council, acting under the provisions of Section IV. of the Bye-Laws, had since the last announcement admitted as students of the institution, Benjamin Hall Blyth, M.A., Alfred George Brookes, Richard Ernest Brounger, William Augustus Kennedy Gostling, Arthur Henry Heath, Charles Assheton Whately Pownall, Percy Frederic Tarbutt, and Frederick Toplis.

## ROYAL GEOGRAPHICAL SOCIETY.

The seventh meeting of the present session of this society was held at Burlington House on Monday evening last, Sir R. I. Murchison, Bart., President in the chair.

The following new Fellows were elected:—Captain Edward Baynton, N. Cork, W. R. Dalziel, A. Gillett, D. Haysman, Henry Kingsley, R. L. Middleton Kitto, J. W. Miers, M. L. Mavrogordato, J. E. C. Pryce, Hon. Edward Stirling, and J. W. S. Wyllie.

Two papers were read "On the Geographical Results of the Abyssinian Expedition, to Jan. 22, 1868," by Clements R. Markham. Commencing with a description of the shores of Annesley Bay, Mr. Markham stated that the ancient Greek city of Adulis, the emporium of Greek trade in the time of the Ptolemies, formerly stoood close to the shore; but the ruins were now at a distance of four miles. On a few mounds, concealed by salicornia bushes, there have been found broken pieces of fluted columns, capitals, and other fragments. But a great wealth of antiquarian treasure may be concealed under the mounds; and Dr. Lumsdaine, after making a very slight excavation, found the bronze balance and chain of a pair of scales, an appropriate first discovery in the ruins of a great commercial city. The Shohos, who inhabit the plain, are a black race, with rather woolly hair and small boned; but with regular and in some instances, even handsome features. They wear a cotton cloth round the middle, and a cloak of the same material, the head and feet bare, and are always armed with a curved sword, worn on the right side, spear, club, and leathern shield. They have cattle of a very diminutive breed, asses, goats, and sheep. Their mode of sepulture is peculiar; the graves are marked by oblong heaps of stones, with upright slab at each end. A hole is dug about 6ft. deep, at the bottom of which a small cave is excavated for the reception of the body. The tomb is then closed with stones, and the hole leading to it is filled up. The reconnoitering party, under General Merewether, Colonel Phayre, and Colonel Wilkins, made extensive explorations of the approaches to the Abyssinian highlands in the months of October, November, and December. At the head of Annesley Bay an extinct volcano was observed, with a double crater 100ft. deep and 300ft. across; and scoria and pumice were seen scattered over the plain. Beyond Arafali extends a plain, where ostriches and antelopes were met with. Travelling southwards, the river Ragolay was reached, 49 miles distant from the sea; and the northern limit of the great salt plain, east of the Abyssinian highlands, was traced. It was discovered that the eastern drainage of the Abyssinian plateau from Senafe to Atsbi, which are 70 miles apart, consisted of tributaries of the Ragolay. At the point reached the river was a perennial running stream, in spite of thirsty sand and scorching sun. Afterwards in flowing towards the sea it descends into a depression 193ft. below the sea-level, which was probably caused by some volcanic action, and its waters are finally dissipated by evaporation. Opportunities would be taken, during the march of the field force along the watershed from Senafe to Atsbi of completing the examination of the tributaries of the Ragolay to the eastward; and possibly, if any of the ravines through which they flow afford tolerable roads, it may be deemed advisable to open another line of communication by the Ragolay to the sea at Howakel Bay. The author travelled up the Senafe pass, with Sir Charles Staveley and his staff, between the 20th and 22nd of December. The road enters the pass immediately on leaving Komayli, and winds up the dry bed of the Nebhaguddy. In several places the alluvial deposit brought down by the torrent was from 10 to even 20ft. thick. The pass winds much and is narrow, while the gneiss-mountains rise up perpendicularly on either side. Near Sonakte the gneiss ceases, and a dark schistose metomorphic rock, with strata thrown up at angles of upwards of 70 degrees, takes its place, apparently overlying it. It It was observable that, whenever there was running water, the strata were nearly horizontal, or but slightly tilted, while the waterless tracts were met with where the strata were tilted at great angles. Further on the scenery becomes very fine, the cliffs higher, with peaked mountains towering up behind them, and the vegetation richer and more variety. Very fine trees of the fig tribe, peepul, banyan, and sycamore figs, grow in this part of the gorge, with the feathery tamarisk, tamarinds, jujub trees, and an undergrowth of mimosa, lobelia, and solanum. The author climbed to the top of a hill above Raraguddy, and obtained a splendid view. To the south and west extended the edge of the Abyssinian table-land; running in almost a straight line, with scarped sides of white sandstone. The mountain-ridges or spurs, between which the passes wind, appeared to run off from the table-land at right angles, but afterwards turning to the north and throwing up peaks here and there. Observations for altitude and for latitude were taken at all the principal halting-places. Mr. Markham stated that he had been in the Alps and Pyrenees, had walked or ridden up nearly every pass in the Western Ghauts of India, from Bombay to Cape Comorin, and knew most of the passes in the Peruvian Andas; and could confidently affirm that in none of these ranges was there any natural opening so easily accessible as that from Komayli to the highlands of Abyssinia. On examination of the area of drainage of the torrents which flow down these passes Mr. Markham believed that the danger of floods in the rainy season was not so great as had been supposed. Advantage had since been taken of the delay at Senafe to explore a great part of the neighbourhood, a description of the natural features of which was given in the second paper. The table-land lay at a general altitude of 8,000ft. above the sea, and was diversified by valleys, ridges of hills, and peaks; some of which, as Mount Sowayra, ascended by the author, proved to be 9,100ft. in height. The geological formation is sandstone, resting uncomformably on the same highly-tilted strata as visible in the pass. One of the most interesting points is the character of the vegetation as varying with the elevation; the plants and trees forming successive zones of different character in ascending from the plains to the mountain summits. On the summit and slopes of Mount Sowayra (9,100ft.) the *flora* is of a thoroughly temperate and even English character. The only tree is the juniper, while the most common plants are lavender, wild thyme, dog-rose, violets, cowslips, and various *compositæ*. The sandstone plateau have a similar *flora*, but on the lower slopes of the hills bounding the valleys it is enriched by many trees and shrubs of a warmer clime. Italian here mingles with English vegetation. In the lovely gorge of Baraka, on the western side of the Mai Mena Valley, masses of maiden-hair fern droop over the clear pools of water, and the undergrowth consists of a *Myrsine*, a large lobelia, and solanum. At this elevation a vegetation akin to that of the Bombay ghauts commences. In the Hamas Gorge (5,850ft.) there is nothing but acacias and mimosæ. The open valleys, as a rule, are bare of trees. The temperate flora extends over a zone from 9,000 to 6,000ft. the sub-tropical from 6,000 to 3,000, and the dry tropical coast-vegetation from 3,000ft. to the sea.

The President, in returning thanks for these communications, pointed out the the services Mr. Markham had before rendered as an explorer in two journeys he had performed in the interior of Peru, the second of which had for object the transportation of all the best varieties of the cinchona tree from Peru to India—a mission most successfully accomplished, and for which he deserved to be considered one of the benefactors of mankind.

Sir Stafford Northcote, at the invitation of the President, addressed the meeting on the subject of Mr. Markham's communications. He stated that Mr. Markham had received the grand *medaille d'or* at the recent Paris Exhibition for his services to humanity in successfully introducing cinchona trees into India. It would be one consolation, under the melancholy necessity which we were under of sending a military expedition to Abyssinia, that the cause of science would be promoted incidentally, and useful results thereby achieved. The hon. gentleman added that the expedition hitherto had been attended by unfavourable circumstances as regarded the season. It had been a season of unusual drought in the coast-lands of Abyssinia, and there had been an exceptional visitation of locusts; circumstances which had increased greatly the difficulty of procuring water and forage, and rendered necessary some delay whilst further supplies were procured from a distance. There were, perhaps, compensating advantages connected with this, for the scientific apparatus which had been brought into use for converting sea water into a beverage fit for man had made a salutary impression on the minds of the native chiefs with regard to our power and resources.

Dr. Beke make a few remarks respecting the present native names of the sites of ancient Greek settlements in Abyssinia. He believed that Senafé was a corruption of Sinope, as Zulla was of Adulis. With regard to the depressed areas of the salt lakes, he had made the observation many years ago, during his journey in the southern part of the same country, that Lake Assul must be about 750ft. below the sea level; and he believed that these lakes were simply the remnants of ancient arms of the sea.

Sir Samuel Baker said he was familiar only with the mountain slopes of the north-west part of Abyssinia. The slope of the great highlands was there nearly perpendicular and he supposed that the soil had been washed away to the Nile delta in Egypt by the numerous tributaries of the great river which descend from the Abyssinian plateau. During the rainy season the rain poured down in torrents, and he believed our troops would suffer greatly when this season set in. Although disclaiming any intention of touching on the political question, he strongly advocated the retention of Abyssinia, instead of leaving its Christian population to be annexed by the Egyptians, as would certainly happen when we vacated the country.

The President called the attention of the meeting to a series of photographs of the country now occupied by our troops, which were exhibited by permission of the Secretary of State for India. He also mentioned a new map of the eastern part of Abyssinia just received from Dr. Petermann, of Gotha, in Germany, in which all the latest geographical material furnished by the expedition was already incorporated—a striking example of the resources of the cartographical establishment of M. Perthes, in Gotha. In our own country all the new material had been elaborated with great ability and promptitude by Colonel Cooke, of the Topographical Office, who had issued successively four editions of the official map. There was also lying on the table a small volume of exceedingly graphic sketches of Abyssinian scenery made by M. Essler, one of the captives, which was about to be engraved and published in London.

Sir Henry Rawlinson, M.P., quoting from the digest of the geography prepared by Colonel Cooke, in his "Routes in Abyssinia," explained to the meeting that by following the route to Magdala, commencing at Senafe, the British army would pass round the heads of all the deep and precipitous river-valleys which made travelling so arduous in Abyssinia, and he apprehended that no great difficulty would henceforward present itself, as the road lay along a plateau over which camels have travelled. All the real difficulties terminated with the ascent of the Senafe pass. The rainy season was not severe in Abyssinia proper; the Portuguese expedition of the 16th century had marched and gained their great battles in that season. With respect to the annexation of the country, England had given a pledge to the world that no territorial acquisition was contemplated, and they were bound to carry out that pledge. Still, for purposes of commerce and philanthropy, as well as a matter of general policy, it might be found desirable to retain a port on the sea-coast.

Sir Stafford Northcote begged to be allowed to disclaim any agreement with the opinion that had been expressed with regard to the subject of annexation. The Government were resolved to adhere to the policy of withdrawing entirely the British forces as soon as the objects of the expedition were attained.

At the ordinary meeting of this society, on Monday last, a paper was read "On the Geography and Mountain Passes of British Columbia, with reference to an Overland Route," by Mr. A. Waddington, a gentleman who has devoted many years in exploring, personally or by his agents, the different valleys and passes in order to ascertain which is the most practicable for a waggon-road and railroad from the Pacific across the Rocky Mountains. In explaining the nature of the country, the author said that the two mountain-ranges—the Cascade or Coast Range, having an average width of 110 miles, and the Rocky Mountains a width of 150 miles—nearly meet on the southern frontier of the colony; but diverge farther north, and leave a fertile central plain 120 miles wide. In the southern part of the country all attempts to discover practicable passes had been in vain, and no through route was possible by way of the mouth of the Frazer River. He had examined the various long inlets or fiords to the northward, and found Bute Inlet to be by far the most suitable as the Pacific terminus of the future overland route. He had discovered a river flowing into the head of the inlet, and had planned a dray-road through the narrow valley thus formed through the whole width of the Coast Range. The road that he had projected ran north-eastwardly across the plain, and struck the Upper Frazer, opposite the mouth of the Quesuelle River; the Frazer is here a navigable stream, and affords a route to the Yellow-head Pass of the Rocky Mountains, which leads to the rich level country on the eastern side of the range, extending towards the Red River Settlement. The Yellow-head Pass, according to Dr. Rae, is 3,760ft. above the sea-level, the central plain is 2,500ft. in its southern part, and the Bute Inlet trail runs across it between 51° and 53° N. lat.; the pasture is excellent and the cereals (including wheat) can be grown. Mr. Waddington stated that the Canadian Government had already begun to construct the eastern end of the overland waggon-road between Lake Superior and Red River, but that no arrangement had yet been entered into with regard to the other sections; and he urged the importance of the undertaking, on political and commercial grounds.

The President, Sir Roderick Murchison, bore testimony to the great geographical value of the map constructed by Mr. Waddington, on which all his various explorations were recorded. Captain G. H. Richards, R..N, Dr. Cheadle,, Mr. Dallas (late Governor of the Hudson Bay Company's territory), Dr. Rae Mr. Frederick Whymper, and others, took part in the discussion which followed.

## SOCIETY OF ARTS.

### ON A DAILY MAIL ROUTE TO INDIA.

By HYDE CLARKE, Esq., Cotton Commissioner in Turkey.

The desire of improving the communications between England and India has given rise to many projects, and occupied the time of many distinguished Englishmen. Two names particularly stand forward, that of General Chesney, as the pioneer of the Euphrates route, and that of Lieut. Waghorn, in connection with the Egyptian route. On the latter, English enterprise has been particularly successful, for by steam navigation and by railways, it has been brought to such a stage of advancement that the French have been stimulated to co-operation, and have engaged in the great work of the Suez Canal.

Local circumstances have hitherto given the preference to Egypt over the Euphrates, and this latter route remains unused, notwithstanding surveys, agitation, and a steam expedition on the rivers. Events have, however, been moving in its favour. Railways have been creeping in from the interior to Bombay, steamers have been run from Bombay to Bussorah, and communicate with Bagdad, while from London railways have advanced to the Lower Danube, and are now promised beyond it. If, therefore, the intervals can be bridged over, we get, step by step, continuous railway communications from London, with an intervening steamboat transit, which will in itself bring about the day when the locomotive will run from the opposite shore of the Continent to Calcutta, and even the frontier of China.

The plans for accomplishing communication by the Euphrates Valley, have been either by steam navigation, or by railway, steam navigation being limited to the river, railway transit being proposed throughout from London, or simply to fill up the Valley route. Thus there are various claims of priority. General Chesney is the parent both of steam and railway routes from the Euphrates, having commenced his labours in 1830. The progress of railways in Europe led to projects of railways for through communication. In 1842 Mr. Wm. Pare, a gentleman of great activity in the railway world, published a plan for a Calais, Constantinople, and Calcutta Railway. Mr. Alexander F. Campbell, formerly of the Royal Engineers, proposed to the East India Company, a system of railways on the wide gauge to India, under dates 6th of September, 1843, 25th April, 1845. His map was published by Mr. Wyld, in 1851. Mr. John Wright, in 1849, took up the same subject. The title of his work was "Christianity and Commerce, the Natural Results of the Geographical Progression of Railways." Dr. James Bowen Thompson, a zealous promoter of the Euphrates route, and who died at Constantinople while advocating it, exhibited in the Great Exhibition of 1851, a plan for a railway from London to Calcutta.

The chief competitors for the through line of railway by the Euphrates have, however, been Mr. W. P. Andrew, and Sir R. M. Stephenson. Each claims priority. Sir R. M. Stephenson appears to have paid cursory attention to the subject in 1850 and 1851, but he adopted the alternative project of a Persian route. In 1859, on the ground of ill-health, he abandoned the agitation. Mr. Andrews, in conjunction with the Euphrates pioneers, has continuously prosecuted the Euphrates Valley Railway, and has casually advocated a through line. Credit must be given to Sir R. M. Stephenson for the part he took in these discussions, and which created at the time great interest in the public press.

For practical labours the public is greatly indebted to General Chesney, and next to him to Captain Lynch, R.N., who has kept the undertaking alive; also to Mr. W. F. Ainsworth, General Estcourt, Lieutenant Murphy, and Captain Campbell, I.M. Of late years the prominent promoter of the Euphrates route has been Mr. Andrew, who, in 1857, was the organ of a powerful deputation to Lord Palmerston, who has been the representative of the Euphrates Valley Railway Company, and who continues to urge the subject on the Imperial and Indian Governments, and on the public.

The time has now come when the agitation must assume greater proportions than a mere Euphrates Valley route; the economical conditions have greatly altered. We are no longer limited to a consideration of the steam transit between Trieste and Brindisi and Scanderoon, for we may hope confidently for a railway to Constantinople; and if we take up the matter seriously, we may more easily obtain a through line from Constantinople to Bussorah than a half-way line from the Mediterranean to that port. The leading fact is that the political circumstances are altogether altered from what they were ten years ago. India has come home to us at length, for its vast development has produced a great impression on the public mind here. We are no longer afraid of the Suez Canal, but the Egyptian route is not now felt to be so reliable nor is it so much in favour. Telegraphic movements have become the precursors of railway routes: and the telegraph has made the central lines by the Euphrates familar to us. It would have familiarised us with the Persian route, but the downward bearing of Russia equally towards Turkestan, India, Persia. and Turkey, has produced a powerful sensation on the minds of England and India, nor have European events been without their influence. We feel we must have more resources, more than one expedient, safety for the present, security under future contingencies.

Hence the middle route to India from many causes is brought prominently before us. It is not a rival to any line; it is certainly not one to the Suez Canal now, any more than it was in 1857, when M. Lesseps said, "I have personally maintained, and I shall continue to maintain, that the Euphrates Railway will be a benefaction to countries now disinherited." The Egyptian route will not be injured and abandoned on the opening of the middle route. It has its own peculiar advantages, but so has the middle route, which will do even more than the Egyptian route in the opening up of little frequented countries, and in the impulse it will give to the commerce of the world.

The middle route has this characteristic, that, beyond even the Suez Canal, it can claim to be a European undertaking. It must greatly benefit this country; but it will benefit directly or indirectly every country of Europe. In the silk trade alone it will confer direct advantage on France and Italy, in opening up Asia Minor, Mesopotamia, and Persia, and it will carry to the sealed up East the manufactures of France, Belgium, Holland, Switzerland, Prussia, Saxony, and Austria; for if we talk of a railway from London to Asia, it is no less a railway likewise from Paris, Lyons, Rouen, Mulhausen, Brussels, Liège, Verviers, Utrecht, Geneva, Berlin, Elberfield, Nuremberg, Augsburg, Leipsic, Vienna, and Pesth. It will open new markets for every manufacturing town in Germany, and for their growing trade with the East.

It will give to them and to us a daily mail for all India, and a proportionate acceleration for China, Japan, Java, Sumatra, Cochin China, the Philippines, and Australia. The French have mails to China, and their growing possessions in Cambodia; the Hollanders to the Netherlands East Indies; and Spain to Manilla. Thus, in one way or another, the nations of Europe have a great stake in the development of this route; and it is to be hoped, as all will profit on its completion, so all will assist in its realisation. Do what we will for our own good, we must benefit others; we must open the way for others, as we have done in Egypt and elsewhere. Let us, therefore, invite and welcome the co-operation of others.

Of the lines of railway from London and the European capitals, constituting the great railway system, it is unnecessary to say more than that they now reach Basiash on the Danube, near Belgrade, on the Turkish and Servian frontier. For the junctions with Constantinople, a route of about 500 miles, which will pass through Adrianople, has been granted by the Sublime Porte to a combination of English, Belgian, and Hungarian capitalists, represented by Messrs. Vander Elst and Co.

In the condition of Turkish finance there are difficulties to be encountered, which may cause modifications of arrangements and delays, but it may now be felt assured that this line will be completed. The Ottoman Government is resolute on carrying out its railway system, and will find some resources. This line is, however, a political and commercial necessity for the newly-restored state of Hungary, and very great efforts will be made by that patriotic people to accomplish their purpose, and secure their frontiers against their several enemies. Austria is not alsogether dead to enterprize, and her government and capitalists will give their assistance. This railway is represented at Constantinople by two distinguished men, Count Zichy, and General Eber. According to the latest official advices the arrangements with the government have been complete, and the works will be begun at an early date on four points. The chief engineering works are in the passage of the Balkan. The line passes through countries having considerable resources, which will be further developed by a railway, and if the financial measures be honestly and rationally conducted, the line will in a few years be remunerative. Until that period the Ottoman Government will be able to meet the guarantee through the increase of its own revenues, resulting from the expenditure of capital on the works and the working of the railway. A bridge across the Bosphorus, between the Rumeli Hissar and Anadoli Hissar, or Castles of Europe and Asia, has been projected by Mr. M'Clean, late President of the Institution of Civil Engineers; and a plan was also exhibited at the Paris Exhibition in 1867, and illustrated in the *Engineer*, of February 14th, by Herr Rüppert, a distinguished Austrian engineer.

The line from Constantinople, and its Asiatic suburb Scutari, to Bagdad and Bussorah, of 1,400 or 1,500 miles, is granted by the Ottoman Porte to a company represented by Mr. L. Greig and the Hon. Randolph Stewart, Messrs. Sharpe, Stewart, and Co., and Baron Winspeare. The route has to be decided on survey, for which two years are granted, and is roughly traced by Izmid, Kutahiah, Afioon Kara Hissar, Koniah, Ak Serai, Yenisheher, Kaisarieh, Aleppo, the Euphrates Valley, Bagdad, and Bussorah, with a branch to Skanderoon, Seleucia, or Suedia.

The guarantee of the Government is limited to five per cent. on £12,000 a kilomètre, or £20,000 a mile. The special funds set apart are the postal subsidies and transport of mails, the Indian telegraph receipts, and one per cent. transit duties. At the present moment the guarantee in its simple state will not allow of capital being raised, nor do the *concessionnaires* propose to resort to any of the accustomed modes of financing. Having got what may be called the collateral guarantee of the Ottoman Government, not an absolute guarantee of five per cent., but a guarantee to make up the revenue of the company to that rate in case of deficiency—it is the business of the *concessionnaires* to make effective the revenues appropriated to them.

The first of these consists of the postal subsidies to be negotiated with the several Governments. These Governments are our own Indian Government, that of the Netherlands Indies, those of Australia, that of Persia, Muskat, England, France, Holland, Belgium, North Germany, Switzerland, Italy, Saxony, and Austria.

The second consists of telegraph business and subsidies from several Governments and commercial communities.

The third consists of the transit duties.

The fourth consists of the revenues of the railway itself, local passengers, through traffic, the transport of troops, and the carriage of goods.

In aid of all these comes the general guarantee of the Ottoman Government.

The question, therefore, is whether, with all these resources, and such further aid as may be obtained from friendly quarters, the funds can be provided; and this presents no insuperable difficulties, if there be but a real conviction on the part of those interested, of the true value of the undertaking, and the urgency of its execution.

From Bussorah mail steamers run to Bombay, but these only afford accommodation to the local trade between India, Bussorah, and Bagdad, and yet this is sufficient to justify the Government of India in maintaining this service. It may be conceived that the Government can afford a larger subsidy to carry letters further, and to open up the trade with the Mediterranean and with Europe. If Bagdad and Bussorah are now of such importance to India for local purposes, they will become still more so when their ports and markets are enriched by the advantages of railway communication.

Bombay has opened or has in progress lines of railway, which connect it with the great Indian system, and give it access to Calcutta, Madras, and all the main stations. The traveller from Europe would, on reaching Bombay, proceed at once to railway stations in the interior, for which a voyage to Calcutta and Madras would entail circuitous travelling.

Such is the present state of the route from London to Calcutta.

The sources of income on which the Constantinople and Bussorah Company have to rely have already been enumerated. It may be useful to make some estimate of them.

The railway, it may be assumed, passing in many parts through an undeveloped country, cannot for a long time pay of itself, nor will the through traffic be sufficiently large to yield a dividend. Under these circumstances, the net income may be taken during its early years at 2 per cent. The capital may be assumed at £20,000,000; it may by economy be less; it may by delays and misfortunes become larger. Two per cent. per annum on £20,000,000, gives £400,000.

The Indian telegraph already yields a profit to the Ottoman Government. It may be taken, on the completion of the line, at £100,000.

The transit duties may be taken on £5,000,000, imports and exports, or £100,000 per annum. The trade to South Persia would follow this route; also that to Muskat, the Mokran, and the Arab ports on both shores of the Persian Gulf. The transit duties would be levied on valuable articles exported from England, France, &c., to the countries named, to India, China, Japan, the Archipelago, Manilla, and many eastern regions, and on imports from them. Thus we have—

| | |
|---|---|
| Traffic | £400,000 |
| Telegraph | 100,000 |
| Transit duties | 100,000 |
| | £600,000 |

The question is what England and India can afford to give as a postal subsidy leaving the other mails as matters of subsequent arrangement; the French, Spanish, Netherlands, Belgian, North German, Saxon, Swiss, Italian, Austrian, and United States mails.

Can our Government afford to risk £200,000 in subsidies to secure the great advantages dependent on this undertaking? The first help to answering this is, that a great increase of postal revenue will result from the acceleration and more frequent transit of the mail. If this be taken at £100,000, it leaves only £100,000 as the amount of effective subsidy, in substitution of other subsides, to be divided between England and India, to be diminished by other mail receipts, and to be ultimately extinguished by the development of the railway system, and the augmentation of the transit duties.

Thus the effective liability of the home treasury is reduced to a casual £500,000 a year, or some comparatively small amount. For this our empire will obtain great political advantages, a greater assurance of European peace, a further guarantee against invasion or revolt in India, an immense commercial development, readier correspondence with the increasing markets of the eastern world, a speedier and more convenient transit for our merchants, officials, civil and military, and soldiers to India and the adjoining regions.

To secure these advantages more effectually, the railway must be constructed as bheaply as possible—that is, for ready money, and not for Lloyd's bonds; it must not pass into the hands of financiers; there must be wholesome supervision over the contracts, construction, and expenditure; there must be a low capital cost and cheap working, so that our commercial and political travellers may have to pay only reasonable fare. To effect all this the line must be assimilated to the Indian system; it must not be financed on the Turkish guarantee; but it must have a solid English or European guarantee of 4 per cent., in the shape of a postal subsidy, in principle assimilated to that of the Peninsular and Oriental Company, securing not direct political but direct postal advantages to our Government, making the rate of its contribution dependent on the earnings of the line, and ultimately assuring either our direct participation in the profits, or our indirect benefit in the reduction of charges.

Will France, will Austria, will Hungary participate in this undertaking, from which each is to derive so much? Will France neglect this opportunity for upholding her position in the eyes of Europe, one still more honourable to her than even the patronage of the Suez canal? The question is whether these countries will leave the whole share of the prosecution of these works to the English. This appears inconsistent with the attitude of France. Originally assisted by English capital and English experience her railways were begun, but they were completed by French industry, and she has since extended her railway operations outside to Austria, Italy, and Spain. A nation which has never loved to be left behind—which has followed us to India, to China, to Egypt—will not leave to us the sole conduct of railways in Turkey, or the sole development of Persia, a country in which she has so long sought to acquire trade and influence. French capitalists have tried singly, or in conjunction with English capitalists, to carry out the Adrianople railway; and they will claim their due share in its companion enterprise, which is to connect Paris and Constantinople with the Indian Seas.

In fact, this great enterprise is not one calculated to excite European jealousies, but to contribute to European Union. It will be a new bond among the cabinets of Europe, a common tributary to the industry and commerce of each nation.

Such, it is to be hoped, will be the result produced, and, as the undertaking is represented by an able and energetic man of great public spirit, the Hon. Captain Stewart, there is every prospect of its claims being efficiently advocated. Captain Stewart has addressed a memorandum to the Earl of Derby on the claims of the undertaking, which shows very forcibly the importance to national interests of its immediate completion and liberal support being afforded to it by Her Majesty's Government.

The constructive questions of a line as yet only partially or roughly surveyed cannot be fully dealt with, but enough is known to declare the practicability of the undertaking.

With regard to the plan, the geographical features of Asia Minor limit the course to be chosen both on the north and south of that peninsula. Even on starting from Constantinople or Scutari, after coasting the Gulf of Izmid to the town of that name, a difficult country has to be be approached. This has, however, been in part surveyed, and in part examined by English engineers, while the whole line Scutari to Izmid and Eski Sheher has long since been carefully planned under the direction of the former concessionnaire, Mr. James Landen. From Izmid there are two routes across the central plateaux, one by Hajgi Hamzah and Boli, the other proceeding by Kutahiah, and so by Afioon Kara Hissar, Koniah, Ak Serai, Yenisheher, Kaisarieh, by the valley of the Halys and plains of Nigdeh, or whatever may be found the best route to the Koolak Boghazi, the Syrian or Cilician Gates, the great pass through Taurus.

The passage of the Koolak Boghazi will be the great work on the line, and it is one which will require the most care and expense. Since the time when it was first considered, the execution of the railway passages over the Alps and the Ghauts have materially contributed to lessen the responsibility of such an enterprise.

Questions then arise as to the connection of the line with the Euphrates, and as to the direction of the branch from that line to the Mediterranean shore, so as to make the Euphrates Valley line an alternative route, in case of need, either by through railway communication with Europe, or by steamer. The routes surveyed for General Chesney's Company, under the direction of Sir John Macneill, have been from Seleucia or Suedia to Aleppo. As this makes needful the construction of an expensive harbour, and the Ottoman Government prefers a connection between the fine port of Skanderoon or Alexandretta and Aleppo, although across a heavy pass. They therefore caused it to be surveyed, at my request, by Col. Messoud Bey, who has reported fully in its favour.

From Aleppo onwards to Bagdad and Bussorah the route presents the usual features of a line in a great southern river valley.

No sound estimate can be made of the expense, as the distance even is not known. An estimate of 100 miles for the Scutari and Ismid concessionnaire gives £8,000 to £10,000 per mile, but the country beyond is heavier. The estimate of the Euphrates Valley section is given at the same rates, for 850 miles as those of the Scutari and Ismid. Taking these as 100 miles and 850 miles, or 950 miles together, and the total length as 1,500 miles, although it may prove only 1,400, we have a remainder of 550 miles, which, if we take at £15,000, would cost £8,250,000.

Estimates:—

| | £ | £ | £ |
|---|---|---|---|
| Scutari and Izmid | 800,000 | 1,000,000 | 1,000,000 |
| Ismid and Aleppo | 8,250,000 | 8,250,000 | 11,000,000 |
| Euphrates Valley | 6,800,000 | 8,500,000 | 8.500,000 |
| Totals £ | 15,850,000 | 17,750,000 | 20,500,000 |

In the last estimate the cost of the Asia Minor heavy section is taken at £20,000 a mile, and the others at £10,000; £12,000 a mile would bring the total cost up to £22,000,000. The total cost appears to be within the limits of £16,000,000 and £25,000,000. The smaller sum we can hardly, under all contingencies, hope to stop at, the larger we may try to avoid, and the capital may be taken at £22,000,000.

The line can be begun at several points simultaneously, namely, at Skutari, Ismid, the plain below the Koolak Boghazi, Skanderoon, Aleppo, Bagdad, and Bussorah; all very heavy works in the interior of Asia Minor can be begun early or together. A great advantage of the geographical situation is that the line touches the sea at its ends and middle, affording convenient places for landing plant, rails, and engines, thereby facilitating the works. In case of need, some further point on the river may be used as a point for operations.

The question of labour, as to which anxiety was formerly expressed, has been solved by the operation of the railway companies in Turkey, which have organised labour on the English system. The lines existing in Turkey are the Danube and Black Sea, or Kustenjeh, 40 miles; the Varna and Ruschuk, 140; the Ottoman, Smyrna, and Aidin, 82; and the Smyrna and Cassab, and Bournabat branch, 62; total, 250. On these works have been trained a large body of labourers of all kinds, and a number of managers, sub-contractors, and foremen. So far as staff is concerned, a thousand miles of railway can be put in hand, and labourers can be found. The old hands will serve to train labourers in the new districts, as yet untried, and in case of any refractory or unwilling population, it will be replaced by imported labour. There is no real ground to expect refractory Arabs, or that any population will not work for high wages. Besides local labour, the northern districts will be supplied by Armenians and Croats, the middle districts by Armenians and Greeks from Candia, Rhodes, and other islands, and the southern portion, besides local and imported labour from accustomed supplies, will most likely receive labourers from refractory tribes or from India. The earthworks and masonry will be executed by native labour as well as in Europe, and the line will be as well laid.

Attacks from Arab tribes are not to be feared by bodies of stout and organised labourers, for whom military aid can be made available, but in all likelihood in the most disturbed districts the labourers will work unarmed. Imagination is one thing, but the practical experience of railway works is another. Brigands and outlaws there will be, but most will be employed as labourers, teamsters, and woodmen, the most crafty aa gaugers, petty contractors, and dealers; the most lazy as loafers and beggars, and they will little contribute to the annals of murder and robbery. The chiefs of predatory tribes will be engaged in numerous speculations in milk, beasts of burden, cutting timber and sleepers, and turning to their own profit the labour of every man and woman of their tribes.

The progress of the works will be regulated by the same circumstances as at home, the supply of labour on economical conditions, the supply of timber and other materials, and the skill in battling with administrative and constructive difficulties.

From the Ottoman Government every assistance is to be expected. The government and its officers have not interposed vexations and administrative delays in railway construction, but have acted on the principle of encouraging these undertakings. The Sultan has a settled and earnest desire to promote railways, and is seconded by his ministers. The Council of Pub ic Works is directed by French and English engineers. The commissioners appointed to supervise the lines have been chiefly Europeans, and instead of exercising an interference with the managers and engineers, they have confined themselves to co-operating with them and with the local authorities in promoting the execution of the works.

Money being provided, there is no more difficulty in carrying on railway works in Turkey than in any country in the world, indeed it may be said less than in many countries.

With regard to the advantages of completing the railway communication, the direct advantages are so great that it is not necessary to dwell on the political advantages. Everything that improves and insures our commercial correspondence with India must give us political advantages; everything that contributes to the material well being of Europe is a greater security from danger, and further guarantee of peace. Thus the European junction with Constantinople will throw open to enterprise 500 miles of country in Roumelia of great resources, hitherto of little profit to the community, and by so doing increase the stability of Turkey and the well-being of Austria and Hungary.

The Asia Minor portion of the Constantinople and Bussorah Railway will do the same service for that great peninsula; it will connect the great cities on the caravan routes, and open for them outlets to the sea, now only to be obtained by long and troublesome canal transport down the river valleys to Smyrna, or across the mountain ranges to Adalia and the ports of Tarsus. The productive countries of the interior are now so pent up that only their richer produce of opium, silk, and cotton can get to the sea, but the railway reaching the midland districts at a point not more distant than Manchester or York from London, will allow bulky objects to be shipped, for which beasts of burden are now wanting. Thus a development of traffic will take place beyond the immediate region of the railway; caravan traffic will be intercepted or become tributary, while new outlets will be fostered. The interchange of commodities between these districts will be carried on upon a larger scale, and the westerly immigration of Armenians, Turkomans, and Koords seeking industrial employment will be increased, and the nomad tribes be further arrested.

When the western regions are unsettled the nomad tribes set further towards the west, but as cultivation extends the nomads are driven back, or become cultivators or townsmen. Thus a railway intersecting Asia Minor in the course proposed would exercise a material influence on the well-being of the eastern countries of the peninsula, assisting the government in its efforts to regulate the turbulent tribes. The same remarks apply in a great degree to the Euphrates section, and on a course of 1,500 miles will be constituted as it were a telegraphic current for the propagation of civilisation, in what once were the empire states of the eastern world. Pontus, Armenia, Babylon, Media, and Persia would be restored, if not not to their historic power, at all events to rivalry with their ancient prosperity.

If in Asia Minor, which has on the line traversed some evidences of its former well doing, this influence would be great, still more would it be exercised on the neglected valleys of the Euphrates and the Tigris. The immediate effect produced by a railway in developing a backward country is more particularly due to the nature of the railway itself. It is not on an increase of population, as supposed, that these results are dependent, though an increase of population does take place, but on an increase of the absolute produce, and on the realisation of that produce for export. To a country where the largest iron-worker is the shoeing-smith and the gipsy, and where all implements of labour and manufacture are wooden and rude, the railway supplies metal, tools, implements, and machines. Thus the produce of the field and the forest is augmented. What it does in the distribution of capital is still more. The agriculturist, always in debt to the trader, and in bondage for small sums to the chandlers' shop keeper, is visited by the larger native capitalist of the towns, and gets greater advances on more favourable terms; and the same agency sets up mills and factories. If there is a demand for produce for the European market, opium, cotton, or madder, the English merchant comes into competition with the native, and his agents make advances more liberally, and at easier rates. It is by throwing open the interior easily and safely to the native and European merchant that capital, intelligence, and enterprise are bought to the doors of each cultivator. It is thus that the provinces of Smyrna, Magnesia, and Aidin have already largely benefited from railway communication. The government, too, becomes stronger, and has better means of coping with gang robberies, and restraining the vexations of nomadic and predatory tribes.

It is more particularly by its peculiar mode of transport that a railway relieves a country. What is taking place in the Abyssinian expedition is the key to the commercial conditions affecting remote districts in Asia and South America. The mule, laden with forage at Annesley Bay, eats most of his forage on the road to Senafe and on his return, and leaves but a small reserve at Senafe. So is it with the transport of grain; even the hardy camel must be to some extent fed, and so must his attendants, and thus, after a certain distance, his own load will be consumed. Thus, in all these countries, transport absorbs food for a large number of camels, mules, horses, buffaloes, and oxen, and the men attendant upon them, while the consumption of cereals consequent upon railway transport is small. Agriculture therefore gains, on the introduction of a railway, not only this economy of food, but the liberation of men and beasts for the further cultivation of produce. If the produce remained the same, at Konieh, for instance, the exportable produce would be greater, but the fact is the total produce would be greater had it railway transit. In corn alone, to be shipped at Constantinople, it is acknowledged by all who know that the increase of production in the interior would be enormous. The railway, therefore, tends in every way to increase the existing traffic and to create new resources.

In the single article of cotton, too, a great augmentation would take place on the line of 1,500 miles; if in the spring, the agents of a few European houses could readily and speedily traverse the country to arrange advances for sowing and if in the autumn they could get in the produce from the growers, have it ginned by English gins, and be assured of its rapid transmission to their own warehouses in the ports of shipment. In India, the impulse of railway transit has caused a production beyond the present means of the railway to transport.

So far as to the ancient world, which would be restored to our enterprise, and yet we must not dismiss it without a special reference to Persia. It has always been a great object with English as with French adventurers to communicate with Persia. Now no means which have been devised will effect this so surely as through railway transit. At present, in every direction, Persia finds difficulties in exporting her productions. On the east she is barred; on the north she has only the Caspian, or circuitous routes through Russia, before she can reach the seats of consumption; on the north-west she has long caravan routes to reach the Black Sea at Trebizond, or the Levant at Aleppo or Scanderoon; on the south the Persian Gulf only affords a long sea voyage to Europe. As just shown, Persia by the railway will not only obtain a means of exporting produce, but will obtain capital, capitalists, the appliances of production, the means of internal development, and a protection against foreign aggression.

Whether English or French preponderate there, one policy must be pursued in maintaining Persia against Russia. We shall be handsomely recompensed if we can receive the productions of a country as populous as Spain and richer, and supply her with our manufactures.

There is an old ally of ours, the Imam of Muskat, or Sultan of the Oman, at the southern mouth of the Gulf. His relations with the Arabs on both coasts are extensive; and while we increase his power, we may look forward to a diminution of local disorder, and an increase of Arab commerce.

The advantages of this route as a postal and passenger route depend on its directness and thereby shorter length, and on its rapidity of transit.

The distance from London to Bussorah by railway will be about 3,600 miles, and the distance from Bussorah to Bombay about 1,600 miles (1,584). The transit, being slower in the beginning, may be expected to improve.

| | Hours. | | Days. |
|---|---|---|---|
| London to Bussorah at 25 miles per hour ......... | 144 | ... | 6 |
| Sea voyage to Bombay at 10 ........................... | 160 | ... | 6⅔ |
| Total........................ | | | 12⅔ |
| London to Bussorah at 30 miles per hour ......... | 120 | ... | 5 |
| Sea voyage to Bombay at 10 ........................... | 160 | ... | 6⅔ |
| Total........................ | | | 11⅔ |
| London to Bussorah at 30 miles per hour ......... | 120 | ... | 5 |
| Sea voyage to Kurrachee.................................. | 120 | ... | 5 |
| Total........................ | | | 10 |

The transit to Calcutta may be represented as by the quicker route 16 days, but to be reduced to 13 days on the junction of the Indian railways.

Where a reduction of transit tells most materially is by its double effect in reducing the course of post. Thus the single post to Bombay will be 12 days instead of 22, or a saving of 9½ days, and the course of post will be 25 days instead of 44, plus the interval of mails, or say 51 days. Thus in a year, 15 sets of letters or communications can be dispatched, instead of seven.

The advantages to passengers are of a corresponding nature, for in case of need it will be possible to get to and from London and Bombay in a month. In these calculations no account is taken of the ultimate completion of the railway system from Bussorah to India, nor of the Indus Valley Railways, which will further facilitate and shorten the communication with the Punjab and the north-western provinces of India. When this takes place the distance between London and Calcutta will be performed in from ten to twelve days, and ultimately, most likely, in a still shorter period.

Thus, in whatever light this important measure be regarded, it is found to be fraught with great advantages to this empire and to the world at large.

## INSTITUTION OF ENGINEERS IN SCOTLAND.

## ON CERTAIN POINTS IN THE MANUFACTURE OF MALLEABLE IRON, WITH SPECIAL REFERENCE TO THE RICHARDSON PROCESS,

By Mr St. John Vincent Day, C.E.

Since the year 1784, when Cort introduced the process of puddling, there has not been any really great advance made in improving the general results obtainable from the conversion of crude or pig into malleable iron in the puddling furnace until very recently.

By no means do I here intend to arrogate for Cort the raising of the puddling process to its present state of comparative efficiency, for no matter how very imperfect that process yet remains, still it is well known that the results produced by it were not generally to be depended upon until long after the inventor's unfortunate career terminated with his death—indeed, the first quarter of the present century had nearly passed away ere the puddlers' manipulations could be relied upon continuously, and it is highly probable that even then the uncertainties of production would not have been largely removed but for the careful attention of some of the North of England Ironmasters who perceived a wide field opening up for a high class of manufactured material in the iron canal and river boats, and railways then coming into vogue; and, later still, in supplying that required for our great tubular and girder bridges and lines of Trans-oceanic steamships.

During the present century, however, innumerable attempts at improving the process have been made at home, on the continent, and in America, still with no good effect generally; indeed, the value of what has been done taken on a broad, practical, and therefore commercial basis, has been extremely small. It is, however, perfectly true that the failures which have been encountered have increased our stock of information as to the peculiarities, or rather specialities of the compound we have been treating in the puddling furnace, and in this particular view recorded failures when accompanied by a faithful declaration of what took place are of the highest importance. As a very striking instance, I may allude to the most recent and gigantic failure that has, and, probably, ever will occur in a future time in the metallurgy of iron; I allude to the impossibility of making good commercial iron out of the ordinary ores of this country by the Bessemer process. Mr. Bessemer has himself on several occasions openly confessed that he could not succeed in making good malleable iron by his process purely on account of the impossibility of removing sulphur, but more particularly phosphorus, in the converter; his early experiments showed distinctly that whilst the highly oxidising effect of the blast injected into the converter was most efficient in removing carbon and silicon and some of the lesser impurities, still the phosphorus and sulphur remained untouched, the immediate consequence of which has been that his process has never come into practice for making iron from the ordinary run of British ores—by far the larger portion of which contain notable quantities of these two elements, of which phosphorus is the greater enemy, its presence rendering the iron cold-short, whilst sulphur has the opposite effect of rendering it red-short.

I have before referred to Cort's process, and prior to directing attention to the more immediate subject of this paper it will be an advantage, in a casual way, to refresh our memories by considering what has been done successfully towards the improvement of puddling since his day up to the present day. Before doing so, however, I wish to remark that although the invention of puddling is usually ascribed to Cort, there exists very grave reasons for withdrawing from him the origination of it, as a reference to the specification of a patent granted to Thomas and George Cranage in 1766 will easily show.

The Messrs. Cranage were workmen employed at Colebrookdale, and it is recorded that puddling was practised there prior to Cort's invention, for when the latter applied to Mr. Reynolds, at that time the manager of the works, he replied in his Quaker tongue, "If thou wilt come with me to the works I will show thee the thing done." Cort went, and, at the command of Reynolds, Tom Cranage made a puddled ball in their presence. It appears, however, that the process was not carried out on a large scale at Colebrookdale until after Cort had been there, so that it is probable some practical difficulty existed in what the Brothers Cranage had done. This fact would show that to Cort must unquestionably be attributed the high distinction of being the perfecter rather than the inventor of the process called "puddling."

The process of puddling, too, was very completely set forth in the specification of Peter Onions in May, 1783, about a year prior to the date of Cort's patent; indeed, it appears extremely probable that iron masters at that period hearing of the partial success of the Cranage process had begun to set themselves the task of perfecting it, hence the inventions of Onions and Cort so close one upon the other. The question of Cort's invention has however been so frequently discussed elsewhere, that I need not further allude to it here, the deplorable tale connected with it so well known to us all that it need not be again enlarged upon.

The next great step of improvement that presented itself was that of Mr. Samuel Baldwyn Rogers of Nante-y-Glo, who substituted the "iron bottom" for Cort's sand bottom. This, like every other really valuable discovery, was condemned by the Welsh ironmasters, and after it had been derided at by Mr. Hall of the Rhymney Iron works, Mr. Hill of the Plymouth Iron works, Mr. Homfray of Tredegar, Mr. Crawshay of Cyfartha, Mr. Forman of Pendarren, and others, it was ultimately tried at Ebbw Vale by Mr. Richard Harford, who, on discovering its advantages about or shortly after the year 1818, adopted it, since which time others followed his course until wherever puddling is now practised the cast iron bottoms are used.

Rogers' fate as an inventor was as sad as his unfortunate predecessor Cort, both lived for years, and ultimately died, in absolute penury.

The "boiling process" was the next great stride, it is generally attributed to Mr. Joseph Hall of the Bloomfield Iron Works.

"Boiling" is produced by charging certain oxidised compounds of iron on the puddling hearth, from which, as soon as melted, some of the oxygen begins to separate, and, uniting with some of the carbon of the iron, forms carbonic oxide, the presence of which may always be detected by the well known bubbling about of the metal, attended with endless escaping jets of blue flame. Until the charge is melted the solid oxide is covered with liquid cinder, composed in great part part of protoxide of iron, this being combined with silica, constitutes a silicate of protoxide of iron, which, after melting, combines with additional silicon in the pig, and some of the iron of the charge forming the tribasic silicate of protoxide of iron ($3\ Fe\ O, Si\ O^3$), without the presence of which the process of puddling could not be carried on, this silicate possessing the peculiar property of not further oxidising iron at the most exalted temperatures employed, and being easily separated from it, so that although the granules of iron in the puddling furnace after the boiling stage is over, and the temperature of the furnace is lowered, are lying scattered about in it, still, on being pressed together, they unite, the fluid silicate being easily squeezed out from between the surfaces of contact by means of the puddlers' balling rod; whilst that portion which still clings to the iron after the balling is over is what we see extracted from the mass under the shingling hammer and between the roughing rolls. Boiling, then, along with the use of roasted tap cinder, or "bull-dog," as it is generally termed, constitutes the last great step in the chemistry of the process since the time of Cort.

In the mechanical operations of puddling and in the construction of the furnace several attempts towards improvement have been and continue to be made. In the furnace itself the use of water-troughs through the bridge, and in some cases forming the sides of the puddling hearth, have come into practice, but their value in a sense of effecting ultimate economy, for several reasons, appears to me to be very questionable. Double furnaces, too, have been tried—that is to say, furnaces capable of containing a double charge of metal, and with a puddler working at both sides, but it is a striking fact that they are being given up, and the old fashioned single furnace still obtains. I am informed by some of the Scotch ironmasters, that the iron from the double furnace is never so good as from the single furnace, and the charge is generally longer in melting. The chief object intended by their introduction was a diminution in the fuel consumed per weight of iron manufactured; this to some extent is obtained, and probably herein consists the reason why the charge is longer in melting. Considerably less than twice the weight of fuel has to melt exactly twice the weight of iron, but the furnace is not twice as large, generally not more than 10 or 11in., or less than a foot broader than a single furnace, the height and length being the same, so that the space occupied by the heat from the fuel in the double is nearly proportional to that of a single furnace, but as the charge of iron therein is proportionately very much greater than the fuel it follows that a longer time of melting should obtain, at least the question having been submitted to me for consideration, this is the only reasonable view I have been able to arrive at. As to the quality of the iron produced in double puddling furnaces being frequently inferior and of indifferent nature, I cannot account for that in any other way than by looking at the cause as inherent in the difficulty of getting the two puddlers to work the two portions of the charge in concert with each other, it is almost certain that one will work his part of the charge more or less than the other, thus producing iron in the same furnace necessarily of dissimilar quality. However, the cause of inferiority of double puddling furnaces against single is a question by no means thoroughly investigated, and it forms a topic which I think this Institution might discuss with obviously great advantage. It is probable that when a perfect system of mechanical puddling is devised, that then, provided such is effected by the movement of rabbles, double furnaces may be generally adopted, as certainty of similar action of the two instruments may then be insured by their being placed under the control of properly arranged machinery.

Speaking of mechanical puddling, numerous expedients have been tried but with no practical success, generally, in Great Britain. At Dowlais almost every hitherto conceivable means for doing away with the puddler has been resorted to, but with what result? I have no doubt that many of the members of this Institution will remember the singular paper read by Mr. Menelaus to the Institution of Mechanical Engineers who met at Paris during the past summer; a paper I say singular, because it was so very dissimilar to what papers read before such institutions usually are—we generally and naturally find ourselves and others recounting our and their successes,, but here Mr. Menelaus in the most laudable manner has placed on record everything that has been done at those gigantic works under his control—all of which has ended in failure, and he has not attempted to hide the failures either.

At Dowlais, too, Mr. Anthony Bessemer's revolving puddling furnace has been used, but it has failed, as well, I believe, the injection of steam by a tube or blast-pipe, according to Mr. Nasmyth's plan, also air and steam combined after the process of Guenyveau, and, I am told, even the introduction of a blast of air alone through a blast-pipe, still all ended in absolute failure.

The most successful experiments in connection with mechanical puddling that have come under my notice were those conducted by MM. Dumeny and Lemut at the Clos-Mortier Forge, in the commune of St. Dizier (Haut Marne). I will not now take up your time in describing the various mechanical arrangements they have adopted, but merely state that I some time since received a report in which they assert the practical results of their apparatus are—1st, That the consumption of fuel is greatly reduced per ton of metal produced; 2nd, The work is accelerated and the production of the furnace increased, from which economy in the general and working expenses has resulted; 3rd, The obviating the necessity of workmen in stirring the cast-iron lowers the price of labour, whilst at the same time it enables the wages of the regular puddler to be augmented, although their labour is lightened; 4th, The waste is about the same as in the system of ordinary puddling, which is equivalent to saying (in other words) that the yield is the same as under the hand system; 5th, The improvement in the quality of the iron is undoubtedly the effect of the mechanical puddler.

Having now drawn a sketch of puddling from its earliest date down to the present time, I proceed to direct your attention to some remarkable facts connected with a new process, viz.—"The Richardson Process," which I am sure will be of great interest, as it is of the gravest importance to nearly every member of this institution, being particularly interesting because the chief practice with it has taken place in the neighbourhood of Glasgow. Of this process and its results some facts have lately appeared in the engineering journals, and I am happy to be able to state that, in the views which I originally formed, my conclusions have since been fully borne out by the remarkably accordant results we have obtained at the Glasgow Ironworks, but more particularly at Parkhead Forge.

Generally, I have no doubt the members of this institution are aware in what the "Richardson Process" consists. I will presently, in a few words, explain its chief feature, but first wish to mention what has been previously attempted in a similar direction. Reuben Plant was among the first to introduce blasts of air and steam into the puddling furnace, and, provided he had continued his experiments to completeness, there is little doubt but that what is now known as the "Richardson Process" would have been an established mode of manufacture twenty years ago. As it is, to Mr. Richardson, who was associated with Plant at that time, the credit is due of having made the first recorded experiments of blowing air below the surface of pig-iron; when he obtained that peculiar series of changes which we daily see produced in the Bessemer converter. Had Mr. Richardson continued the blowing of air long enough there is no doubt he would have succeeded in making worthless malleable iron, as Mr. Bessemer has done, through not being able to eliminate the sulphur and phosphorus. Other circumstances, as Mr. Richardson informs me, interfered, that a stop was put to the prosecution of the experiments, and thus it became reserved for Mr. Bessemer to follow up that same line of triumphant investigation by which he has immortalised his name —the process for making "Bessemer steel."

At Dowlais, in particular, as well at Cwm-Avon Ironworks, in Glamorganshire, blasts of air were blown into the metal on the puddling hearth, but for a very different object to that which the "Richardson Process" seeks to effect. In all the experiments, as I am informed, that were made prior to Richardson's, the blowing was continued for a long time after the iron had been brought to the boil. Now it is perfectly clear that in an ordinary furnace such continuous pouring in of oxygen would boil the metal to such an extent that it must run rapidly away with the slag from the stopper-hole, and being continued long after the desilicatisation and decarburisation of the charge were effected, would oxidise the iron to an enormous extent, thus diminishing the yield so much as to reduce the ironmasters' profits to a degree that could not be tolerated.

But these are not all the defects of such a constant in-pouring of oxygen, the powerful attack upon the carbon and the silicon, and after that the combination with the iron itself must raise the temperature of the furnace to such an extent that the bricks usually employed in the construction of such furnaces would melt away, and the duration of the furnace would therefore be reduced to a comparatively brief existence; and I may here remark what is a singular fact that although persons originally engaged in such experiments did not discover a remedy for this evil, it is well known that for puddlig furnaces common soft bricks are employed, the higher limit of temperature employed for puddling not requiring the use of the harder and more durable kinds which are used for furnaces wherein the temperature ranges higher. The same defect of the more rapid destruction of the roof has been met with in recent processes for making steel, but that has been entirely overcome by the use of harder bricks and a higher roof.

Having now shown the general nature of previous attempts, I proceed to explain the different course of action that Mr. Richardson adopts. In place of continuous blowing, the blast is introduced through a tubular rabble connected with a blast receiver immediately after the charge is melted, and continued until the metal is brought to "the boil," when it is withdrawn. The period from the melting to the boil with the iron used at Parkhead under the common method of puddling occupies form twenty-five to forty minutes; this, by the Richardson process, is reduced to ten minutes. The temperature of the furnace being higher, the period from the commencement of the boil to that when decarburisation and desilicatisation are completed, and the iron separates from the slag and cinder, is again reduced. But the balling operation is of a little longer duration than under the old method, on account also of the greater temperature, the granules of iron requiring more time to cool down to that temperature at which they adhere when pressed together.

Table, No. 1, of some of the first experiments made at the Glasgow Ironworks shows the time occupied in conducting each stage of the process, as well as the yield.

In these experiments the time of working a charge composed entirely of Scotch pig was brought down to one hour and eight minutes, whereas the usual time is from one hour 30 minutes to one hour 45 minutes under the old method; the yield is considerably higher; so high, indeed, as to require only 21 cwts. 1 qr. 17lbs. of pig-iron to produce a ton of malleable iron, showing a loss on the conversion of only about 6 per cent. Then as to the purity of the iron, it is most remarkable, two samples which I sent to

Dr. Stevenson Macadam of Edinburgh to be analysed have given the following results:—

ANALYSIS.

| Name of Element. | Square Bar. | Round Bar. |
|---|---|---|
| Iron | 99·569 | 99·648 |
| Carbon | 0·035 | 0·031 |
| Silicon | 0·076 | 0·065 |
| Sulphur | 0·025 | 0·028 |
| Phosphorus | 0·031 | 0·034 |
| Manganese | Trace. | Trace. |
| | 99·736 | 99·817 |

We see the sulphur and phosphorus are within the merest shadow of being entirely eliminated, evidently showing that some special influence must be present when puddling iron, according to Richardson's system, that is not found elsewhere; iron never has been made from British ores, on a commercial scale, so pure as in these two instances. Made from inferior Scotch pig, which always contains such a very large percentage of these two elements, the extent of their elimination is all the more remarkable. But not to draw any hasty conclusions, I have prepared tables Nos. 2, 3, 4, 5, 6, 7, and 8, showing the percentages of these elements in all the British pig-irons, from the analyses published in the Blue Book "On Cast-iron experiments."

The only analysis of pig-iron from North Staffordshire that I possess contains the very high proportion of 1·07 of phosphorus, and 0.04 of sulphur.

It is a very remarkable fact that I have not been able to obtain any reliable analysis of black band pig-iron, or indeed of the other Scottish irons that are guaranteed by authority; this is not only a peculiarly striking fact, but is, moreover, one to be deeply deplored. It is true that I am in possession of several analyses in which phosphorous does not present itself at all; this certainly is notorious, as it is well known that the black band pig-irons do contain a very large percentage of phosphorous, and I can therefore only suppose that this element, always most difficult of detection, has not been carefully sought for. The paucity of analyses in this respect is no doubt principally due to the fact that so much of the Scotch pig-iron is used and exported from the country as "foundry-iron." Now it is perfectly evident that for foundry purposes the presence of phosphorous is of considerably less importance than would result if the pigs were so largely used for making malleable iron as the English, Welsh, and Continental ores. It being certain that the presence of phosphorous has so much to do with the tensile strength of malleable iron, this, no doubt, has been the chief incentive to the undertaking so many careful analyses of those pig-irons from which malleable iron is principally made, in order that to produce the highest quality of finished iron, ores containing the least amount of phosphorus might be selected.

I may call attention to one analysis of Scotch black-band ironstone, which we may safely take as a very fair mean representative of the productions of this country—it is from Gartsherrie, and my authority for it is a report made to the Prussian Government, by M. A. Erbeich. In the raw state it gives phosphoric acid ($Po^5$) 0·90, which corresponds to rather above 0·5 per cent. of phosphorus in the pig-iron, but we may with safety take it at 0.5 per cent. for the sake of avoiding error in excess. Some samples of Scotch pig-iron give sulphur and phosphorus in other proportions; for instance, some No. 3 grey coke iron from the Calder Ironworks contained sulphur 0·35 and phosphrous 0·39, and another specimen from Clyde contained sulphur 0·40 and phosphorus 1·30; the former of these is probably a fair mean representative of the quantities of sulphur and phosphorus combined in irons from the Scotch coal measures, whilst the latter is no doubt an extreme; taking, however, the mean of these three we got—

| | |
|---|---|
| Sulphur | 0·375 |
| Phosphorus | 0·73 |

From the appended tables we have the values of British pig-irons in regard to phosphorus represented in the following scale of ascending values of the quantity of that element by their mean of means:—

| | Phosphorus per cent. |
|---|---|
| Hæmatites (various) | 0·144 |
| South Wales | 0·473 |
| Staffordshire (South) | 0·48 |
| Yorkshire | 0·54 |
| Scotland | 0·73 |
| Derbyshire | 0·865 |
| Staffordshire (North) | 1·07 |
| Northamptonshire | 1·143 |
| Cleveland | 1·32 |

On the other hand, taking the mean of means of sulphur we got the following order of ascending values in respect of the quantity of this element contained in the ores of different localities of Great Britain:

| | Sulphur per cent. |
|---|---|
| Cleveland | 0·035 |
| North Staffordshire | 0·04 |
| Derbyshire | 0·0447 |
| Yorkshire | 0·052 |
| Whitehaven (Ulverstone) | 0·056 |
| South Staffordshire | 0'0614 |
| South Wales | 0·098 |
| Northamptonshire | 0·267 |
| Scotland | 0·283 |

Now since the effect of combined sulphur is to prolong the time of melting, and phosphorus, on the other hand, diminishes that period, comparisons like those we have made are extremely useful in indicating the other chemical conditions in addition to those produced by the presence of carbon and silicon, that affect the duration of the period of melting of pig-irons made in different localities. I am now of course speaking independently of the construction of the furnace, for this modifies the time of melting to a considerable extent, a high bridge and great depth of hearth tending to drive off and prevent the tips of the reverberated flame from attacking the charge so easily as in a furnace with a low bridge and shallow hearth.

In the case of the Cleveland ore, we see at a glance that in the phosphorus series it is the very last, whilst singularly enough in the sulphur series it takes the first place; this theory shows it should be a very fast melting pig-iron. In the case of North Staffordshire it is second in the sulphur series, and seventh in the phosphorus series, the presence of sulphur being low and that of phosphorus very high, it should be a very fast melting iron. In the case of Derbyshire the phosphorus is much lower than in the preceding, and the sulphur but very slightly increased, it therefore should take a little longer in melting than the North Staffordshire pigs. In the case of Yorkshire the sulphur is increased and the phosphorus diminished, the time of melting should be longer still.

By making comparisons like the foregoing we obtain the period of melting of British pig-irons in terms of the combined sulphur and phosphrous in the following order;

Cleveland,
North Staffordshire,
Derbyshire,
Yorkshire,
Northamptonshire,
Whitehaven, Ulverston (Hæmattie),
South Staffordshire,
South Wales,
Scotland.

Here we see the order is nearly the same as in the sulphur series, the exception being in the case of Northamptonshire pig, where the percentage of phosphorous is so very high that it predominates over the sulphur, and therefore materially shortens the period of melting. If these conclusions which I have deduced are compared with practical results they will, I believe, be found to very fairly coincide. In the case of Scottish irons these should take longer to melt than any others present in this country, and from the number of trials at different works that have been made on this point such deduction will, I believe, strictly correspond with the practical results.

We have now to consider the extent to which phosphorus and sulphur are removed in the ordinary process of puddling. On this point I have not had time to prepare tables, as in the case of pig-iron, but it is my intention to do so on the earliest opportunity, as their value is evident enough to anyone whose pursuits are directed towards improving the metallurgy of iron and steel. On the present occasion, then, I shall, to shorten the time I am occupying, merely bring forward analyses from the very best makes of malleable iron I have met with, some of these being taken from Dr. Percy's excellent work on "Iron and Steel." An armour plate at Lowmoor was found to contain 0·104 per cent. of sulphur, and 0·106 per cent. of phosphorus; now, as we have before seen, the mean values for Yorkshire pig iron are—

| | |
|---|---|
| Sulphur | 0·052 |
| Phosphorus | 0·549 |

in which case, either in the puddling or re-heating furnace, but most probably in the former, the sulphur is doubled, but the phosphorus diminished by the very great amount of ·433 per cent. This, however, being an armour plate, is a special case, and it is highly probable that a portion of better pig iron was mixed with the Yorkshire pigs ordinarily used at Lowmoor. The sulphur is considerably increased, it may possibly have been added from the fuel. In several other specimens of armour plates we find sulphur existing in the following per-centages:—

Sulphur, 0·058, 0·121, 0·190, 0·118, ·053 0·104

And phosphorus in the following :—

Phosphorus, 0·030, 0·173, 0·020, 0·228, 0·089, 0·106

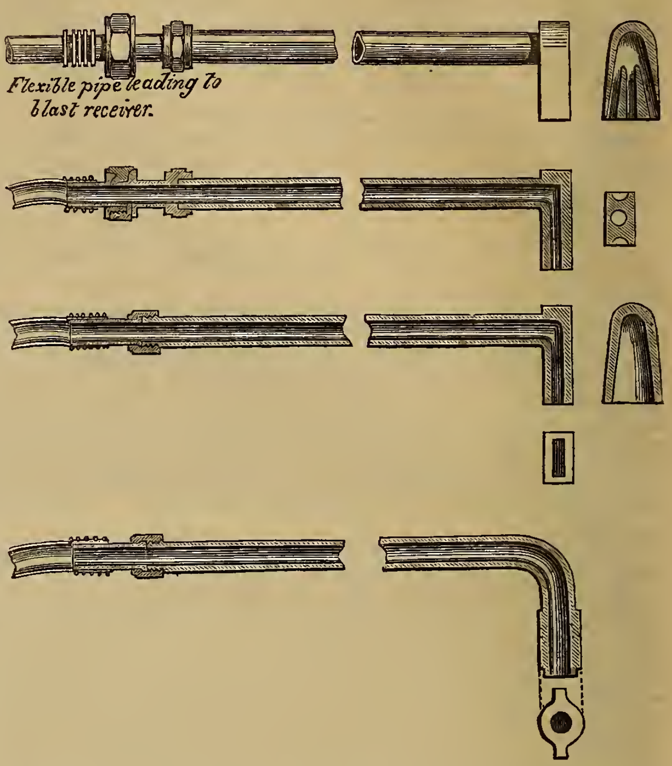
In regard to the sulphur, it is higher in the examined plates than in all the different qualities of British pig-iron except two, namely, Northamptonshire and Scotch, and since it is not in the least likely that either of these pigs were used in producing the plates, we may infer that sulphur has been added to the iron during its conversion and working into the malleable state, whilst the phosphorus is eliminated in every case to a very large extent, bringing its percentage considerably lower than in any known analysis of British pig-iron. Comparing malleable iron of South Staffordshire with the pig we have for the former :—

| | |
|---|---|
| Sulphur | 0·165 |
| Phosphorus | 0·140 |

Here also the sulphur is increased and the phosphorus diminished to a very considerable extent, and the same result obtains generally with any other comparisons that we make. We are therefore led to infer that during the conversion of pig into malleable iron, sulphur is added to the iron from the fuel whilst the phosphorus is eliminated in a very large ratio. Of course, in considering the increase that takes place, we must bear in mind that the percentage in malleable iron is greater in proportion to the absolute amount of iron itself present than obtains in the pig-iron, for the reason that in the latter case the carbon and silicon are present, whereas in the former they are nearly eliminated.

Comparing the foregoing results with analyses of iron made by the Richardson process, the superior eliminating power of that process is forcibly striking. In the analysed samples of the irom made at the Glasgow Ironworks by that process, as I have before stated for the experiments, common Scotch pigs were used, and yet from that material we have obtained finished bar iron purer than anything that has ever heretofore been manufactured from British ores, and that, too, from pig-irons which contain the highest percentage of sulphur, and rather above a medium of phosphorus; indeed, the removal of these two elements is so nearly complete, that practically, they are not found. There can be no doubt remaining that the Richardson process has effected what has never before been in Great Britain ; by it we are enabled to produce a better and purer iron from the commonest pigs than we can yet depend on obtaining continuously by the common process of puddling from the best pigs. We can save a third of the time hitherto occupied in puddling, get a higher yield, save fuel, and therefore cheapen the production of malleable iron.

For the last two or three months there have been several furnaces making iron by this process at Parkhead; I have a large number of the returns as to the time of puddling a charge, besides a large number of results which I have noted myself from watching the conduct of the process on several occasions ; these, however, I have not had sufficient time to tabulate, but I may state that the time from the moment of charging to taking out the balls varies from one hour 15 minutes to one hour 30 minutes, whilst in another experiment that we made, having previously "fettled" the furnace very heavily all round, both the bridge, sides, and flue, the heat was out in one hour 20 minutes; this, without the fettling, would correspond to about one hour and 10 minutes, a remarkably short time, when we remember that at this forge, where very gray pig-iron is principally used, the the amount of time usually occupied for puddling by the old method is one hour 45 minutes, and very often two hours. The period of melting in the case of such pig-iron is very high, I have on several occasions noted it and find it to vary between 35 and 50 minutes ; this is doubtless due in a great measure to the high percentage of combined sulphur, and very probably to some extent depending upon the large proportion of silicon contained in it, as well as the hæmatite, a small portion of which enters into the mixture. Out of the hundreds of bars that have now been made in this manner at Parkhead from the "common mixtures," too, it is particularly important to remark that not a singe bad bar has been met with. The iron works better under the shingling hammer as well as the rolls. In the puddled bars after they have passed through the mill and are cooled their appearance externally is frequently as smooth and even as good finished merchant bars, whilst the fracture shows the perfect regularity of the metal. With puddled bars of the same mixtures made in the ordinary manner, when cold and worked to the same extent they are much more full of flaws and fissures gaping wide open at the surface, and the fractures always show much want of uniformity, while the microscope usually reveals the presence of a great deal of graphitic carbon. Puddled bars from the common mixtures will not usually bend through a greater angle than 40 degs., without cracking right across, some of them break off quite coldshort before having reached that angle, whilst the best bars of such mixtures rarely if ever bend 45 degs., and usually break in half before reaching that extent of flexture; but with bars made by the "Richardson process" out of precisely the same materials I have seen them, I may with certainty say, on most occasions bend completely round to 90 degs. without breaking, frequently without showing a surface crack, and some specimens that have been tried were doubled up without effecting a complete fracture. Altogether, the advantages of working by this process are so great as to require no further comment from me.



Note.—Since writing the foregoing it has occurred to me that I should mention the now well ascertained fact that in the puddling furnace some of the phosphorus passes from the charge into the cinder, but by no means the whole of it. This circumstance led Dr. Percy to propound his theory that still more of that element existing in the charge as phosphide of iron was liquated or sweated out after the metal was balled. If there be any truth in this supposition, it appears to be confirmed by the results of the mode of working to which I have now called your attention. The balling process is of longer duration, as I have already explained, therefore greater time is afforded for this supposed liquation of the phosphide. I merely throw this out as a hint; it is rather soon yet to attempt to form a conclusive theory. That phosphorus is not got rid of by oxidation in combination with iron is certain, or it would unquestionably be eliminated in the Bessemer converter, every means hitherto tried having utterly failed to remove it. (For Tables I. to VIII. see pages 91, 92, and 93.)

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## ROYAL INSTITUTION OF GREAT BRITAIN.

### ON FARADAY AS A DISCOVERER.

By John Tyndall, Esq., LL.D., F.R.S., Professor of Natural Philosophy Royal Institution.

It has been thought desirable to give you and the world some image of Michael Faraday, as a scientific investigator and discoverer. The attempt to respond to this desire has been to me a labour of difficulty, if also a labour of love. Michael Faraday was born at Newington Butts, on the 22nd of September, 1791, and that he finally fell asleep at Hampton Court, on the 25th of August, 1867. When thirteen years old, that is to say in 1804, Faraday was apprenticed to a bookseller and bookbinder in Blandford-street, Manchester-square; here he spent eight years of his life, after which he worked as a journeyman elsewhere.

You have doubtless heard the account of Faraday's first contact with the Royal Institution: that he was introduced by one of the members to Sir Humphry Davy's last lectures; that he took notes of those lectures, wrote them fairly out, and sent them to Davy, entreating him at the same time to enable him to quit trade, which he detested, and to pursue science, which he loved. Davy was helpful to the young man, and this should never be forgotten; he at once wrote to Faraday, and afterwards, when an opportunity occurred, made him his assistant.

Faraday did, as you know, accompany Davy to Rome; he was re-engaged by the managers of the Royal Institution on the 15th of May, 1815. Here he made rapid progress in chemistry, and after a time was entrusted with easy analyses by Davy. In those days the Royal Institution published "The Quarterly Journal of Science," the precursor of our own "Proceedings." Faraday's first contribution to science appeared in that journal in 1816. It was an analysis of some caustic lime from Tuscany, which had been sent to Davy by the Duchess of Montrose. Between this period and 1818 various notes and papers were published by Faraday. In 1818 he experimented upon "Sounding Flames." Professor Auguste De la Rive, father of our present excellent De la Rive, had investigated those sounding flames, and had applied to them an explanation which completely accounted for a class of sounds discovered by De la Rive himself. By a few simple and conclusive experiments Faraday proved that the explanation was insufficient. It is an epoch in the life of a young man when he finds himself correcting a person of eminence, and in Faraday's case, where its effect was to develop a modest self-trust, such an effect could not fail to act profitably.

From time to time, between 1811 and 1820, Faraday published scientific notes and notices of minor weight. At this time he was acquiring, not producing; working hard for his master and storing and strengthening his own mind. He assisted Mr. Brand in his lectures, and so quietly, skilfully, and modestly was his work done, that Mr. Brande's vocation at the time was pronounced "lecturing on velvet." In 1820 Faraday published a chemical paper "on two new compounds of chlorine and carbon, and on a new compound of iodine, carbon, and hydrogen." This paper was read before the Royal Society on the 21st of December, 1820, and it was the first of his that was honoured with a place in the "Philosophical Transactions."

Oersted, in 1820, discovered the action of a voltaic current on a magnetic needle; and immediately afterwards the splendid intellect of Ampère succeed in showing that every magnetic phenomenon then known might be reduced to the mutual action of electric currents. The subject occupied all men's thoughts; and in this country Dr. Wollaston sought to convert the deflection of the needle by the current into a permanent *rotation* of the needle round the current. He also hoped to produce the reciprocal effect of causing a current to rotate round a magnet. In the early part of 1821 Wollaston attempted to realize this idea in the presence of Sir Humphry Davy in the laboratory of the Royal Institution. This was well calculated to attract Faraday's attention to the subject. He read much about it; and in the months of July, August, and September he wrote "a history of the progress of electro-magnetism," which he published in Thompson's "Annals of Philosophy." Soon afterwards he took up the subject of "Magnetic Rotations," and on the morning of Christmas Day, 1821, he called his wife to witness for the first time the revolution of a magnetic needle round an electric current. Incidental to the "historic sketch" he repeated almost all the experiments there referred to; and these, added to his own subsequent work, made him practical master of all that was then known regarding the voltaic current. In 1821 he also touched upon a subject which subsequently received his closer attention—the vaporization of mercury at common temperatures; and immediately afterwards conducted, in company with Mr. Stodart, experiments on the alloys of steel. He was accustomed in after years to present to his friends razors formed from one of the alloys then discovered.

During Faraday's hours of liberty from other duties he took up subjects of inquiry for himself; and in the spring of 1823, thus self-prompted, he began the examination of a substance which had long been regarded as the chemical element chlorine, in a solid form, but which Sir Humphry Davy, in 1810, had proved to be a hydrate of chlorine, that is, a compound of chlorine and water. Faraday first analyzed this hydrate, and wrote out an account of its composition. This account was looked over by Davy, who suggested the heating of the hydrate under pressure in a sealed glass tube. This was done. The hydrate fused at a blood-heat, the tube became filled with a yellow atmosphere and was found to contain two liquid substances. Dr. Paris happened to enter the laboratory while Faraday was at work. Seeing the oily liquid in his tube, he rallied the young chemist for his carelessness in employing soiled vessels. On filing off the end of the tube its contents exploded and the oily matter vanished. Early next morning Dr. Paris received the following note:—

"Dear Sir,—The *oil* you noticed yesterday turns out to be liquid chlorine.—Yours faithfully, "M. Faraday."

The gas had been liquefied by its own pressure. Faraday then tried compression with a syringe, and succeeded thus in liquefying the gas.

To the published account of this experiment Davy added the following note:—"In desiring Mr. Faraday to expose the hydrate of chlorine in a closed glass tube, it occurred to me that one of three things would happen: that it would become fluid as a hydrate; that decomposition of water would occur; . . . or that the chlorine would separate in a fluid state." Davy, moreover, immediately applied the method of self-compressing atmospheres to the liquefaction of muriatic gas. Faraday continued the experiments and succeeded in reducing a number of gases, till then deemed permanent, to the liquid condition. In 1844 he returned to the subject, and considerably expanded its limits. These important investigations established the fact that gases are but the vapours of liquids possessing a very low boiling-point, and gave a sure basis to our views of molecular aggregation. The account of the first investigation was read before the Royal Society on the 10th of April, 1823, and was published, in Faraday's name, in the 'Philosophical Transactions.' The second memoir was sent to the Royal Society on the 19th of December, 1844. I may add that while he was conducting his first experiments on the liquefaction of gases, thirteen pieces of glass were on one occasion driven by an explosion into Faraday's eye.

Some small notices and papers, including the observation that glass readily changes colour in sunlight, follow here. In 1825 and 1826 Faraday published papers in the "Philosophical Transactions" on "new compounds of carbon and hydrogen," and on "sulpho-naphthalic acid." In the former of these papers he announced the discovery of Benzol, which, in the hands of modern chemists, has become the foundation of our splendid aniline dyes. But he swerved incessantly from chemistry into physics; and in 1826 we find him engaged in investigating the limits of vaporisation, and showing, by exceedingly strong and apparently conclusive arguments, that even in the case of mercury such a limit exists; much more he conceived it to be certain that our atmosphere does not contain the vapour of the fixed constituents of the earth's crust. This question, I may say, is likely to remain an open one. Mr. Rankine, for example, has lately drawn attention to the odour of certain metals; whence comes this odour, if it be not from the vapour of the metal?

In 1825 Faraday became a member of a committee, to which Sir John Herschel and Mr. Dollond also belonged, appointed by the Royal Society to examine, and if possible improve, the manufacture of glass for optical purposes. Their experiments continued till 1829, when the account of them constituted the subject of a "Bakerian Lecture." This lectureship, founded in 1774 by Henry Baker, Esq., of the Strand, London, provides that every year a lecture shall be given before the Royal Society, the sum of four pounds being paid to the lecturer. The Bakerian Lecture, however, has long since passed from the region of pay to that of honour, papers of mark only being chosen for it by the council of the Society. Faraday's first Bakerian Lecture, "On the Manufacture of Glass for Optical Purposes," was delivered at the close of 1829. It is a most elaborate and conscientious description of processes, precautions, and results: the details were so exact and so minute, and the paper consequently so long, that three successive sittings of the Royal Society were taken up by the delivery of the lecture. This glass did not turn out to be of important practical use, but it happened afterwards to be the foundation of two of Faraday's greatest discoveries.

The experiments here referred to, were commenced at the Falcon Glass Works, on the premises of Messrs. Green and Pellatt, but Faraday could not conveniently attend to them there. In 1827 therefore a furnace was erected in the yard of the Royal Institution; and it was at this time, and with a view of assisting him at the furnace, that Faraday engaged Sergeant Anderson, of the Royal Artillery, the respectful, truthful, and altogether trustworthy man whose appearance here is so fresh in our memories. Anderson continued to be the reverential helper of Faraday and the faithful servant of this Institution for nearly forty years.

In 1831 Faraday published a paper "On a peculiar class of Optical Deceptions," to which I believe the beautiful optical toy called the Chromatiope owes its origin. In the same year he published a paper on Vibrating Surfaces, in which he solved an acoustial problem which, though of extreme simplicity when solved, appears to have baffled many eminent men. The problem was to account for the fact that light bodies, such as the seed of lycopodium, collected at the vibrating parts of sounding plates, while sand ran to the nodal lines. Faraday showed that the light bodies were entangled in the little whirlwinds formed in the air over the places of vibration, and through which the heavier sand was readily projected.

The phenomena of ordinary electric induction belonged, as it were, to the alphabet of his knowledge: he knew that under ordinary circumstances the presence of an electrified body was sufficient to excite, by induction, an unelectrified body. He knew that the wire which carried an electric current was an electrified body, and still that all attempts had failed to make it excite in other wires a state similar to its own.

What was the reason of this failure? Faraday never could work from the experiments of others, however clearly described. He knew well that from every experiment issued a kind of radiation, luminous in different degrees to different minds, and he hardly trusted himself to reason upon an experiment that he had not seen. In the autumn of 1831 he began to repeat the experiments with electric currents, which, up to that time, had produced no positive result.

He began his experiments "on the induction of electric currents" by composing a helix of two insulated wires, which were wound side by side round the same wooden cylinder. One of these wires he connected with a voltaic battery of ten cells, and the other with a sensitive galvanometer. When connection with the battery was made, and while the current flowed, no effect whatever was observed at the galvanometer. But he never accepted an experimental result, until he had applied to it the utmost power at his command. He raised his battery from ten cells to 120 cells, but without avail. The current flowed calmly through the battery wire without producing, during its flow, any sensible result upon the galvanometer.

"During its flow," and this was the time when an effect was expected, he noticed that a feeble movement of the needle always occurred at the moment when he made contact with the battery; that the needle would afterwards return to its former position and remain quietly there, unaffected by the flowing current. At the moment, however, when the circuit was interrupted the needle again moved, and in a direction opposed to that observed on the completion of the circuit.

This result and others of a similar kind led him to the conclusion "that the battery current through the one wire did in reality induce a similar current through the other; but that it continued for an instant only, and partook more of the nature of the electric wave from a common Leyden jar than of the current from a voltaic battery." The momentary currents thus generated were called induced currents, while the current which generated them was called the inducing current. It was immediately proved that the current generated at making the circuit was always opposed in direction to its generator, while that developed on the rupture of the circuit coincided in direction with the inducing current. It appeared as if the current on its first rush through the primary wire sought a purchase in the secondary one, and, by a kind of kick, impelled backward through the latter an electric wave, which subsided as soon as the primary current was fully established.

The mere approach of a wire forming a closed curve to a second wire through which a voltaic current flowed was then showed by Faraday to be sufficient to arouse in the neutral wire an induced current, opposed in direction to the inducing current; the withdrawal of the wire also generated a current having the same direction as the inducing current; those currents existed only during the time of approach or withdrawal, and when neither the primary nor the secondary wire was in motion, no matter how close their proximity might be, no induced current was generated.

Magnetism has been produced from electricity, and Faraday, who all his life long entertained a strong belief in such reciprocal actions, now attempted to effect the evolution of electricity from magnetism. Round a welded iron ring he placed two distinct coils of covered wire, causing the coils to occupy opposite halves of the ring. Connecting the ends of one of the coils with a galvanometer, he found that the moment the ring was magnetised by sending a current through the other coil, the galvanometer needle whirled round four or five times in succession, the action, as before, was that of a pulse which vanished immediately. On interrupting the circuit, a whirl of the needle in the opposite direction occurred. It was only during the time of magnetisation or demagnetisation that these effects were produced. The induced currents declared a change of condition only, and they vanished the moment the act of magnetisation or demagnetisation was complete.

The effects obtained with the welded ring were also obtained with straight bars of iron. Whether the bars were magnetised by the electric current, or were excited by the contact of permanent steel magnets, induced currents were always generated during the rise and during the subsidence of the magnetism. The use of iron was then abandoned, and the same effects obtained by merely thrusting a permanent steel magnet into a coil of wire. A rush of electricity through the coil accompanied the insertion of the magnet; an equal rush in the opposite direction accompanied its withdrawal. The precision with which Faraday describes these results, and the completeness with which he defines the boundaries of his facts are wonderful. The magnet, for example, must not be passed quite through the coil, but only half through, the needle is stopped as by a blow, and then he shows how this blow results from a reversal of the electric wave in the helix. He next operated with the powerful permanent magnet of the Royal Society, and obtained with it, in an exalted degree, all the foregoing phenomena.

And now he turned the light of these discoveries upon the darkest physical phenomenon of that day. Arago had discovered in 1820, that a disc of non-magnetic metal had the power of bringing a vibrating magnetic needle suspended over it rapidly to rest; and that on causing the disc to rotate the magnetic needle rotated along with it. When both were quiescent, there was not the slightest measurable attraction or repulsion exerted betwen the needle and the disc; still when in motion the disc was competent to drag after it not only a light needle, but a heavy magnet. The question had been probed and investigated with admirable skill by both Arago and Ampére, and Poisson had published a theoretic memoir on the subject; but no cause could be assigned for so extraordinary an action. Now, however, the time for theory had come. Faraday saw mentally the rotating disc under the operation of the magnet flooded with his induced currents; and from the known laws of interaction between currents and magnets he hoped to deduce the motion observed by Arago. That hope he realised, showing by actual experiment that when his disc rotated currents passed through it, their position and direction being such as must, in accordance with the established laws of electro-magnetic action, produce the observed rotation.

Introducing the edge of his disc between the poles of the large horseshoe magnet of the Royal Society, and connecting the axis and the edge of the disc, each by a wire with a galvanometer, he obtained when the disc was turned round a constant flow of electricity. The direction of the current was determined by the direction of the motion, the current being reversed when the rotation was reversed. He now states the law which rules the production of currents in both discs and wires, and in so doing uses for the first time a phrase which has since become famous. When iron filings are scattered over a magnet, the particles of iron arrange themselves in certain determinate lines called magnetic curves. In 1831, Faraday for the first time called these curves "lines of magnetic force;" and he showed that to produce induced currents neither approach to nor withdrawal from a magnetic source, or centre, or pole, was essential, but that it was only necessary to cut appropriately the lines of magnetic force.

On the 12th of January, 1832, he communicated to the Royal Society a second paper on Terrestrial Magneto-electric Induction, which was chosen as the Bakerian Lecture for the year. He placed a bar of iron in a coil of wire, and lifting the bar into the direction of the dipping needle, he excited by this action a current in the coil. On reversing the bar, a current in the opposite direction rushed through the wire. The same effect was produced, when, on holding the helix in the line of dip, a bar of iron was thrust into it. Here, however, the earth acted on the coil through the intermediation of the bar of iron. He abandoned the bar and simply set a copper-plate spinning in a horizontal plane; he knew that the earth's lines of magnetic force then crossed the plane at an angle of about 70°. When the plate spun round, the lines of force were intersected and induced currents generated, which produced their proper effect when carried from the plate to the galvanometer. "When the plate was in the magnetic meridian, or in any other plane coinciding with the magnetic dip, then its rotation produced no effect upon the galvanometer."

At the suggestion of a mind fruitful in suggestions of a profound and philosophic character—I mean that of Sir John Herschel—Mr. Barlow, of Woolwich, had experimented with a rotating iron shell. Mr. Christie had also performed an elaborate series of experiments on a rotating iron disc. Both of them had found that when in rotation the body exercised a peculiar action upon the magnetic needle, deflecting it in a manner which was not observed during quiescence; but neither of them was aware at the time of the agent which produced this extraordinary deflection. They ascribed it to some change in the magnetism of the iron shell and disc.

But Faraday at once saw that his induced currents must come into play here, and he immediately obtained them from an iron disc. With a hollow brass ball, moreover, he produced the effects obtained by Mr. Barlow. Iron was in no way necessary: the only condition of success was that the rotating body should be of a character to admit of the formation of currents in its substance; it must, in other words, be a conductor of electricity. The higher the conducting power, the more copious were the currents. He now passes from his little brass globe to the globe of the earth. He plays like a magician with the earth's magnetism. He sees the invisible lines along which its magnetic action is exerted, and sweeping his wand across these lines he evokes this new power. Placing a simple loop of wire round a magnetic needle he bends its upper portion to the west; the north pole of the needle immediately swerves to the east; he bends his loop to the east, and the north pole moves to the west. Suspending a common bar magnet in a vertical position, he causes it to spin round upon its own axis. Its pole being connected with one end of a galvanometer wire, and its equator with the other end, electricity rushes round the galvanometer from the rotating magnet. He remarks upon the "singular independence" of the magnetism and the body of the magnet which carries it. The steel behaves as if it were isolated from its own magnetism.

*(To be Continued.)*

Tunnelling the Niagara River.—The plan proposed fifteen years since, of tunnelling the Niagara river at Buffalo, has been revived and is now in the hands of capitalists and practical men, both in Canada and New York. If, as seems probable, the project is carried out, a direct, uninterrupted railroad connection will be established between Buffalo and Chicago, *via* Canada.

## ON CERTAIN POINTS IN THE MANUFACTURE OF MALLEABLE IRON, WITH SPECIAL REFERENCE TO THE RICHARDSON PROCESS.

(*See p.* 88, *ante.*)

### TABLE No. I.—EXPERIMENTS AT THE GLASGOW IRON COMPANY'S WORKS.

| Date of Experiment, and Number of Furnace. | Weight of Charge. | Charge composed of. | Time of Charging. | Iron melted at | Blas tput in at | Blast on till | First Ball out. | Last Ball out. | Time occupied from charging until the Iron was finished. | Yield. | Diminution of charge. | Remarks. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | cwt. lbs. | | h. m. | h. m. | h. m. | h. m. | h. m. | h. m. | b. m. | cwt. qrs. lbs. | cwt. qrs. lbs. | |
| May 30th, 1867. Furnace No. 17 ... | 4 0 | Pig-Iron exclusively...... | 7 0 | 7 27 | 7 28 | 7 36 | 8 4 | 8 8 | 1 8 | Not ascertained. | Not ascertained. | |
| June 11th. Furnace No. 17 ... | 4 0 | Pig-Iron exclusively...... | 6 12 | 6 42 | 6 43 | 6 47 | 7 18 | 7 22 | 1 10 | 3 3 14 | 0 0 14 | Three rabbles used to prevent any one becoming too hot. |
| June 11th. Furnace No. 17, refettled ......... | 4 0 | 3 cwt. pig-iron and 1 cwt. refined or plate-metal | 7 30 | 8 1 | 8 1·5 | 8 6·5 | 8 35 | 8 40 | 1 10 | 3 2 14 | 0 1 14 | Same number of rabbles used as in the preceding experiment. |
| June 13th. Furnace No. 17 ... | 4 0 | Common pig of the worst quality used in the works for a long time | 6 5 | 6 35 | 6 35 | 6 43 | 7 16 | 7 20 | 1 15 | 3 2 7 | 0 1 21 | Three rabbles used. |
| June 13th. Furnace No. 17. Furnace refettled and again charged | 4 0 | Same as in the preceding experiment.............. | 7 30 | 8 3 | 8 4 | 8 12 | 8 36 | 8 41 | 1 15 | 3 3 18 | 0 0 10 | es used. |
| Means ............... | 4 0 | | Mean time of blowing in 6·36 minutes. | | | | | | 1 11 | 3 2 27·25 | 0 1 0·75 | The rabbles are very little affected, and therefore will last a long time. |

### TABLE II.—HÆMATITES.

Sulphur and Phosphorus Combined in Pig-Iron made in Whitehaven and Ulverston Districts from Hæmatite Ores.

| Particulars as to the ores from which the pig-iron was made. | Sulphur per cent. | Means of Sulphur. | Phosphorus per cent. | Means of Phosphorus. | Remarks. |
|---|---|---|---|---|---|
| Red Hæmatite from Whitehaven, Cumberland, and Cleator Moor. | 0·01, 0·10, 0·05 | 0·053 | 0·05, 0·03, 0·06, 0·05 | 0·0175 | Whitehaven Foundry, Pig Nos. 1, 2, 3, 4, Hot Blast. |
| Ulverstone Ore. | 0·03 | 0·03 | 0·10 | 0·10 | Pig Iron made at the Newland Furnaces, Ulverstone. |
| Ores in the locality of Durham | 0·06, 0·04, 0·12<br>0·04, 0·230, 0·06 | 0·09 | 0·07, 0·19, 0.19, 0·14, 0·12, 0·14 | 0·141 | Iron Smelted by the Weardale Iron Company, and by the Forest of Dean Company, at Parkhead Ironworks |
| Ulverstone Hæmatite (Anhydrous sesquioxide), 25 parts; Forest of Dean Hæmatite (Hydrated sesquioxide), 5 parts; Brown Hæmatite, believed to be from Froghall, 25 parts; Gubbin Ironstone, 10 parts (roasted); Bottom Whitestone, 5 parts (roasted). | 0·05 | 0·05 | 0·29 | 0·29 | Pig-Iron made by Messrs Firmstone and Co., Lays Ironworks. |
| | Mean of Means | 0·056 | Mean of Means | 0·1146 | |

## TABLE III.—CHIEFLY ARGILLACEOUS ORES FROM THE COAL MEASURES.

### Sulphur and Phosphorus combined in Pig-Iron made in South Wales.

| Particulars of the ores from which the Pig-Iron was made. | Sulphur per cent. | Means of Sulphur. | Phosphorus per cent. | Means of Phosphorus. | Remarks. |
|---|---|---|---|---|---|
| Wholly of Welsh mine without cinder or red ore. | 0·11, 0·28, 0·46, 0·09 | 0·235 | 0·63, 0·63, 0·64, 0·63 | 0·032 | Pig-iron made at Dowlais, of which the first three samples were of No. 3 best mine pig, cold blast; mottled mine pig, cold blast, and white mine pig, cold blast respectively; whilst the fourth was best mine pig, melted in a furnace with three twyers, of which two were hot and one cold blast. |
| Black Pins, Pwll Llaeca Bottom Vein, Ball Mine and Grey Vein | 0·06, 0·07, 0·08, 0·08 | 0·074 | 0·38, 0·29, 0·27, 0·38 | 0·32 | Made at Blanaevon with cold blast |
| From the coal measures of the locality, the precise names of ore unknown. | 0·06, 0·07, 0·04 | 0·059 | 0·32, 0·28, 0.33 | 0·31 | Made at Blanaevon, and specified as cold blast gray pig-iron, analysed at the Arsenal, Woolwich |
| Red, or Welsh Mine and cinder. | 0·77, 0·73 | 0·75 | 0·82, 0·76 | 0·79 | The first of these samples cast in chills, the second in sand, to ascertain the difference chemically by the two modes of being cooled. It is surprising that whilst so small a proportionate difference shows itself in the carbon, the proportionate difference in the phosphorus is very great. |
| From the coal measures in the locality of Pontypool. | 0·12, 0·08, 0·09 | 0·096 | 0·32, 0·46, 0·50 | 0·426 | Cold blast gray pig made at Pontypool. |
| Caus-y-Glo or Cheese Mine, Pimmelyn Mine; or Yellow Pin with red Hæmatite from Ulverstone. | 0·05, 0·06, 0·05, 0·05, 0·09, 0·06 | 0·06 | 0·41, 0·29, 0·38, 0·42, 0·38, 0·27 | 0·36 nearly | Made at Ystalyfera, near Swansea, hot blast |
|  | Mean of Means | 0·098 | Mean of Means | 0·473 |  |

## TABLE IV.—ARGILLACEOUS ORES FROM THE COAL MEASURES.

### Sulphur and Phosphorous combined in Pig-Iron made in South Staffordshire.

| Particulars as to the Ores from which the Pig-Iron was made. | Sulphur per cent. | Means of Sulphur. | Phosphorus per cent. | Means of Phosp'rus. | Remarks. |
|---|---|---|---|---|---|
| Binds, Whitestones, Gubbins, and Grains, proportions unknown | 0·04, 0·04, 0·03, 0·06, 0·05 | 0·044 | 0·34, 0·31, 0·43, 0·29, 0·44 | 0·362 |  |
| Ibid | 0·03, 0·07, 0·04, 0·08 | 0·0675 | 0·42, 0·42, 0·34, 0·45 | 0·40 | Cold blast grey pig-iron. |
| Bottomstone and Binds, two-thirds Gubbin; and Rubble one-third | 0·06, 0·03, 0·10 | 0·63 | 0·58, 0·55, 0·48 | 0·53 | Pig. grey—forge, and forge pig respectively, cold blast iron made at the Parkhead Furnaces, Dudley. |
| Ibid | 0·08, 0·08, 0·05, 0·05, 0·07, 0·06 | 0·063 | 0·55, 0·51, 0·48 0·49, 0·58, 0·60 | 0·53 | Cold blast grey pig made at the Parkhead Furnaces, Dudley. |
| Gubbin one-half, Whitestone the other half | 0·04, 0·05 | 0·045 | 0·72, 0·63 | 0·67 | Hot blast and cold blast respectively, from Earl Dudley's Level Ironworks, Brierley Hill. |
| Whitestone, Gubbin, Grains, Pins, Balls, and Poor Robins, with a little Red Hæmatite from Ulverstone | 0·03, 0·04, 0·07, 0·11 | 0·0625 | 0·38, 0·63, 0·55, 0·41 | 0·49 | Pig-iron made by Messrs. Badger and Co. Old Hill Furnaces, Dudley; whether by hot or cold blast is unknown. |
| Uncertain as to name | 0·08, 0.09, 0·09, 0·07, 0·07 | 0·08 | 0·36, 0·30, 0·41, 0·55, 0·23 | 0·39 | Grey Pig, both hot and cold blast, from Lays Ironworks, Dudley. |
|  | Mean of Means, | 0·0614 | Mean of Means, | 0·48 |  |

## TABLE V.—ARGILLACEOUS ORES FROM COAL MEASURES.

Sulphur and Phosphorus combined in Pig-Iron made in Yorkshire.

| Particulars as to the Ores from which the Pig-Iron was made. | Sulphur per cent. | Means of Sulphur. | Phosphorus per cent. | Means of Phosphorus. | Remarks. |
|---|---|---|---|---|---|
| Black Bed Ironstone from the Coal Measures of this locality | 0·05, 0·04, 0·06, 0·03, 0·06, 0·07, 0·04 | 0·05 | 0·50, 0·57, 0·56, 0·49, 0·44, 0·67, 0·52 | 0·54 | Various kinds specified as pig and grey pig made at the Bowling Ironworks. |
| Ibid | 0·06, 0·07, 0·05, 0·05, 0·04 | 0·054 | 0·52, 0·53, 0·64, 0·55, 0·55 | 0·558 | Cold blast pig-iron made by Messrs. Harding and Co., Beeston Manor Ironworks, Leeds. |
| | Mean of Means. | 0·052 | Mean of Means. | 0·549 | |

## TABLE VI.—ARGILLACEOUS ORES FROM THE COAL MEASURES.

Sulphur and Phosphorus combined in Pig-Iron made in Derbyshire.

| Particlars as to the Ores from which the Pig-Iron was made. | Sulphur per cent. | Means of Sulphur. | Phosphorus per cent. | Means of Phosphorus. | Remarks. |
|---|---|---|---|---|---|
| The first three samples in this case made of Brown Rake Ironstone, and the fourth from Blue Rake Ironstone (Ore roasted) | 0·02, 0·02, 0·04, 0·11 | 0·0475 | 1·09, 1·21, 1·15, 0·75 | 1·05 | Pig Nos. 1, 2, 3, 4, made by Messrs. Needham, Butterley Ironworks, near Alfreton, Derbyshire—hot blast |
| Black and Grey Rake two-thirds, and Honeycroft, or Striped Rake, one-third | 0·02, 0·06, 0·05, 0·03, 0·05 | 0·042 | 0·72, 0·34, 0·72, 0·95, 0·70 | 0·68 | Various, foundry pig, and grey forge pig, made at the West Hallam, Iron-Ironworks. |
| | Mean of Means. | 0·0447 | Mean of Means. | 0·865 | |

## TABLE VII.—SULPHUR AND PHOSPHORUS IN PIG-IRON MADE ENTIRELY OF NORTHAMPTONSHIRE ORES.

| Particulars as to the Ores from which the Pig-iron was made. | Sulphur per cent. | Means of Sulphur. | Phosphorus per cent. | Means of Phosphorus. | Remarks. |
|---|---|---|---|---|---|
| The usual ores of this neighbourhood | 0·197, 0·414, 0·702, 0·440 | 0·438 | 0·936, 1·807, 1·368, 1·300 | 1·127 | |
| Ibid | 0·10, 0·13, 0·07 | 0·10 | 1·19, 1·07, 1·31 | 1·16 | Made by Messrs. Buttlin and Co., with cold blast. |
| | Mean of Means, | 0·269 | Means of Means, | 1·1435 | |

## TABLE VIII.—SULPHUR AND PHOSPHORUS COMBINED IN PIG-IRON MADE FROM CLEVELAND ORES.

| Particulars as to the Ores from which the Pig-iron was made. | Sulphur per cent. | Means of Sulphur. | Phosphorus per cent. | Means of Phosphorus. | Remarks. |
|---|---|---|---|---|---|
| Uncertain | 0·0,3 0·04 | 0·035 | 1·24, 1·30 | 1·27 | Iron known as No. 2 foundry pig, made at South Bank Furnaces, Middlesbro'-on-Tees, hot blast. |
| Cleveland ore from Belmont mines, and a little red hæmatite | 0·04, 0·03 | 0·035 | 1·38, 1·36 | 1·37 | Made by Messrs. Holdsworth, Bennington, and Byers, at Stockton, hot blast. |
| | Mean of Means. | 0·035 | Mean of Means, | 1·32 | |

## LONDON GAS COMPANIES.—THEIR CAPITAL AND PRODUCTIVE POWERS.

By George Pinchbeck, C.E.

The lighting of this vast metropolis is at present effected by thirteen wealthy gas companies, representing the enormous capital of £6,835,538, and producing an aggregate of 8,653,517,551 cubic feet of gas sold in the year 1866, with a consumption of 1,072,908 tons of coal, the average cost of the coals being 17s. per ton.

The following table shows in detail the capital of each company, the consumption and cost of coals per annum, as well as the average price per ton.

Coal carbonised being the productive power of a gas works, the first column in the table shows at a glance the amount of capital employed by each company for every ton of coal used, which varies considerably, being only £4 per ton in the case of the Independent, whereas it amounts to £8 10s. in that of the Phœnix Company.

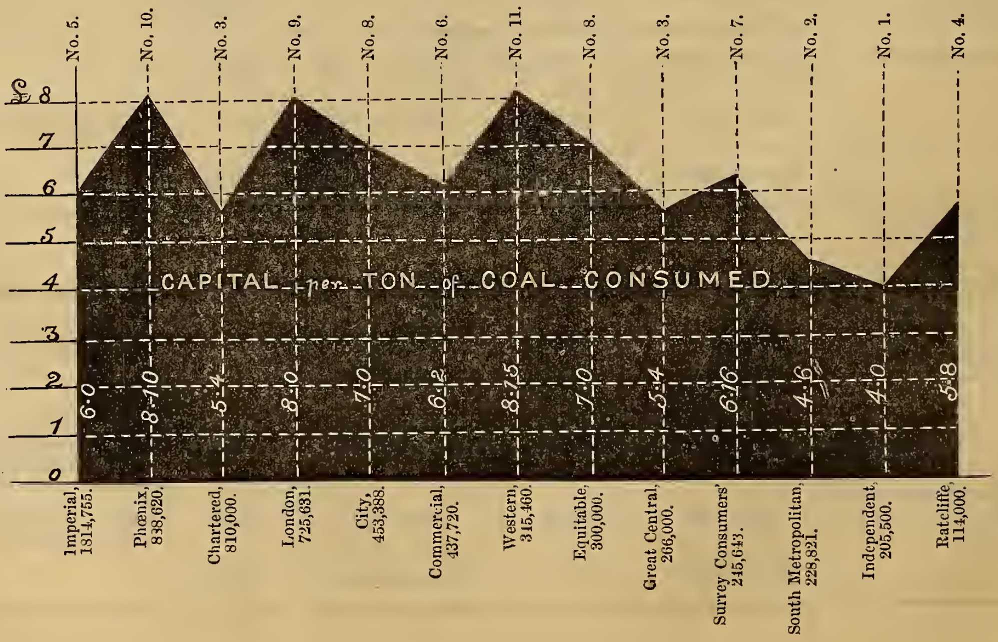
TABLE.

| Name of Company. | Ratio between Capital and Coal used. | Capital of Company. | Coals. Tons. | Coals. Cost. | Coals per Ton. |
|---|---|---|---|---|---|
| | £. s. | £. | | £. | s. d. |
| City | 7 0 | 453,388 | 64,156 | 54,822 | 17 1 |
| Chartered | 5 4 | 810,000 | 153,634 | 140,358 | 18 3 |
| Commercial | 6 2 | 437,720 | 71,608 | 62,303 | 17 5 |
| Equitable | 7 0 | 300,000 | 42,298 | 36,931 | 17 7 |
| Great Central | 5 4 | 266,000 | 51,393 | 39,802 | 15 6 |
| Imperial | 6 0 | 1,814,755 | 299,009 | 246,560 | 16 6 |
| Independent | 4 0 | 205,500 | 50,958 | 43,849 | 17 3 |
| London | 8 0 | 725,631 | 89,946 | 80,018 | 17 9 |
| Phœnix | 8 10 | 888,620 | 103,471 | 81,793 | 15 9 |
| Ratcliffe | 5 8 | 114,000 | 21,087 | 17,242 | 16 3 |
| South Metropolitan | 4 6 | 228,821 | 48,484 | 36,968 | 15 3 |
| Surrey Consumers' | 6 16 | 245,643 | 37,207 | 28,090 | 15 1 |
| Western | *8 15 | 345,460 | 39,657 | 46,162 | 23 3 |

* Cannel coal is used by this company.

The accompanying diagram will better illustrate the useful effect of the capital employed by the several gas companies above named. It will be seen that while some of the smaller companies are doing their work with a capital of £4 to £5 per ton of coal, others of larger pretensions require more than double that amount for the same work, viz., a ton of coal.

The diagram shows that the Independent, the South Metropolitan, the Chartered, and the Great Central do their work with the least capital, while the Phœnix, the Western, and the London show a much larger amount—more than double; the Independent, for instance, shows that with considerably less than one-quarter of the capital, they are doing nearly half the work of the Phœnix.



## NOTES AND NOVELTIES.

### MISCELLANEOUS.

A complaint in Chancery has been lodged against the Anglo-American Telegraph Company by Mr. W. P. Piggott and others, for a suspected infringement of Mr. Piggott's patent for improvements in the mode of generating electric currents.

The attention of shipbuilders, engineers, and others interested in the shipping trade is called to the fact that the time for applying for space in the Havre Maritime International Exhibition is drawing to a close. As the Board of Trade, Admiralty, and other public departments have set the example, it is hoped that a good display will be made of all that relates to the great maritime interests of the country. The Concessionaires, Messrs. J. M. Johnson and Sons, of Castle-street, Holborn, are prepared to receive applications for space until the 15th inst.

### NAVAL ENGINEERING.

The *Avon*, 2, twin-screw (unarmoured, composite built) gunboat, 467 tons, 120-horse power, one of the class of vessels recently designed by the Controller of the Navy's office. as representing ideas on the construction of vessels possessing an iron frame with an outer sheathing or shell of wood, and the application of the twin-screw principle, was put through her trial over the Admiralty standard measured mile in Stokes Bay, near Portsmouth, on the 7th ult. The vessel was trimmed to a dip of 13in. by the stern for the trial, her draught of water being 7ft. forward, and 8ft. 1in. aft. She was rigged, had her armament on board, and a certain portion of her stores. To place her in sea-going trim she would have required her stores and coals to be completed, and her officers and crew with their belongings placed on board. With her engines working at high pressure she attained a mean speed of 10·056 knots, and working at low pressure a mean speed of 9·731 knots. There were several objectionable features connected with the trial, but these may be remedied when the ship makes her final trial at deep or seagoing draught. The machinery of the *Avon* consists of two sets, of 60-horse power each, by Maudslay, Field, and Co., removed from the hulls of two of the gunboats recently broken up at Haslar-yard.

### MILITARY ENGINEERING.

The Nine-inch Palliser Rifled Gun.—The trial of Major Palliser's 9-inch gun, which was exhibited last year at the Paris Exhibition, was concluded on the 9th ult., at Woolwich. Its test was as follows:—420 rounds of 43lbs. of powder, 87 of 45lbs., and 4 of 55lbs. of powder, with 250lb. shot throughout, in all 511 rounds. The vent remained serviceable to the end. The great mass of this gun is composed of cast iron, which is lined with two barrels of coiled wrought iron, one inside the other. A crack appeared at the muzzle portion of the inner barrel shortly after firing 200 rounds. This, however, produced no ill effect whatsver. It was caused by the vibration of the barrel, which was accidentally loose in the muzzle. The gun was manufactured by the Elswick Ordnance Company, and remains practically uninjured. The successful result of this trial has created much surprise, and proves the soundness of the advice of the Ordnance Select Committee in having recommended Government to incur the expenditure upon it.

### SHIPBUILDING.

The shipbuilding trade has not been so dull in Dundee for thirty years as at present and in two of the yards only a few men are employed, the majority being engaged in repairing vessels. Most of the vessels on the stocks are being built for sale. Since the stagnation of trade has set in, wages have been reduced about 25 per cent. Carpenters are receiving 20s. per week for new work, and 22s. for old; blacksmiths, from 22s. to 23s.; joiners, from 20s. to 23s.; and riveters, from 23s. to 28s. The average number of men and boys employed in the five yards is upwards of 600, being about 300 less than the number employed in September last.

**Shipbuilding in Scotland.**—The following detailed return of the number and tonnage of vessels built in Scotland during the year 1866, will show the extent of the shipbuilding trade in that year, at all the ports:—Vessels above 50 tons—Aberdeen, 12 wooden vessels, tonnage 7,560; 2 composite vessels—*i.e.*, partly of wood and partly of iron—tonnage 2,79 9; 2 iron steam vessels, tonnage 1,212—in all 16 vessels, total tonnage 11,571. Alloa, 2 wooden, tonnage 497. Arbroath, 1 wooden, tonnage 97. Ardrossan, 3 wooden, tonnage 297. Ayr, 3 wooden, tonnage 428. Banff, 21 wooden, tonnage 3,123. Borrowstonaness, 3 wooden, tonnage 421; 1 iron steam vessel, tonnage 277—total, 4 vessels and 698 tons. Dumfries, 2 wooden, tonnage 232. Dundee, 2 iron, tonnage, 998; 3 wooden, tonnage 853; 3 composite, tonnage, 2,284; 2 iron steam vessels, tonnage 1,200; 2 wooden steam vessels, tonnage 662—total, 12 vessels of 5,997 tons. Glasgow, 17 iron tonnage, 11,168; 7 wooden, tonnage 966; 10 composite, tonnage 6,778; 85 iron steam vessels, tonnage 47,816; 2 composite steam vessels, tonnage 1,406—total, 121 vessels of 68,134 tons. Grangemouth, 2 wooden, tonnage 279; 1 composite, tonnage 674—total, 3 vessels of 953 tons. Granton, 1 wooden, of 99 tons. Greenock, 3 iron, tonnage 3,614; 4 wooden, tonnage 354; 1 composite, tonnage 879; 10 iron steam vessels, tonnage 9,429—total 18 vessels of 14,276 tons. Inverness, 5 wooden, tonnage 1,034 Kircaldy, 2 iron steam vessels of 1,934 tons. Kirkwall, 1 wooden, tonnage 97. Montrose, 7 wooden, of 1,563 tons. Perth, 14 wooden of 2,644 tons. Peterhead, 8 wooden of 1,320 tons. Port-Glasgow, 8 iron of 6,041 tons; 16 iron steam vessels of 4,648 tons—total, 24 vessels of 10,689 tons. Troon, 1 wooden 1,113 tons. Wigtown, 2 wooden vessels, tonnage 472.

## STEAM SHIPPING.

**Steam Shipbuilding on the Clyde.**—Messrs. Randolph, Elder, and Co., have launched from their yard at Fairfield, Govan, a screw of 687 tons, builder's measurement, and 180 horse-power nominal. The dimensions of the *St. Clair* are as follows:—Length over all, 217ft.; breadth, 26ft. 6in.; and depth (moulded), 15ft. The *St. Clair* has been built to the order of the Aberdeen, Leith, and Clyde Shipping Company, Aberdeen, and she is intended for the Leith, Aberdeen, Orkney, and Shetland trade. She is fitted by Messrs. Randolph, Elder, and Co., with engines on their patent double cylinder expansion principle. Messrs. Randolph, Elder, and Co., have contracted to build two screws of 2,500 tons each, to ply direct between Liverpool and Valparaiso. Messrs. R. Napier and Sons have launched a twin-screw Monitor, built by them for the Dutch Government, and of 1,600 tons burden, builder's measurement. The dimensions of this Monitor are as follows:—Length over all, 187ft. breadth, 44ft.; depth, 11ft. 6in. The armour-plating on the sides of the vessel is 5½in. thick, with 10-inch teak backing, and an iron inner skin 1in. thick, supported by strong iron frames. The turret is on Captain Coles' system, plated with 8in. of armour, with 12-inch teak backing on a 1-inch inner skin. The vessel, which has been named the *De Tyger*, is to be armed with two 300-pounder 12½-ton Armstrong guns. The engines, which are also by Messrs. Napier, are of 140 horse-power nominal.

## LAUNCHES.

The double screw gun-vessel *Seagull*, 3, was launched at Devonport dockyard on the 7th ult. She measures 663 tons, is 170ft. long, 29ft. broad, and has a depth of hold of 12ft. 5in. Her engines will be 160-horse power nominal. The *Seagull*, like her sister gunboat, the *Lapwing*, in the same yard, is built of wood with iron stringer plates on the beams, for the purpose of obtaining increased strength. Immediately after being launched the *Seagull* was removed into the basin, ready for being placed in dock, where she will be coppered.

A **gunboat**, one of eight building in private yards for the Admiralty, was launched from the iron shipbuilding yard of Messrs. Richardson and Duck, Stockton, on the 10th ult. She is named the *Hornet*, and has been built from the designs of Mr. E. J. Reed. Her dimensions are—length between perpendiculars, 155ft; breadth, moulded, 25ft.; depth, 14ft. 2in.; burden, in tons, 463 88-94. She is a composite vessel, having iron frames, beams, &c., covered with two thicknesses of teak planking, the whole of the fastenings being of brass and copper. She is barque rigged. Her armament will consist of two guns, one 100-pounder and one 64-pounder. Her machinery consists of two pairs of horizontal trunk engines, with three boilers of the nominal power of 120 horses. She is on the twin-screw principle, one pair of engines driving each propeller, the latter being of gun-metal, and of the form known as Griffith's patent. The *Hornet* is for the Indian service, and when fully equipped will only draw 7ft. water.

## TELEGRAPHIC ENGINEERING.

**Belgian Telegraphs.**—The telegraphic systems of Belgium, which are managed by the State, have now been established 16 years, and the cost of their establishment has been entirely covered by the surplus receipts. The annual cost of the service is about 840,000f.; but this sum does not strictly represent all the cost of administration, inasmuch as many buildings occupied and much assistance rendered by the railway and Post-office *employés* should be included in the general estimate. But, on the other hand, the telegraph gives to the other departments more than it borrows from them, for, according to returns for the year 1866, it appears that out of nearly 312,000 official messages transmitted during the year 28,000 only were on account of the telegraph service itself. There are 106 telegraphic-offices in operation in the stations of the State railways, 50 of which are used almost exclusively by the various departments of the Government, and very seldom indeed by the public. The night service also, which is managed by a staff of 15 clerks, is seldom required for other than messages in connection with passengers' and goods' trains, so that, in fact, it is difficult to estimate the total cost of the service, inasmuch as it receives and gives in return benefits that could not be obtained on equally advantageous terms elsewhere. During the years 1864, 1865, and 1866 the inland messages cost more than they produced, and it was found that all the profit which had accrued arose from international messages—for inland messages require two sets of operations, international messages one set of operations only, and a message in transit merely requires re-transmission, without any cost for receipt or delivery. The tariff for an inland message is now reduced to half a franc, which involves a present sacrifice that could not have been borne unless the result of the first ten years had been superlatively prosperous. The real net profit of the year 1866 amounted to more than 122,000f., and it is anticipated by the administrators that a reduction will shortly take place in the cost of working and on the average loss on each inland message, and that an increase of profit will obtain on each international or transit passage.

## RAILWAYS.

**Railways in America.**—From a recent report of the Commissioner of the General Land Office, it appears that the construction of railroads in America since their first introduction, has been at the rate of thousand miles a year; and that there are now completed no less than 37,000 miles, and in course of construction 17,860 miles additional, or more than one-third the length of all the railroads in the world. To assist this wonderful development, Government has contributed 184,000,000 dollars, and 800,000 acres of land.

## LATEST PRICES IN THE LONDON METAL MARKET.

| | From | | | To | | |
|---|---|---|---|---|---|---|
| | £ | s. | d. | £ | s. | d. |
| **COPPER.** | | | | | | |
| Best selected, per ton | 79 | 0 | 0 | 81 | 0 | 0 |
| Tough cake and tile do. | 76 | 0 | 0 | 78 | 0 | 0 |
| Sheathing and sheets do. | 82 | 0 | 0 | 83 | 0 | 0 |
| Bolts do. | 83 | 0 | 0 | ,, | ,, | ,, |
| Bottoms do. | 86 | 0 | 0 | 88 | 0 | 0 |
| Old (exchange) do. | 68 | 0 | 0 | 70 | 0 | 0 |
| Burra Burra do. | 83 | 0 | 0 | 83 | 10 | 0 |
| Wire, per lb. | 0 | 1 | 0 | ,, | 1 | 0½ |
| Tubes do. | 0 | 0 | 11½ | 0 | 1 | 0 |
| **BRASS.** | | | | | | |
| Sheets, per lb. | 0 | 0 | 9 | 0 | 0 | 10 |
| Wire do. | 0 | 0 | 8½ | 0 | 0 | 9½ |
| Tubes do. | 0 | 0 | 10½ | 0 | 0 | 11 |
| Yellow metal sheath do. | 0 | 0 | 7¼ | ,, | ,, | |
| Sheets do. | 0 | 0 | 7 | ,, | ,, | ,, |
| **SPELTER.** | | | | | | |
| Foreign on the spot, per ton | 20 | 5 | 0 | 20 | 7 | 6 |
| Do. to arrive | 20 | 5 | 0 | 20 | 7 | 6 |
| **ZINC.** | | | | | | |
| In sheets, per ton | 25 | 10 | 0 | 26 | 0 | 0 |
| **TIN.** | | | | | | |
| English blocks, per ton | 96 | 0 | 0 | ,, | ,, | ,, |
| Do. bars (in barrels) do. | 97 | 0 | 0 | ,, | ,, | ,, |
| Do. refined do. | 99 | 0 | 0 | ,, | ,, | ,, |
| Banca do. | 93 | 0 | 0 | 94 | 0 | 0 |
| Straits do. | 91 | 10 | 0 | ,, | ,, | ,, |
| **TIN PLATES.*** | | | | | | |
| IC. charcoal, 1st quality, per box | 1 | 7 | 0 | 1 | 10 | 0 |
| IX. do. 1st quality do. | 1 | 13 | 0 | 1 | 16 | 0 |
| IC. do. 2nd quality do. | 1 | 5 | 0 | 1 | 7 | 0 |
| IX. do. 2nd quality do. | 1 | 11 | 0 | 1 | 13 | 0 |
| IC. Coke do. | 1 | 2 | 0 | 1 | 4 | 0 |
| IX. do. do | 1 | 8 | 0 | 1 | 10 | 0 |
| Canada plates, per ton | 13 | 10 | 0 | ,, | ,, | ,, |
| Do. at works do. | 12 | 10 | 0 | ,, | ,, | ,, |
| **IRON.** | | | | | | |
| Bars, Welsh, in London, per ton | 6 | 5 | 0 | ,, | ,, | ,, |
| Do. to arrive do. | 6 | 5 | 0 | ,, | ,, | ,, |
| Nail rods do. | 6 | 15 | 0 | 7 | 0 | 0 |
| Stafford in London do. | 7 | 7 | 6 | 8 | 10 | 0 |
| Bars do. do. | 7 | 7 | 6 | 8 | 10 | 0 |
| Hoops do. do. | 8 | 7 | 6 | 9 | 12 | 6 |
| Sheets, single, do. | 9 | 2 | 6 | 10 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 5 | 7 | 6 | 5 | 10 | 0 |
| Do. mrch. Tyne or Tees do. | 6 | 10 | 0 | ,, | ,, | ,, |
| Do. railway, in Wales, do. | 5 | 5 | 0 | 5 | 10 | 0 |
| Do. Swedish in London do. | 10 | 0 | 0 | 10 | 5 | 0 |
| To arrive do. | 10 | 0 | 0 | 10 | 5 | 0 |
| Pig No. 1 in Clyde do. | 2 | 13 | 0 | 2 | 18 | 0 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | ,, | ,, | ,, |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 7 | 0 | 0 | 7 | 10 | 0 |
| **STEEL.** | | | | | | |
| Swedish in kegs (rolled), per ton | 14 | 5 | 0 | ,, | ,, | ,, |
| Do. (hammered) do. | 15 | 5 | 0 | 15 | 10 | 0 |
| Do. in faggots do. | 16 | 0 | 0 | ,, | ,, | ,, |
| English spring do. | 17 | 0 | 0 | 23 | 0 | 0 |
| Quicksilver, per bottle | 6 | 17 | 0 | ,, | ,, | ,, |
| **LEAD.** | | | | | | |
| English pig, common, per ton | 19 | 10 | 0 | ,, | ,, | ,, |
| Ditto. L.B. do. | 19 | 15 | 0 | ,, | ,, | ,, |
| Do. W.B. do. | 21 | 10 | 0 | ,, | ,, | ,, |
| Do. sheet, do. | 20 | 5 | 0 | ,, | ,, | ,, |
| Do. red lead do. | 20 | 15 | 0 | ,, | ,, | ,, |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 10 | 0 | 23 | 0 | 0 |
| Spanish do. | 18 | 10 | 0 | 18 | 15 | 0 |

* At the works 1s. to 1s. 6d. per box less.

## 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 February 18th, 1868.

539 W. Weild—Treating sewing threads, &c.
540 W. Betts—Trade marks
541 H. Chamberlain—Compressed bricks

### Dated February 19th, 1868.

542 J. Higginbotham and L. Moore—Machinery for turning, &c.
543 T. Beeley—Improvements in keirs
544 R. Blezard—Cleaning wheat
545 J. Kirkland—Pumps
646 E. Wright—Apparatus applicable to steam boiler and other furnaces
547 W. Cooke and J. Cooke—Irons
548 E. W. Young—Bridges
549 J. J. King—Sewing machines
550 W. H. Steel—Hand saws
551 W. Edwards—Roughening the shoes of horses
552 R. P. Faucheux—Reels or bobbins
553 W. E. Lake—Seasoning wood
554 G. B. Dodge—Valves
555 G P. Dodge—Packing for the stuffing boxes of steam engines
556 F. H. Renault—Combined umbrella and walking stick
557 J. G. Jones—Machinery for exhausting air
558 W. S. Guinness—Sewing machines
659 J. Lord—Coupling and uncoupling railway carriages
560 L. B. Joseph—Wheels and tyres
561 M. Henry—Nails
562 W. Myers—Lockets

### Dated February 20th, 1868.

563 P. Bauer, J. Johnson, and W. Jones—Lubricating revolving shafts
564 J. M. Kilner—Compartment bedsteads, &c.
665 W. Weldon—Manufacture of chlorine, &c.
566 P. N. Goux—Collecting and disinfecting human excreta, &c.
567 J. H. Johnson—Increasing the draught in steam boilers
668 J. Hullett—Aeronautical apparatus
569 J. G. Tatters, W. Keeble, and B. Newbery—Cigars
570 T. A. L Murray—Rails for tramways
571 W. E. Newton—Mechanical movements adapted for use in watches and clocks
572 G. Davies—Taps
573 W. R. Lake—Shearing
574 W. R. Lake—Stoves for heating air
575 R. Fennelly and P. Kenny—Singeing off the hairs, &c., on pigs

### Dated February 21st, 1868.

576 G. Davies—Manufacture of gas
577 G. A. Bridgett—Slide valves, &c.
578 L. M. Becker—Indicating the position and supply of fire plugs
589 C. Cochrane—Blast furnaces
580 W. Thompson and T. Statber—Washing and drying grain
681 H. Walmsley and T. Walmsley Taylor—Apparatus to register the number of persons entering into and on omnibuses
582 M. A. F. Mennons—Bristle brushes
583 T. Altham, J. Clark, and S. Ridehalgh—Sizeing yarn
584 T. Bury and J. R. Bury—Shuttles
585 J. Wheatley—Improved chimney pot
586 A. V. Newton—Reaping and mowing machines
587 W. Wilson—Lubricating the sliding valves and pistons of steam engines

### Dated February 22nd, 1868.

588 A. De Metz—Commode pots
689 R. B. Mitchell—Plane irons, &c.
590 J. McCall—Preserving meat
591 C. J. Galloway—Wrought iron and steel piles
592 W. R. Lake—Supplying type forms with various coloured inks for each impression
593 J Needham—Fastenings for gloves
594 A. V. Newton—Improvements applicable to steam boilers
695 J. J. Aston—Propulsion of ships
696 B. E. R. Newlands—Treating spent oxide of iron
597 W. H. Ryland—Fastenings for articles of dress
598 F. Sangster—Parasols and umbrellas
599 W. R. Lake—Signal apparatus
600 S. Firth—Cutting coal
601 E. J. Nicoll and T. M. Ablett—Springs for boots
602 W. Kruizsch—Machines for washing
603 R. Heathfield—Cut nails

### Dated February 24th, 1868.

604 H. Chamberlain, J. Craven, and H. Wedekind—Burning bricks, &c.
605 J. W. Watts—Preparing vegetable fibres
606 A. Stenger—Umbrellas
607 P. H. Hancock and J. P. French—Printing machines
608 J. S. Gisborne—Apparatus for indicating a ship's course
609 J. Macintosh and W. Boggett—Elastic goods
610 J. Fordred, F. Lambe, and A. C. Sterry—Treatment of paraffine
611 W. E. Newton—Illuminating gas
612 R. Nicholls—Combined material for fabric
613 G. S. Drscopulo—Apparatus for raising water
614 W. R. Lake—Steam boilers
615 R. Bodmer J. J. Bodmer, and L. R. Bodmer—Artificial stone
616 W. R. Lake—Artificial breasts

### Dated February 25th, 1868.

617 H. Defries—Opal or glass lamp
618 J Vevers—Spinning and twisting machinery
619 F. Le Roy—Non-conducting composition
620 J. Elce—Lubricating spindles
621 E. T. Hughes—Hoop skirts
622 E. Hutchinson—Drilling machines
623 E. Hutchinson—Planing machines
624 G. W. R. Pigott—Coated wire
625 J. Dobbs and W. Dobbs—Ventilation of hats
626 J. J. Harrison and E. Harrison—Healds of looms
627 J. C. Cavies and E. Zahn—Muffs
628 F, Remy—Steel seat
629 J. McLeod—Washing yarns
630 J. T. Kent—Mattresses
631 O. Ollivier—Exhibiting advertisements
632 J. L. Jaquet—Heels for boots
633 C. Pieper—Wood for the manufacture of paper
634 G. T. Bousfield—Raising water
635 C. Pieper—Reaping machines
636 R. Kerr—Heating conservatories
637 A. M. Birchall—Twist tobacco
638 R. Ramsey and J. Cooke—Signal indicators

### Dated February 26th, 1868.

639 G. C. Mackrow—Batteries for ships
649 T. Lythgoe and H. Thornton—Construction of walls, &c.
641 L. Pocock—Bookbinding
642 T. Hill—Bearings for axles
643 R. Laidlaw and J. Thomson—Apparatus for exhausting gas
644 E. R Walker—Transmitting motive power to potters' machinery
645 W. E. Gedge—Machine intended to divide, break, or crush all substances capable of being triturated, for converting them into manure
646 J. Perrett—Bottles
647 A. V. Newton—Electro-magnetic apparatus
648 F. Lambe and A. C. Sterry—Purifying hydrocarbon oils
649 F. Mittonette—Furnace doors
650 W. E. Newton—Washing machine
551 W. Dowell—Locks
652 R. Gaunt and J. W. Gaunt—Spinning and twisting machinery

### Dated February 27th, 1868.

653 F. Wirth—Pedals for pianofortes
654 F. Dumas—Bathing dresses, &c.
655 J. R. Cooper—Breech-loading firearms
956 R. A. Hope—Machine for adding sweetening to aerated and other beverages
657 T. Blocksage—Construction of boilers
658 C. C. Walker and W. T. Walker—Centre valves
659 R. E Green—Cotton yarns
660 L. Boyce—Raising Venetian blinds
661 J. B. Whiteley—Stretching or drying woven fabrics
662 W. Weldon—Regeneration from chlorine residues of oxides of manganese
663 J. Adams and H. Barrett—Stopper for bottles
664 W. E. Newton—Construction of boats
665 W. E. Newton—Pens and pen holders
666 J. Petrie—Washing wool
667 J. H Bass—Double cans
668 W. M. Bollivant—Preventing the fouling of ships' bottoms
669 G. Eldridge and W. C. Loe—Stoppering bottles
670 G. Hart—Prevention of smoke

### Dated February 28th, 1868.

671 J. Christie—Lithographic printing machine
672 R Mills—Machines for washing
673 J. Livesey—Coupling, &c., wheels on railways
674 J. G. Stidder—Waterclosets
675 A. Southwood Stocker—Caps for bottles
676 R. Howard—Taps
677 C. E. Brooman—Moulds
678 J. Leacock—Paving for streets
679 J. Robinson—Cleaning and preventing deposits upon feed-water heating apparatus
680 J. Dunkerley—Hats
681 G. Thomas—Sewing machines
682 T. Warren—Glass furnaces
683 J. F. Low—Preparing jute
684 T. Trotman—Doubling-up carriages
685 W. E. Newton—Drying felted goods
686 C. Sanderson—Iron and steel
687 T. S. Whilock and H. Harford—Fastenings for window sashes
688 J. Gjera—Homogeneous iron

### Dated February 29th, 1868.

689 C. Cochrane—Blast water tuyeres
690 E. Baker—Screw bolts
691 H. B. Wilder—Electric telegraph apparatus
692 J. Collins—Filling cartridge cases
693 L. C. Detouche—Omnibus indicator
694 J W. McC rter—Heating the feed-water of steam-engine boilers
695 G. Lindsley—Applying motive power
696 W. Smith, J. Giddings, and J. Rank—Fire escape
697 A. H. Hill—Labels
698 R. Zwez—Improved can
699 J. L. Norton—Sinking wells
700 W. Barford—Raising and stacking straw
701 B. Solomons—Telescopes
702 L. B. Schmolle—Skeleton skirts

### Dated March 2nd, 1868.

703 W. J. Armstrong and C. Browne—Anchors
704 H. Wilson—Meters
705 L. Roman—Motive power from rivers
706 W. Rollo—Waterclosets
707 J. Rawsthorn—Dressing millstones
708 W. E. Newton—Burning hydrocarbons
709 F. Neiber—Fastenings for glove boxes
710 T. Horsley—Breech-loading firearms
711 S. Sharrock—Construction of piles
712 A. Smith—Axle boxes

### Dated March 3rd, 1868.

713 A. A. Usher—Respirators
714 W. E. Gedge—Mineral paperhanging
715 C. Cochrane—Valves
716 H. P. Reynoldson—Portfolios
717 F. Moss—Registering passengers travelling by public vehicles
718 J. Barker—Consuming smoke
719 T. Bisset—Mowing machines
720 W. B. Thompson and W. Gall—Winding yarns
721 J. A. Haswell and G. Brown—Signal apparatus
722 J. Manly—Nails
723 W. Spence—Making nails
724 H. Zox—Hats and caps
725 W. Whittle—Steam engines and boilers
726 J. Dewar—Preserving blood
727 G. Anderson—Moulding substances for artificial fuel
728 E. Burton—Screening coals
729 H. Kennedy—Cutting files
730 S. A. Bell—Match boxes
731 T. Johnson—Treating ores, &c.
732 J. W. Harrison and C. R. Harrison—Parallel rules
733 B. W. Sleigh—Hydrostatic engines
734 J. A. Lee—Cutting wood
735 I. W. Nasarow—Iron and steel

### Dated March 4th, 1868.

736 F. Cadby—Canet frames
737 S. Jeffries—Securing, adjusting, and arranging cords, &c.
738 T. Smith, T. Wood, and T. Don—Preparing, &c., wheat
739 A. Cole and J Carter—Lamps
740 E. Clifton—Door handles
741 J. Lewthwaite—Treating parkesine
742 H E. Smith—Hauling gear of engines
743 A. M. Clark—Paving roads
744 W. K. Stuart—Utilising sewage
745 J. G. Kincaid—Propelling apparatus
746 W. Mitchell and T. Mitchell—Carpeting
747 G. Davies—Gas
748 C. Scholefield—Hanging window sashes
749 J. Askew—Hook and eye
750 J. Brigham and R. Bickerton—Reaping and mowing machines
751 I. Cole—Sewing machines
762 C. R. Rockley—Pipes for smoking tobacco
753 C. Schinz—Process for the partial elimination of the nitrogen from the products of combustion
754 A. V. Newton—Measuring spirituous liquors

### Dated March 5th, 1868.

755 F. T. Baker—Cartridge cases
756 J. J. F. Stevens—Signal apparatus
757 J. Hammersley—Chronometer boxes
758 H. A. Dufrene—Capsules
759 W. Hont—Treating certain compounds, &c.
760 W. R. Lake—Preparing soles
761 W. E. Gedge—Steam engines
762 J. Westry and J. Forster—Drilling
763 J. Hartshorn—Twist lace machines
764 J. L. Clark—Galvanometers
765 C. H. Goold—Single or combined rivets
766 J. B. Fell—Locomotive engines, &c.
767 H. Drake—Essences
768 H. Conybeare—Rails
769 A. V Newton—Cultivating land
770 A. M. Clark—Steam pumps
771 J. Dickson—Lubricators

### Dated March 6th, 1868.

772 D. Price—Improved comb
773 I. L. Pulvermacher—Apparatus for producing, applying, and ascertaining the power of electric currents
774 J. Brinsmead—Pianofortes
775 J. M. Stanley—Furnaces
776 T. Whittaker—Waterproof paper
777 J. Eastwood—Sizing yarn
778 G. Haoxwell and J. Ryder—Preparing hard foreign wheat
779 W. Langwell and H. Spring—Bottles
780 J. Watson—Blast furnaces
781 T. Atkins—Apparatus to facilitate swimming
782 T. Atkins—Extinguishing fire
783 T. Atkins—Feeding bottles
774 J. Parker—Obtaining motive power
784 J. Houston—Candles
786 J. G. Tongue—Steam boilers

### Dated March 7th, 1868.

787 H. Hargreaves—Looms
788 J. Campbell—Floating docks
789 S. Brown—Ornamenting bottles
790 R. Leake and R. Platts—Machinery for etching
791 H. Symons—Fire guards
792 H. Simmonds—Hulling cotton
793 C. E. Brooman—Combing machinery
794 A. C. Kirk—Cast iron
795 W. Berry—Foot steps for upright spindles
796 R. Tooth—Evaporation of liquids
797 R M. Chevalier—Venetian blinds
798 J. Thompson and J. Thompson—Fixing door knobs
799 W. H. Warner and R. C. Murray—Stereoscopes
800 W. W. Greener—Breech-loading guns
801 F. J. Baynes—Ranges
802 E. Casper—Raising and forcing liquors
803 P. Koch—Metallic nuts

### Dated March 9th, 1868.

804 H. Michael Lee—Cases
805 J. Jeavons—Tyres
806 W. Hartley—Preparing yarn
807 H. B. Barlow—Carding fibres
808 C. D. Abel—Screw bolts
809 L. Blumfield—Cigar tubes
810 A. F. Baird—Earth closets
811 W. Pidding—Pockets in gloves
812 H. Willis—Organs
813 P. W. Barlow—Constructing tunnels
814 E. Morewood—Coating metal plates
815 W. H. Halsey—Making articles from hard rubber, &c.
816 A. M. Clark—Freezing liquids
817 P. F. Halbard—Stench traps
818 W. R. Lake—Treatment of fibrous materials

### Dated March 10th, 1868.

819 J. Slater—Heating feed water
820 W. B. Kinsey—Coal gas
821 C. D. Abel—Colouring matter
822 S. Desborough—Cleaning knives
823 J Jones—Finishing bars of iron
824 R. Meldrum—Raising water
825 J. G. Douglas—Valve motions
826 J. Vero—Hats
827 A. Bourdon—Weaving
828 A. V. Newton—Lubricating machinery
829 J. Wallis—Dressing millstones
830 C. Attwood—Steel and iron
831 H. E. Smith—Engines and boilers
832 R. Cocker—Treatment of flax, &c.

### Dated March 11th, 1868.

833 S. Brooks—Preparing cotton
834 E. Broadbent and J. Broadbent—Paper bags
835 F. Winser—Utilisation of the waste products arising from esparto grass
836 F. Winser—Sulphate of magnesia
837 B. Browne—Girders or rails
838 T. Walker—Telegraph cables
839 S. Naylor—Raising water
840 M. T. Shaw and T. H. Head—Rolling iron
841 P. Lennox—Beaming hides
842 W. Hawthorn—Steam generators

### Dated March 12th, 1868.

843 F. A. Paget—Ships' compasses
844 J. Bourne—Auxiliary propulsion
845 F. Ryland—Pulleys
846 W Thompson—Iron castings
847 H. Fletcher—Motive power
848 W. A. Lyttle—Supplying boilers with water
849 W. E. Bush and F. A. Bush—Trap
850 T. Barnes—Preparing rovings from waste
851 A. P. Stephens—Vises
852 J. Hodgeson—Signals
853 W. E. Newton—Ballasting vessels
854 A. Geary and E. Geary—Cinder sifters
855 B. Britten—Manure

### Dated March 13th, 1868.

856 E. K. Dutton, J. Holme, and H. Holme—Sewing machines
857 J. H. Maw—Lamps
858 S. Bates and W. Redgate—Lace machines
859 A. Taylor—Brakes
860 G. F. Lyndon—Rotating shafts
861 M. Rowand—Fermented liquors
862 W. McNaught—Steam engines
863 C. S. Moller—Side weapon
864 H. Kershaw—Spinning
865 C. R. Broadbent—Hats
866 S. H. Salom and T. Field—Clipping or shearing
867 J. Betteley—Sheet metal, &c.

### Dated March 14th, 1868.

868 W. G. Beattie—Steam pistons
869 S. Holness—Speaking tubes
870 N. Jacobsohn—Letter-box
871 W. Bellhouse and R. Ashworth—Carding machines
872 J. B. Handyside—Supplying springs to railway rolling stock
873 J. P. Knight—Indicating lamp
874 J. Petrie—Washing wool
875 F. Mulliner—Apparatus to be used in connection with the poles of carriages
876 J. Clay—Harness
877 J. Cartea—Nails and spikes
878 W. A. Lyttle—Closing boxes
879 P. F. Cubault—Boots and shoes

### Dated March 16th, 1868.

880 J. Norman—Dressing millstones
881 E. V. de Forville—Crushing and sifting flour
882 A. Baumann—Rotary engines
883 T. S. L Beech—Engines
884 H. F. Griffiths and A. Beard—Puddling iron
885 W. Arthur and W. Arthur—Support and cure of hernia
886 H. A. Bonneville—Looms
887 H. A. Bonneville—Permanent way
888 H. A. Bonneville—Cartridges
889 F. H. Elliott and C. A. Elliott—Telescopes
890 D. Greig—Traction engines
891 W. E. Newton—Gas
892 W. E. Newton—Telegraphic apparatus
895 J. Murray and R. Warden—Lamps
894 J. H. Johnson—Wheels
895 P. J. Livsey—Combing cotton
896 J. S. Gee—Ornamenting slate

### Dated March 17th, 1868.

897 R. Sims—Horse rakes
098 R. Smith—Extracting foul air from mines
899 W. Hulse and E. Williams—Metallic bedsteads
900 C. Womersley—Lubricator
901 W. E. Gedge—Improved fuel
902 Sir J. Macneill—Indicating apparatus
903 P. M. Villamil—Apparatus to facilitate the ascending of gradients by locomotive engines
904 H. H. Hazard—Revolving shutters
905 W. R Lake—Hair stuffing
906 J. M Poisuel—Straps
907 J. Thompson—Shaping wood
908 J. M. Poisuel—Coverings for the feet
909 W. E. Newton—Producing steel
910 W. E. Newton—Furnaces
911 W E. Newton—Measuring and administering medicine
912 J F. Spencer—Working the valves of steam engines

### Dated March 18th, 1868.

913 J. M. Ure—Lifting the driving wheels of a locomotive off the rails

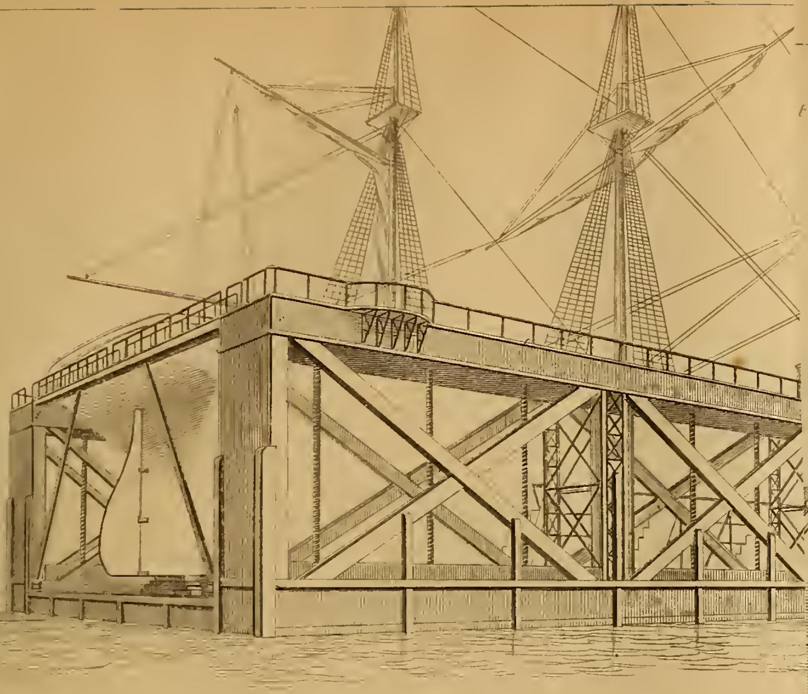
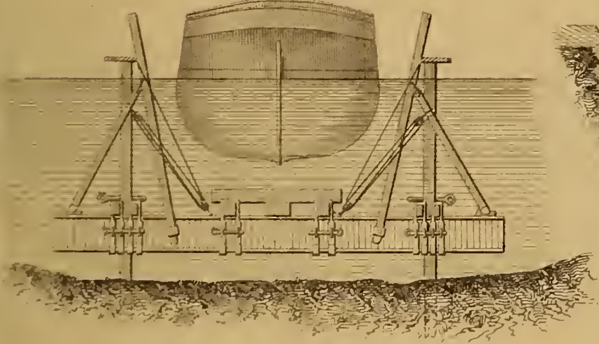


Fig. 3.



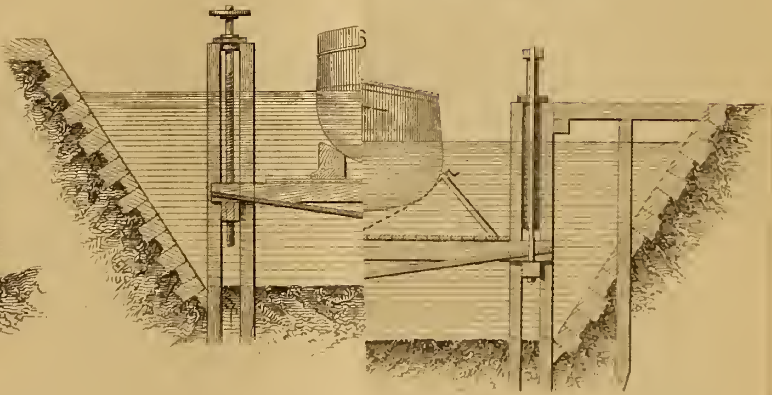


Fig. 7.

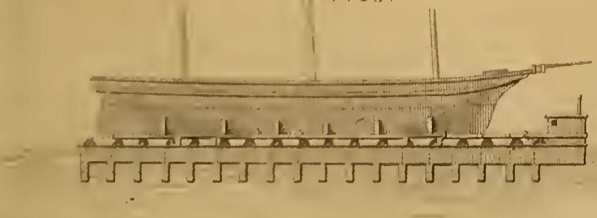


Fig 12

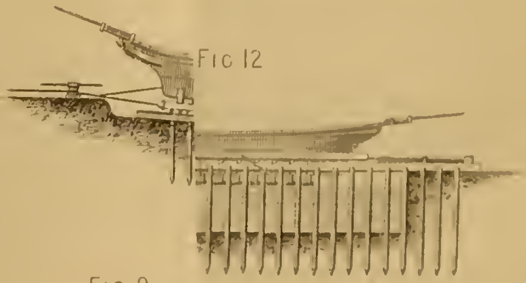


Fig 13

Fig 9

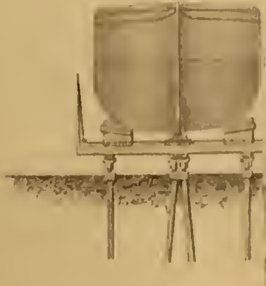


Fig 18

# DESIGNS FOR FLOATING DOCKS, SLIPS, &c.

Fig. 1.

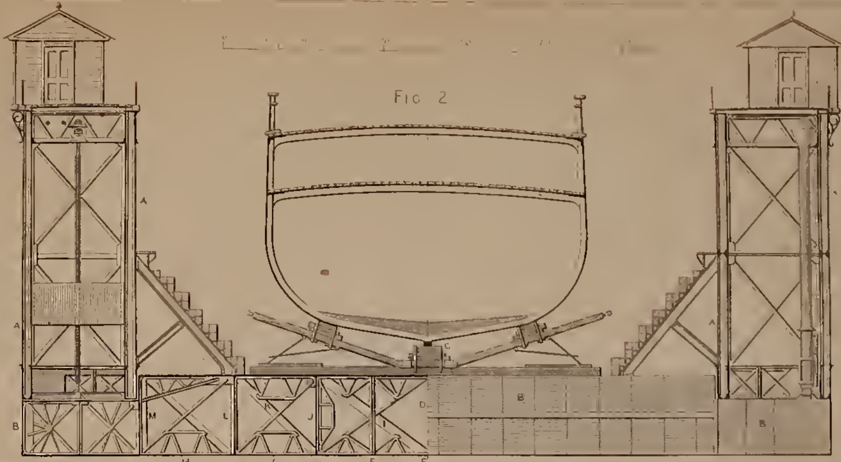


Fig 2

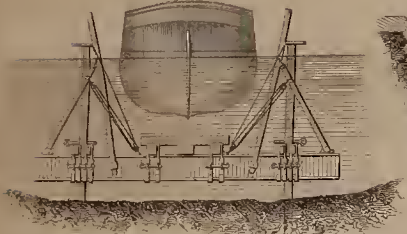


Fig. 3.

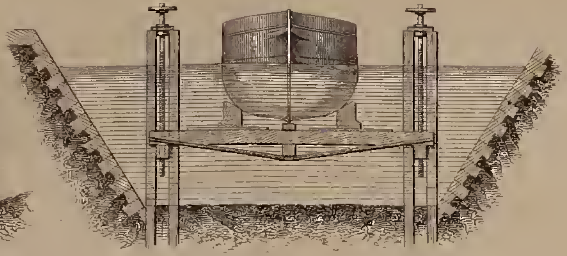


Fig. 4.

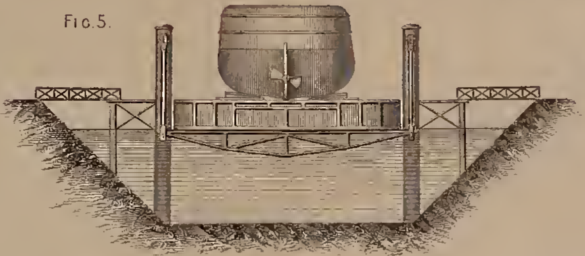


Fig. 5.

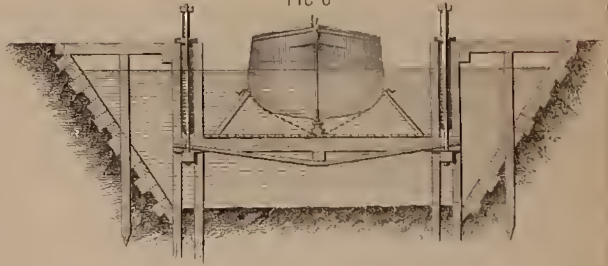


Fig 6

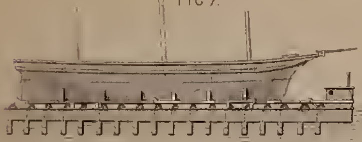


Fig 7.

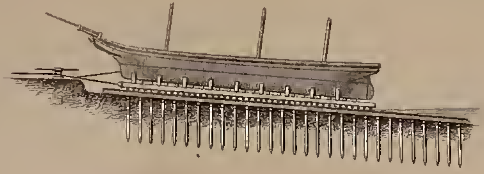


Fig. 8

Fig. 11.

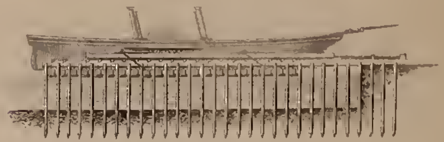


Fig 12

Fig 13

Fig. 9.

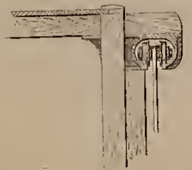


Fig. 10.

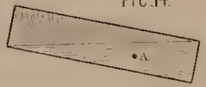


Fig. 14.

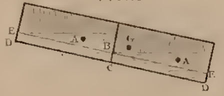


Fig. 15

Fig 16.

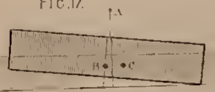


Fig. 17.

Fig 18

# THE ARTIZAN.

No. 5.—Vol. II.—Fourth Series.—Vol. XXVI. From the Commencement.

1st. MAY, 1868.

## THE LONDON COAL TRADE.

According to the official return published by the clerk and registrar of the coal market, the quantity of coals sent to the London market during the year 1867 was 6,329,550 tons, showing an increase in the supply of 5 per cent. over the year 1866; the report further informs us that 3,016,416 tons came by sea, and 3,313,134 tons by railway.

Upon going carefully through the report, we ascertain that one-half of this quantity is for household use, the remainder for gas, steamboats, and manufacturing purposes.

The average price of best coals in 1867 has been 25s. per ton, but, as few people purchase best coals, we will take the price at 22s. per ton; at that figure we come to the knowledge that the householders in London have paid in one year the enormous sum of £3,681,878 sterling for coals.

In these co-operative times, we think if reform and retrenchment is wanted in the establishment of *Paterfamilias*, it is certainly in his coal account.

Perhaps some of our readers will say, how is this to be remedied? We will give two statements, showing the expense of coals by sea and railway, and then proceed to suggest the remedy.

| | | | | | | |
|---|---|---|---|---|---|---|
| 300 tons of best coals bought at market, at 19s.[*] | £287 | 10 | 0 | | | |
| Less market allowances | 7 | 1 | 0 | | | |
| | | | | £280 | 9 | 0 |
| Lighterage, 1s. per ton on 300 tons | | | | 15 | 0 | 0 |
| Loading 270 tons into wagons and barge at 1s. per ton | | | | 13 | 10 | 0 |
| Sifting 30 „ small 1s. 8d. per ton | | | | 2 | 10 | 0 |
| Carting 270 „ large, 2s. per ton | | | | 27 | 0 | 0 |
| Turning 30 „ small into barge, 9d. per ton | | | | 1 | 2 | 6 |
| Lighterage 30 tons small 9d. per ton | | | | 1 | 10 | 0 |
| Wharf rent, salaries, taxes, &c., 9d. per ton | | | | 11 | 5 | 0 |
| | | | | £348 | 11 | 6 |
| Less 30 tons small, sold at 10s. per ton | | | | 15 | 0 | 0 |
| | | | | £333 | 11 | 6 |

By Railway:—

| | | | |
|---|---|---|---|
| 300 tons of best coals at pit's mouth, at 9s. per ton | £135 | 0 | 0 |
| City dues 1s. 1d. per ton on 300 tons | 16 | 5 | 0 |
| Railway dues 7s. „ „ | 105 | 0 | 0 |
| Truck hire 1s. „ „ | 15 | 0 | 0 |
| Loading 292 tons large into wagons, 1d. per ton | 1 | 4 | 4 |
| Loading 8 tons small into wagons, 9d. per ton | 0 | 6 | 0 |
| Carting 300 tons large and small at 2s. per ton | 30 | 0 | 0 |
| Wharf expenses, salaries, &c., 9d. per ton | 11 | 5 | 0 |
| | £314 | 0 | 4 |
| Less 8 tons small, sold at 12s. per ton | 4 | 16 | 0 |
| | £309 | 4 | 4 |

From the above statements, it will be seen that coals by sea cost £1 4s. 9d. per ton and by railway, £1 1s. 2d. per ton, being a difference of 3s. 7d. per ton, which on 3,347,162 tons, amounts to £604,699 18s.

Some years ago it was proposed to construct a railway from the North to London, purely for coal traffic; the promoters of the scheme visited Newcastle, and had an interview with the committee of the coal mines. They requested a celebrated coal viewer, now deceased, to report upon the proposal. His report was unfavourable[*], and so the idea was abandoned, but since then the coal owners of the North have had reason to see the fallacy of the report, and are now fully alive to the advantage it would be to them to have a coal railway direct to London, and would assist by every means in their power the construction of such, as it would enable them to compete with the Yorkshire and other inland coal owners. It is true at present a portion of the coals that come by railway are from the North, but the quantity[†] is not worth notice; the Inland Coal owners having occupied the ground before their northern brethren became aware of the advantage of the railway system for carrying coals, and have taken care to keep possession of the position their foresight had given them, therefore it is time to renew the idea of a coal railway for London. The situation of the best coal field in Durham is 270 miles distant from the metropolis; the following few figures will show that if a railway could be made for £10,000 per mile (and we see no reason why it should not) to convey coals at 7s. per ton, it would leave a very good dividend besides benefiting the householder in London, by enabling him to have best coals fresh wrought and large—a blessing he very seldom enjoys.

| | | | |
|---|---|---|---|
| 270 miles of railway at £10,000 per mile | 2,700,000 | 0 | 0 |
| Trucks, engines, &c. | 300,000 | 0 | 0 |
| | £3,000,000 | 0 | 0 |
| 2,000,000 tons of coals at 7s. per ton | 700,000 | 0 | 0 |
| Working expenses 35s. per cent. | 245,000 | 0 | 0 |
| | £455,000 | 0 | 0 |

or rather more than 15 per cent.

It may be said the working expenses of the different existing railways are much greater than are here given, that we admit, but the expenses of working a coal railway is very different to a passenger line, no large staff of servants is necessary to wait the arrival and the departure of the trains, two or three men would discharge a local train in a few minutes, and dispatch it on its return journey.

Again it may be said that experience proves that railways have not been made at the estimate herewith given, we quite agree with that fact, but then we have the advantage of all the dear bought experience in reference to construction, gradients, and curves, and further no magnificent stations are necessary for a local railway, but simply a hopper or store to which the wagons could run and deliver their freight.

We have only further to say that the existing railways are conveying all the coal they can, but it so interferes with the passenger traffic that they find they can do no more.

---

[*] Average price of best coals at market, 1867.

[*] His opinion was that the coals would be all small when they arrived in London. Experience proves the reverse to be the case, as they only yield 2 per cent. Seaborne coals from 10 to 15 per cent.

[†] The quantity of best coals brought from Durham to London in the month of February was 2,410 tons.

We had almost omitted to mention as an argument in favour of the working expenses on a mineral railway being so much less, the fact that there is no risk of killing or wounding their passengers, the return for which privilege has a very large share in making the working expenses so heavy, and in some cases doing away with a dividend altogether, as in a late serious accident on the South Eastern Railway.

## FLOATING DOCKS AND OTHER ARRANGEMENTS FOR AFFORDING ACCESS TO SHIPS FOR EXTERNAL REPAIRS.

(*Illustrated by Plate* 330.)

This subject, which is of such vast importance to us as a maritime nation, has engaged the attention of naval men and engineers from a very early period; but, with the exception of the ordinary dry-dock, no means seem to have been adopted for repairing large vessels but what was prepared by nature, viz., allowing a vessel to ground at high water, and waiting until the tide left her high and dry. This latter plan is, however, only practicable when the rise and fall of the tide is very considerable, and consequently when our trade developed in the East and West Indies, the Mediterranean and other places, where there is but little difference between high and low water, other means had to be devised. Upon these various plans which have from time to time been proposed, a very able paper was written by Mr. Frederick J. Bramwell, at the Paris meeting of the Institution of Mechanical Engineers, and, as the subject is one of great importance, we now give, in a condensed form, his description of the principal schemes which have been proposed for this purpose:—

The hauling up of ships appears to have been practised from a very early period in the Venetian arsenals, and also at Toulon in France, where it was applied in 1818 to a large vessel; but the ships seem to have been only brought over an ordinary building slip, and then hauled up on the ways, being steadied by a sort of sliding cradle.

A special construction of carriage for this purpose was invented in 1818 by Mr. Morton, of Leith, which is shown in Figs. 8 and 9, Plate 330. An inclined slip-way is formed on a slope of about 1 in 20, and provided with rails, on which travels a wheeled carriage, the railway being extended sufficiently below the water to admit of the ship being floated over the carriage. By then hauling up the carriage by the chains and capstan gear, the ship being attached to the chain is drawn up out of the water and above the influence of the highest tide, and is blocked up upon the floor of the slip so as to admit of the carriage being removed. To prevent the ship from heeling over while in the act of being hauled up, the carriage is provided with bilge blocks sliding on timbers transverse to the slip. As the ship settles down on the keel blocks, and before she is removed from the water, these bilge blocks are hauled in until they support the bilges, the hauling being done by ropes led up to the deck of the ship. This appears to have been the first use of proper bilge-block shores which could be applied while the vessel was still afloat; and, in the writer's opinion, such a mode of sustaining vessels at the bilges before the water support is taken away is of the greatest utility, on account of its importance in preventing undue straining or risk of heeling over. In ordinary graving docks, it is true, bilge shores are used; but they are not applied until the water has been removed from the dock, and therefore not until after the ship has been subjected to the strains arising from the weight of her contents without her natural water support.

Morton's slips, which are now in extensive use, were at first intended for small vessels, but they have lately been constructed for ships of 2,000 to 3,000 tons burden. With small vessels little difficulty was experienced in building the slips, especially where there was a considerable rise and fall of tide, because the lower part of the slip could be constructed at low water; but when the longer modern vessels were required to be taken up, the length of the slip-way below the water became very great, as a slope of 1 in 20 requires the length of slip below water to be 20 times the draft of the vessel merely to reach her stem, and the slip must then be carried still further to extend under the length of the vessel.

The application of this slip to vessels of a larger class soon rendered some improvement necessary in the simple hauling chain that had sufficed for ships of 200 tons. A set of traction rods was first substituted for the body of the chain, and was hauled in by a short flat-linked chain working over a pitched wheel driven by gearing. The end of this flat chain was first attached to the foremost rod, and then hauled in until the second rod was brought up to the place of the first, when the flat chain was overhauled and made fast to the second rod; and this operation was repeated with the successive traction rods until the ship was fully drawn up. A further improvement consisted in making the flat-linked chain endless, so as to avoid the necessity of overhauling it. For some past, however, the larger slips that have been erected have been worked by the direct application of hydraulic rams to the ends of the traction rods; and among other plans double presses have been employed, made to work alternately, so that the hauling up might be nearly continuous.

An important adjunct to the slip is an arrangement of transverse lines of rails in the building yard at the upper end of the slip, so that by the use of carriages the vessels hauled up can be shifted sideways, thereby enabling a single slip to serve for hauling up several vessels in succession, so that their repairs may be going on at the same time.

The simple plan already mentioned, of placing a ship on a beach at high water, so that it may be left dry at the ebb, is still used where there is a considerable rise and fall of the tide; and to enable it to be carried out without risk of unequal support to the ship, a regular open framing of beams is made on the beach, called a "gridiron," by means of which vessels can be blocked up, and properly examined and repaired at low water. There is of course the objection that at the rise of each tide the work has to be suspended; but nevertheless the system is so so simple and inexpensive, and the vessels are so readily got off and on, that it still continues to be used.

In the plans previously referred to for lifting vessels out of the water, the vessels have been hauled up on an incline; and in the class of Direct Lifts, which has now to be considered, the earliest is that of Mr. Alexander Mitchell, the inventor of the screw pile, who, in 1833, proposed to employ the rise and fall of the tide for raising vessels out of the water by means of two parallel rows of piling placed sufficiently wide apart to admit the vessel between them, and having a permanently buoyant floor, made of light materials or of caissons. On the ebb of the tide this floor sinks between the piles, and at low water pins are fixed in the piles above the flooring. When the tide next rises the floor is held down by the pins, and at high water the vessel is brought over the floor and allowed to settle down on it, being maintained in an upright position by shores from the piles. At the next ebb the ship is duly propped up by bilge shores from the floor; and the side shores being then removed, and the holding-down pins withdrawn, the flooring is lifted by the next rising of the tide, taking up the ship with it, which rises and falls with the buoyant flooring at each tide until the repair is completed, when the flooring is again held down for the vessel to be floated off at the next high tide. This plan is evidently not suitable for cases requiring rapid access, as it needs at least three low and three high tides for enabling a vessel to be got on and off.

In 1827 a Screw Lift was constructed in America for raising vessels independent of the tide. This is shown in Fig 4, and consisted of a platform on which the vessel was to be lifted, the ends of the transverse timbers of the platform being steadied by two parallel rows of piles placed far enough apart to admit the vessel between them. The longitudinal timbers which connected the heads of the piles carried a number of vertical screws, as many as 46 having been used in one instance, the lower ends of which were connected to the transverse timbers of the platform, so as to raise the vessel out of the water. Since 1836, however, this lift has been worked by means of hydraulic presses.

In 1842 an improvement upon the screw lifting dock was proposed by Mr. Robert Mallet, which is shown in Fig. 11. The framework on which the ship is to be raised is carried on a number of supports, hinged at their lower ends to eyes supported on the rock or on piles, and at their upper ends to the frame, forming a sort of parallel-ruler motion. The slings attached to the top of the supports are provided at their upper ends with rollers, which run within a tubular rail having a continuous slot on its underside, as shown to a larger scale in the section Fig. 10; and the slings are hauled in by chains worked by powerful steam winches. The frame being lowered and the ship drawn over it, the chains are then hauled in, so as to pull the slings horizontally, thereby raising the framing until the ship is lifted out of the water. This arrangement has the advantage of giving a nearly uniform strain on the chains and machinery throughout the lifting of the vessel, inasmuch as at the commencement, when the supports are nearly horizontal and carry but little of the weight, the slings are vertical and the weight of the ship is almost entirely carried by the water; while by the time the ship has lost the support of the water and the slings have become inclined, the supports have assumed a position more nearly upright, and therefore, although the whole weight of the ship has now to be borne by the lift, the proportionate strain coming on the chains is but small.

In the lift designed by Mr. Scott in 1850, and shown in Fig. 6, the ends of the cross timbers of the platform were attached to slings depending from the crossheads of a number of vertical hydraulic presses, the stroke of the presses being equal to the lift of the vessel. It was intended either to repair the vessel on the platform, or to move it off on railways, either endways or sideways, so as to make one lift answer for the simultaneous repair of several vessels.

The ship lift of Mr. Edwin Clark, which was put to work at the Victoria Docks, London, in 1857, is shown in Figs. 5 and 13. The two parallel rows of cast-iron columns contain hydraulic presses, and the slings from the crossheads of the presses are attached to truss girders which extend from side to side of the dock. If the lift be used at a place where repairs are not frequent, these girders carry the framing on which the ship is to be lifted;

but if the lift is expected to be much used, as in the case of the Victoria Docks, then these cross girders carry a saucer, or shallow wrought-iron vessel of sufficient capacity to float the largest ship which can be taken on the lift. The girders being down and the saucer upon them, the ship is floated and adjusted over it; and the hydraulic presses being put to work, the saucer is raised until the blocks touch the keel of the vessel; bilge blocks are then drawn in against the vessel, and the working of the presses is resumed until the saucer is raised above the water. The saucer is provided with large valves, which are opened during the time of raising, so that the water runs out as the saucer rises; but as soon as the saucer is fully up, these valves are closed, and then the repair is either done on the lift, or else the girders are lowered again, and the saucer left floating with the ship on it. The saucer is then hauled away to one of the basins shown in Fig. 13, which it just fits, both in surface dimensions and draft of water; and the repairs are executed there, leaving the lift at liberty to be used for other vessels. At the Victoria Docks there are now eight of these saucers in use.

As early as 1785 a floating dock was constructed by a shipbuilder named Watson at Rotherhithe. It consisted of a timber vessel, 245ft. long, 58ft. wide, and 23ft. deep on the blocks, having an open end which could be closed by gates. Water being admitted in the vessel to sink it to a sufficient depth, the gates were opened, the ship to be repaired was drawn in, and then the gates being closed and the sluices shut the water was pumped out, leaving the ship in the interior of a true floating dry-dock. Mention is made of one vessel, the *Mercury*, having been docked in this dock with great success.

The balance dock or box dock, introduced in the United States in 1839, consists essentially of a pontoon bottom with two side walls. The pontoon possesses sufficient displacement to carry the whole weight of the dock and of any ordinary vessel that has to be raised. The side walls are hollow and of considerable width, serving the same purpose as the air tanks in the sectional dock, namely to prevent the dock from sinking too far and to preserve its stability in rising and sinking. Port-holes are made in these walls to assist ventilation, and the walls afford the means of shoring up the ship by breast shores as in a stone dock; on the top are the enginehouse and pumps and the working platform. For lifting the heaviest vessel that could be taken inside the dock, gates have been fitted at the ends of the dock, so that it might float with the surface of the pontoon below the water and thus acquire an additional amount of buoyant power according to the depth of immersion.

Several balance docks have been constructed in America, which the writer believes have all been built of wood. The dock at Havana was built at New Orleans in 1858, and was towed out without accident to Havana. It is 300ft. long by 79ft. broad, and the hollow floor is 9ft. 6in. deep; it can lift a vessel of 20ft. draft. It is provided with one steam engine, having a cylinder 12in. diameter and 30in. stroke, working with 60lbs. of steam, and driving seven pumps with barrels 24in. diameter and 30in. stroke, making about 11 double strokes per minute. Being constructed of wood, with a solid thickness of 2ft. 6in. of timber in the flooring, the floating power of this dock is so great, that for sinking it not only has all the available space to be filled with water, but 500 tons of ballast have to added. The total cost of this dock was £100,000.

In 1859 the writer, in conjunction with Messrs. Miers and Maylor, of Rio de Janeiro, designed for the Brazilian government a plan of floating lift which combined the principles of the American hydraulic lift and of the floating dock. This is shown in Fig. 7, and consisted of two parallel floating pontoons, carrying between them a framing on which the ship was to be lifted by chains, pulleys, traction bars, and hydraulic presses, precisely as in the American arrangement, Fig. 12. Two presses, however, were here applied to each traction bar, one at the further end and one half-way, whereby the strains on the traction bars, and therefore their requisite sectional area, were diminished; and the presses were so arranged that they made the lift in two strokes of half the length. The pontoons were arranged to separate into parts, when required for shorter vessels at different places; but when these parts were used combined together for the largest ships, means were provided to ensure the preservation of the full strength of the pontoons as girders.

In considering the essential principles of a good floating dock, and the defects most important to be guarded against, the first and principal requirement appears to the writer to be that the ship should be supported on as rigid a bottom as when on a building slip or in a stone dry dock. This condition, however, is not universally recognised, and on the contrary it is urged that, if a vessel has assumed a certain distorted form in the water, this form ought to be retained when out of the water for the purposes of repair; and it is alleged that this can be accomplished by giving the ship an elastic bearing, such as that afforded by the separate portions of the sectional dock, or by the somewhat yielding saucer of the Thames graving dock. The employment of an elastic bearing appears to the writer, however, to be erroneous, because it is based on the assumption, either that the ship having already gone out of shape to a certain extent will not yield further; or that all the parts of a vessel are of equal weight per foot run, so that the elastic bearing will yield to an equal extent at all parts throughout the entire length of the vessel, which is evidently contrary to fact.

The other requirements of a floating dock are—stability, ventilation facility for repair of the dock itself, and a minimum expenditure of power and time in lifting the dock. The materials employed should also be arranged in such a manner as to obtain a maximum of strength from a minimum of material; and the design should be one admitting of many repetitions of a few forms, so as to allow of the work being done to a few standard templates, avoiding as far as possible any necessity for welding heats and smith's work.

As regards the question of stability, the difficulty is experienced not when the dock is raised with the surface of its floor fairly above the water, but during the time that it is in the act of raising or lowering a vessel. The stability of the dock when raised is great, as illustrated by Fig. 17, where A represents the centre of gravity of the dock with the vessel, B the centre of buoyancy when the dock is not heeled over, and C the new centre of buoyancy when the dock is heeled over. It will be seen that the new centre C is far outside the perpendicular from A, and that there is therefore a strong tendency for the dock to right itself. But when the dock has been sunk so that the bottom is entirely below the water line, then some contrivance must be resorted to not merely for keeping it from sinking to the bottom of the sea but also for keeping it from turning over.

When the vessel in the dock is equally loaded on each side of its centre line, and is placed on the keel blocks perfectly in the centre of the dock, then during the raising of the dock the whole is free from any tendency to run over to one side more than the other, but at the same time is manifestly in a state of unstable equilibrium. Now if the dock heel over a little under any influence, such as the wind, the causes which would increase its inclination and turn it over are, first, the fact of the centre of gravity of the ship and dock being no longer over the centre of support; and secondly and largely, the fact that the water remaining not yet pumped out shifts its position in the dock, and thereby seriously affects the stability, unless proper arrangements be made for preventing such an occurrence. In some docks that have been constructed due attention appears not to have been paid to this point, and the writer believes it is principally from this cause that failures have occurred in floating docks.

If a floating dock made without any longitudinal water-tight bulkheads, as in Fig. 14, were half full of water, and were to be heeled over sideways so that the surface of the water should extend as a diagonal from corner to corner, the result would be to shift the centre of gravity of the water to A, one-third the width of the dock from the lower side or one-sixth from the middle. But if the dock have one longitudinal water-tight bulkhead along the centre, as in Fig. 15, then the same amount of heeling over will cause the surface of the water to assume the shape shown in each compartment, which may be looked on as being divided into two equal parts, a parallelogram and a triangle. The centre of gravity of the two parallelograms B C D E will of course be the same as before the dock was heeled over, while the centres A A of the triangles being one-sixth of the total width from their lower ends, the common centre of gravity G of the two will be at one-twelfth of the width from the centre of the dock, or only half the distance of the centre of gravity in the former case; but as the contents of the two triangles taken together are equal to only half the triangle in the former case. the effective moment tending to turn the dock over is only one-fourth of that which it was without a bulkhead. Similarly if three bulkheads were put in, so as to divide the dock into four compartments, the effect of the water in turning the dock over would be reduced to one-sixteenth of what it was when there was no bulkhead; and generally, the tendency of the water to turn the dock over when it is at all inclined diminishes in the ratio of the squares of the number of chambers into which the dock is divided.

The foregoing principles were kept in view by the writer on the occasion of having to design a floating dock for the Danish Island of St. Thomas, in the West Indies. This dock has been prepared in England, and is now in course of erection at St. Thomas; and it is shown in Figs. 1 and 2. The leading particulars are as follows: length 300ft., external width 100ft., clear width between the side girders 72ft., depth of bottom 9ft. 9in., extreme height 42ft. 3in. The dock can take in and lift, leaving an adequate amount of free board, a vessel drawing 24ft. of water and not exceeding 4,000 tons of actual weight, not tonnage; and the weight of the dock, with machinery and all complete, is about 3,400 tons.

A A are the main longitudinal girders, and B the separate transverse water-tight pontoons, six in number, forming the bottom of the dock. These have "set downs" at the ends, where they receive the bottoms of the main side girders, as shown in Fig. 2; and as any one pontoon may have either to support the girders or to be partially supported by them, the connection has been made by means of very strong attachments riveted to the pontoons and having shanks extending down to the very bottom of them. Cross plates are placed over the diagonals of the main girders, near the junction of the diagonals with the uprights;

and on these plates bear strong cotters, so that if one of the pontoons were quite full of water it could be lifted by the others without the least injury. This attachment of the pontoons to the girders is one which can at any time be readily undone, so that any pontoon can be detached and floated away, and then taken up on the remaining pontoons for examination and repair.

The ship is supported in the usual way upon the keel blocks C, which are provided with folding wedges. These blocks are secured to the upper decks of the pontoons immediately over the longitudinal bulkhead D, which extends along the centre line of the dock in each pontoon. In this way a portion of the weight of the ship is transmitted directly to the bottom plates, say over the area E F. Another portion of the weight is transmitted by the two sloping ties I of the athwartship trusses to the water-tight bulkheads J, and by these to the bottom plates, which take off a further portion represented by the spaces F G. A further portion is transmitted through the ties K to the uprights L, and thence to the bottom at G H, and so on to the end. There are nineteen of the athwartship trusses above described, placed side by side in each pontoon; and at the point M is provided a system of fore-and-aft trussing, whereby the whole of these athwartship trusses are connected with the fastenings by which the pontoons are hung up to the main girders A A. In this way the weight of that part of the ship which bears on any pontoon is upheld either entirely by that pontoon alone, or by transmission of the surplus weight through the main girders to some more lightly loaded pontoon to receive the load brought upon it by the girders, each pontoon is provided with a reverse set of diagonals in the athwartship trusses, which transmit the weight from the sides towards the centre.

The bilges of the ship are supported by the hinged bilge-shores, which are provided with soft wood caps and wedges to take the immediate bearing against the ship, and are upheld by pauls of two different lengths, so that when the range of the shorter pauls is passed the longer pauls come into play. These pauls take into rack plates, which are supported on transverse timbers. The pressure produced by the bilge-shores is transmitted mainly to the longitudinal water-tight bulkheads J in the pontoons. This system of bilge-shores was proposed by Messrs. Miers and Maylor in the Brazilian hydraulic dock before referred to.

When the dock is fully up with the ship on it, the pressure from the water is comparatively trifling, being not more than about 9ft. head of water against the bottom plates; but when the dock, after being sunk to its full depth and having received the ship, is in the act of beginning to rise by the water being pumped out, then the pressure of the external water upon the bottom plates of the sunken portion is about 28ft. head of water or about 12½lbs. per square inch or 4-5ths ton per square foot. In order to economise material, the writer determined on resisting this pressure, not by means of "frames," as in a ship, because for so large an extent of surface their weight would have been excessive; but by means of a system of inverted queen trusses. As regards the vertical plates, forming the sides and ends of the pontoons, these trusses are in most cases complete; but as regards the top and bottom plates and a few of the vertical plates, advantage is taken of the various diagonals of the main trusses to form portions of these minor trusses so far as they extend. This arrangement does not require one piece of metal to fulfil two duties at a time, inasmuch as when the main trusses are fully loaded, by the dock being fully raised and carrying the whole weight of the vessel, the pressure produced by the water is then but slight, and therefore the small trusses come upon the main trusses for only an inconsiderable amount of assistance; whilst when the dock is sunk and the full strain comes upon the small trusses by the pressure of the water, the main trusses are not then required to exert any resistance in respect of the vessel, which at that time is borne by the water.

The bottom members of each of the main girders A A are formed not only to resist extension, but are provided with sufficient lateral stiffness for resisting compression, by being composed of two parallel double girders connected at the bottom by horizontal struts and diagonal ties. The top member of each main girder is composed of two small girders, similar to those of the bottom member but united at their lower edges by a floor forming a trough section. This trough has its sides and bottom made water-tight, and is covered with a wooden deck carried on iron deck-beams; and within it are the various shafts and gearing for the working of the dock. The diagonals of the main girders A A are formed each of two plates, connected by stretchers, bolts, and lattice bracing. The uprights of the girders are made of open lattice columns with strong angle-irons at the corners; and to these angle-irons are rivetted plates and other angle-irons, which act as guides for the floats. From each of the uprights and from the junction of the diagonals extend the main altar frames to the top of the pontoons; and between each pair of these main frames are intermediate lighter altar frames. The feet of all the altar frames are secured to the pontoons by being placed within angle-iron wedging pieces, and by being bolted to the pontoons. This arrangement is adopted to admit of any pontoon being disconnected from its altar frames, when that pontoon requires to be docked for repair. The upper slopes of the altar frames are provided with steps, which receive the wood blocking for the purpose of applying shores to the ship when necessary, and also to afford support for the gangway boards which extend longitudinally from altar to altar. The risers or spaces between these boards are left open, so as not to interfere with the ventilation.

There are in all twelve floats, one to each of the bays of the two main girders A A; each float is 46ft. 9in. long, 11ft. 3in. wide, and 5ft. deep. A longitudinal central web extends from end to end of each float, worked out in three places to form boxes for receiving the tubes of the nuts through which pass three regulating screws. The floats are made with angle-iron "frames" placed transversely at frequent intervals, and every second frame has diagonal ties added which transmit the upward strain to the central web and thence to the screws. Immediately opposite each screw there is a transverse truss having double diagonals, to take the weight of the float when lifted for repairs at any time while the dock is above water. The exterior of the dock is protected by wooden waling pieces and fenders.

It was the original intention to deck over the pontoons with a wooden deck laid with ½in. spaces upon beams placed on the tops of the pontoons; but fears were entertained that during the repairs of iron steamers this deck might be set on fire. The wood deck was therefore abandoned, and a Portland cement deck 3in. thick was decided on; but experience has shown that this is not necessary, and that a coating of cement and tar ½in. thick is all that is required for protecting the tops of the pontoons. Portland cement however has been used in the interior of the pontoons, to fill up all confined places where decay might arise.

The deck on the top of the main girders A A of the dock is widened by brackets for a length of 100ft. at the centre, and on this part are erected the enginehouses with workshops at the ends. Each enginehouse contains a boiler of locomotive construction, having a firegrate 3ft. 4in. square, and a barrel 3ft. 6in. diameter and 7ft. 6in. long, containing 110 tubes 2in. diameter. The boilers are fed by injectors with fresh water carried in tanks made in the top of the girders. A wrought-iron well is also provided to each enginehouse, which hangs down between the central uprights of the main girders and contains a feed pump to draw water from the sea whenever required. Each boiler supplies steam to a pair of inverted direct-acting engines, having cylinders of 10in. diameter by 15in. stroke, working the pumps through line shafts which extend along each side of the dock. The pumps are placed inside the uprights of the main girders, in the spaces between the ends of the floats. At the centre upright there are two pumps, one of which pumps out the pontoon to the left and the other that to the right. In each of the next two uprights on either side there is one pump connected respectively with the second pontoon and the third or end pontoon. The pumps are 17in. bore, and the stroke can be varied from 12in. to 24in. by altering the position of the crank-pin in the disc driving each pump. The linings, buckets, and suction-valve seats are of gunmetal, and there are doors by which the valves and buckets can be examined or removed when the dock is raised; means are also provided for drawing up the bucket and valve when the dock is sunk, or for sending down another valve on the top of the first without removing it; or the lateral outlets through which the pumps discharge can be closed, and the bucket being withdrawn a workman can descend to the suction valve itself. Each pump is provided with a pipe between the clack and the bucket, by which air can be admitted, so as to stop or check the action of any one pump out of each set of three, the admission of the air being governed by a cock. A float in each end of every pontoon indicates the quantity of water in the pontoon; and the tubes through which the float-rods pass up serve as air tubes to the pontoons.

Two small direct-acting inverted engines are also placed in each enginehouse, fitted with link motions and driving by gearing shafts, which extend right and left along the top of the dock to work the regulating screws, of which there are three to each float. These screws are 6in. diameter and 1½in. pitch; their bottom ends are formed with collars like the thrust bearings of a propeller shaft, and cased with gunmetal; they are supported in steps fitted with bearing surfaces made of discs of lignum vitæ. The screws work in cast-iron nuts, which are contained in deep cast-iron tubes fixed to the floats. The spaces in the tubes above and below the nuts are filled up solid with tallow. As the screws make only 200 revolutions during the whole ascent or descent of the dock, the speed of the engines has to be greatly reduced by the gearing; it can however be varied at pleasure, so as to allow for greater rapidity in the descent than in rising.

On each side of the dock a screw-cock inlet-valve is provided on every pontoon, to admit the water for sinking the dock. These valves are worked in four separate sets of three each, by handwheels in the enginehouses, gearing with the shafts extending along the top of the dock. In each enginehouse there are two tell-tales, to show the fore-and-aft and the athwartship level of the dock; each consists of an index magnifying by means of gearing the angular movement of a pendulum. Speaking tubes extend from one enginehouse to the other, and also from each enginehouse to the bridge at the end of the dock, from which the orders are given; this bridge is closed, as shown in Fig. 1, except when the very longest ships are taken in.

The mooring of the dock is made from a single mooring anchor placed to windward, to which is secured a chain of 35 fathoms length, made of flat links of the form employed in suspension bridges, with the eyes rolled in the solid. To this chain are attached two smaller chains, each 35 fathoms long, which are made fast to the mooring rings on the head or windward end of the dock. At the stern end there are two small chains, led away at an angle to two mooring anchors; these chains pass over rollers up to capstans at the top of the side girders, by which they can be hauled in as required. There is a one-ton crane on each of the four quarters of the dock, for raising or lowering material, &c.

From the foregoing description it will be seen that, for the purposes of working, the dock may be considered as divided into four independent sections; for in each of the two enginehouses the engineer has the power of working independently the set of three pumps on the right and the set on the left; and the same with regard to the floats and the inlet valves. In order to lower the dock for receiving a ship, the inlet valves are all opened to admit the water into the ends of the pontoons as far as the water-tight bulkhead; the central portion never requires to be filled, inasmuch as the whole buoyancy of the dock can be overcome by the admission of water into the side compartments While the dock is sinking, the engines working the regulating screws are put to work at such a speed as to keep the floats always one-half immersed in the water. When the dock is sunk to the required depth, the inlet valves are shut, and the ship, which has been moored closed to the dock moorings, and therefore directly to the windward of the dock, is hauled in over the keel blocks, and adjusted by means of breast tackles and shores. The pumping engines are then put to work, and the dock is raised until the keel blocks just take their bearing against the vessel; and the bilge shores being hauled taut, so as to secure the vessel thoroughly, the pumping is resumed, and the screw engines are put to work at their slow speed, so that as the dock rises the floats are still maintained just about half immersed. In Fig 2, the float on the left-hand side is shown raised into an intermediate position, which is the position it would occupy when the dock is rather more than half raised; when the dock is fully up, the float is in its lowest relative position, having its bottom level with the underside of the girders, which form the bottom member of the main girders A A; and when the dock is sunk to the extremity of its range, the top of the float is up against the underside of the girders which form the top member of the main girders A A.

In a properly constructed dock it is difficult to see what influence could force the dock out of level under any circumstances; but supposing it were ever found that, in the raising of the dock now described, one corner was becoming low and the opposite corner high, this would immediately be corrected by altering the working of the screw engines, so as to depress the three floats at the low corner, and elevate those at the high corner. This alone would always be sufficient to adjust the dock, without interfering with the pumping, which might go on continuously: but there is in addition the power of throwing any three of the pumps out of gear while keeping the others at work, and the inlet valves of the high corner might even be opened to let the water in again, if this were desirable in an extreme case.

In designing the construction of the Floating Dock that has now been described, the object of the writer was to supersede the objections that appear to him to attach to the Morton slip and other ship lifts, and also to the two principal of the previous floating docks, namely, the Balance dock and the Sectional dock. The reason for discarding the use of slips and lifts was that they are dependent on the earth for their support. This objection however, did not 'apply to the sectional or in the balance dock, both of which, like the St. Thomas dock, have the important advantage of being wholly independent of the land, and are therefore capable of use in any place where there is sufficient shelter and depth of water, combined with the means of mooring. The grave objection in the writer's opinion to the sectional dock is its entire want of rigidity. Although this does not apply to the balance dock, yet this dock also involves objections which the writer believes to be of importance. One is that, as ordinarily built in one entire structure, the balance dock requires either an excavation into which water can be admitted to float the dock after its completion, or else the construction of very large and expo sive launching ways. Moreover the rigidity and also the stability are obtained by the use of complete side walls, which have a large displacement when the dock is sunk. As far as the question of rigidity is concerned, the writer believes that these side walls involve the use of more iron than is required in an open girder to obtain the same strength; while they absolutely preclude efficient ventilation at the sides of the ship, and present a large extent of surface for reflecting the heat of the sun and for the wind to act upon. The engine power for pumping out the water is also increased as compared with open sides by the great displacement of the solid sides when sunk, which involves a corresponding increase in the quantity of water to be taken in and subsequently pumped out.

In the St. Thomas Dock, although the lower part is composed of six separate pontoons, for facility both of original construction and of subsequent examination and repair, the objection applying to the sectional dock is got over by the use of the strong side girders. These are provided with a double set of diagonals, and have their top and bottom members made of such strength as to be capable of resisting a strain tending to depress either the middle or the ends. Thus, supposing the dock is in the act of raising a paddle-wheel steamer, which has a large portion of its weight accumulated in the centre, and only a small portion at the ends, the girders will transmit the surplus floating power of the end pontoons to the assistance of the heavily loaded central pontoons; and in the event of two small but heavy vessels being taken on at the ends of the dock, the girders will convey the extra flotation of the central pontoons to those at the extremities of the dock.

As regards the important question of stability and the means of controlling it, it is to be observed that even with the balance dock there is nothing to fear so long as the upper surface of the bottom is fairly above the water, because on any attempt at heeling-over, the rectangular bottom produces a change in the position of the centre of buoyancy so rapid compared with any slight inclination of the dock that the tendency to right itself is very strong indeed. Moreover at that time the dock is pumped dry, and the danger arising from shifting the centre of gravity of the internal water is at an end. In Fig. 16, taking A B as the water line, the balance dock is shown fully raised and heeled-over; and the power of restoring an upright position to the dock under these circumstances has already been fully investigated in reference to Fig. 17. But when the dock, while in the act of being raised or lowered, has its floor wholly immersed, as shown by the water line C D, then the tendency to restore equilibrium is not so great, as the effect of the whole triangle E F G is diminished by that of the interior figure H I K L. Moreover there is at that time within the dock a large amount of water, the centre of gravity of which is of course shifted by the heeling-over; and the effect of this is most serious, unless a sufficient number of bulkheads be provided to subdivide it into small sections. From whatever cause, however, the stability of a balance dock may have been disturbed, it is clear that the effect of its sides to restore equilibrium can be increased only in proportion to the amount of heeling-over, and can never be caused to exert any effect in excess of this. If, therefore, a balance dock has once been heeled-over, it cannot be righted by its sides, so long as the force which caused the heeling-over is continued.

With the side-flats, however, in the St. Thomas dock, the case is different, as the position of the floats in reference to the dock can be controlled as desired; and, therefore, in the case of any heeling-over, an extra immersion can immediately be given to the floats on the low side, while those on the high side can at the same time be raised more out of the water. By this means when the heeling-over is only slight, and therefore the tendency to heel-over further is also slight, the floats can be made to exert as great a counteracting power, as the walls of the balance dock would have when the heeling-over was great, and therefore the tendency to go further also proportionately increased.

Another important reason for preferring the open sides of the St. Thomas dock to the close sides of the balance dock was the saving of time in pumping for raising the dock. Supposing that the St. Thomas dock had been made with close sides, these would have had each a sectional area of 14ft. wide by 25ft. deep when fully immersed, which, with 330ft. length, would give 210,000 cubic feet total displacement for the two sides. The section of the bottom is equal to 900 square feet, which, with 300ft. length, gives 270,000 cubic feet. or 7,700 tons; but as the dock, with all its machinery complete, weighs 3,400 tons, only 4,300 tons of water have to run in, equal to 150,500 cubic feet. Hence the close sides would have added $\frac{7}{5}$ to the amount of water to be pumped out; so that the time required for pumping out the dock if the box sides had been used would have been in the ratio of 36 to 15, or 12 to 5, as compared with the open sides.

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## ABSTRACT OF A PAPER ON THE PHENOMENA OF LIFE AND MIND.

By Robert Dunn, Esq., F.R.C.S., &c.

Mr. Dunn began by observing that life and mind are problems which belong to the same category, and that, in respect to their abstract essence or nature, they are alike inscrutable to us. We know nothing of life apart from an organism, and we have no evidence of mind independently of a brain and nervous system. A living organism is required for the display of the vital phenomena, and a brain of nervous system for the manifestations of mind. Life, he said, had accordingly been defined as the collective expression for a series of phenomena which take place exclusively in bodies that are organised; and mind, as the functional manifestation of the living brain. But, be it remembered, he added, that matter and the physical forces of external nature, which underlie all vital phenomena, and the changing states of consciousness, which constitute our mental life, are equally inscrutable to us. Matter and force are co-relatives and co-existent; nor can we conceive of the one, but only in association with, by, and through, the other. The correlations of the physical forces point to an unity of force; nay, lead us, as Mr. Grove thinks, to the belief that "the fundamental conceptions of matter and motion will be found sufficient to explain physical phenomena." Motion, indeed, may be regarded as a kind of common ground, upon which nature, life, and mind may be said to meet. But still the phenomena of life and mind are so antagonistic to, that they are not to be identified or confounded with, nor can they be included under, mere physical phenomena. The fact, indeed, cannot be denied that the agency of matter and the physical forces is so essential to the manifestations of life, as life itself is to the display of intelligence. Still the vital and mental forces are not to be confounded with the physical; for the truly vital phenomena—the processes of formation, growth, and multiplication—occur in living beings only; whereas the development of light, heat and electricity, whether they occur in living organisms or in inanimate matter, are purely physical phenomena. The living germinal matter of the organism is alone the seat of vital actions; and life in its mysterious association with matter is transmitted from one living organism to another. The vital part of the impregnated egg consists of living matter, and which results from the living matter of the beings which produced it. All attempts to give vitality by means of the physical forces to inanimate matter have been vain and futile. Not the slightest approach has been made towards the formation of anything having the properties of the lowest and simplest forms of living matter. Nay, every attempt, by synthesis, at the formation of albumen or fibrine, or even of starch or the cellulose of the very lowest vegetable organisms, has been unsuccessful. Every living particle comes from a previously existing living particle.

As to mental phenomena—Mr. Dunn in considering the phenomena of mind, of which consciousness is the exponent, began by remarking, *in limine*—from the first moment that the priordial cell of a human organism comes into being, and is launched upon the ocean of time and space, the entire individual is present—an organised entity exists, fitted for a human destiny; and, from the same moment matter, life, and mind are never for an instant separated—their union constituting the essential mode of our present existence.

The mind, like the body, passes through its phases of development and growth. In the primordial cell are potentially contained the vital, nervous, and mental forces; for inherent in it are the powers of nutrition, development, under which *in utero*, duly supplied with the nutrient pabulum, the bodily fabric is evolved and built up, in accordance with all the subsequent wants of the future man. Among others, the nervous system also upon the vesicular matter of the encephalic ganglia of which the mind is dependent for the manifestation of all its phenomena throughout the totality of life. As soon as embryonic life is passed, the nascent consciousness becomes awakened. Our outer life begins with consciousness, and with consciousness it ends. This nascent consciousness,, purely sensational at birth, emerges gradually, step by step, from self-consciousness to world-consciousness, and, through the ideational and emotional up to its highest phase of intellectual development. Consciousness itself, as the exponent of mind, is an ultimate fact in animal life, and implies mental existence. It is the universal condition of intelligence; for it is involved in every sensation which we experience, and in every mental act which we perform in feeling, perceiving, thinking, and willing. We can best conceive of it, in relation to time, as an incalculably rapid succession of acts or states from the moment of birth, and as passing through a series of developments.

Self-consciousness is the primary condition of intelligence; and Psychology has been briefly but aptly defined—developed consciousness.

There are three phases of consciousness successively developed, characterised by different mental phenomena. 1, the Sensational; 2, the Perceptive, or Ideational and Emotional; and 3, the Intellectual. To feel, to perceive or idealise, and to think; in other words, Sensation, Ideation, and Intellection, are distinct states or acts of consciousness.

1. The phenomena which formulate the Sensational Consciousness, besides the intuitions of the special senses, are sensori-motor, consensual, and instinctive actions and feelings. Common sensibility and the capability of receiving pleasure and pain, among these, is primordial, and the most essential to human existence,

The nervous apparatus of the sensational consciousness consists, to the exclusion of the cerebrum, of the spinal axis and nerves, the medulla oblongata, and the chain of sensory ganglia, including those of the special senses at its summit; forming as they do a distinct nervous centre of action, independent of, and not to be confounded with, that of the ideational or intellectual consciousness.

2. Phenomena of the Perceptive or Ideational and Emotional Consciousness.—These are ideation and volition, with their associates memory and emotional sensibility. Here ideation is effected. Sensory impressions and the intuitions of the perceptive faculties in the cerebrum are idealised—transformed and converted into intellectual phenomena—and become the pabulum of thought.

The genesis of the memory and of the will is in the perceptive consciousness. And all the ideational activities appertaining to man, as an individual, emotional, and social, as well as a religious being, are evolved and brought into play in the development of the perceptive consciousness. The great hemispherical ganglia, the seat of all intellectual action and volitional power, together with the centres of emotional sensibility, in the meso-cephale, constitute the nervous apparatus of the ideational consciousness.

3. Phenomena of the Intellectual Consciousness.—Imitation, imagination, ratiocination, and reflection, with memory, and volition, are the distinguishing phenomena of the intellectual consciousness. The human mind, rising above sensation and above perception to its highest phase of intellectual development, soars into the region of representative knowledge, grasping, through its intellectual faculties and reflecting powers, abstract ideas, the necessary and universal truths, and finding articulate expression for them, through the noble faculty of speech in language. All physiological psychologists are agreed, that the great hemispherical ganglia of the brain are the sole and exclusive seat of all intellectual action and volitional power—of the understanding and the will. They are superimposed upon the sensory, emotional, and motor ganglia, in the encephalon, for purposes and offices the noblest and most exalted in the economy of man. They are the seat of all the distinct and different psychical activities appertaining to man as an intellectual, social, moral, and religious being.

That different parts or portions of that great sheet of vesicular matter which crowns the convoluted surface of the cerebral hemispheres, subserve, and are the seat of, different and special physical activities, Mr. Dunn considered to be a fact fully established. The microscopic investigation of its ultimate structure, in the three main divisions of the cerebrum—the anterior, middle, and posterior lobes—revealing, as it does, distinguishable structual differences and varying degrees of complexity, warrants, as he thinks, the inference of diversity of office. As complexity of function is necessarily connected and associated with complexity of structure, and as it is in the ultimate structure of the vesicular matter of the anterior lobes, that the greatest complexity of the nerve-cells, nerve-fibres, and circuits, is demonstrable, he argued, as a legitimate deduction, that the grey matter of the anterior lobes is the seat of our highest and most complex psychical activities.

In conclusion, Mr. Dunn avowed what are his own convictions as to the psychical activities of the the three main divisions or lobes of the cerebrum—not hastily, he said, taken up, but founded upon the facts of pathology observed by himself or recorded by others, and upon those of developmental anatomy, comparative and human; namely, that the anterior lobes of the brain are the seat of the intellectual, the middle of the personal or individual, and the posterior of the social and effectional activities or attributes of the human mind. In other words, as he had said elsewhere: "His mind rests in the conviction that the anterior are the intellectual lobes of the brain, the seat of the intellectual faculties, the reasoning and reflecting powers; that the middle lobes are the personal and the seat of the animal activities, of the individual or personal affections or attributes, and of the moral and religious intuitions of the mind; and that in the posterior lobes are seated the social and affectional activities and propensities, those endearing attributes which are the charm of our existence here, binding together in the bonds of affection, the ties of family, of friendship, of country, and of race."*

## QUARTERLY MEETING OF THE IRONMASTERS' ASSOCIATION AT MIDDLESBOROUGH.

The quarterly meeting of the Ironmasters' Associationwas held, for the first time in Middlesborough, on Tuesday last. There was a large attendance of ironmasters, and others interested in the trade, and the Freemasons' Hall was made the rendezvous of numerous steel patentees and other exhibitors of models of machinery, calculated to excite attention.

Mr. James Hargreaves, analytical chemist, Darlington, was the first whose stall claimed attention on entering the room. In exemplification of his new process of manufacturing steel, he showed three samples—of converting materials showing the manner in which those materials are applied, by being held in cohesive masses to the bottom of the operating vessel, till the operation is completed. For refined iron a layer of oxide of iron and nitrate of soda is first placed in the converting vessel, and above this is poured the liquid metal. In the same way oxide of manganese is used by Mr. Hargreaves for the manufacture of steel. Alongside these were a piece of refined iron and a sample of malleable iron, cut with a chisel, and then bent ones to show its toughness. Both samples were from Cleveland pig, and the latter exhibited likewise a number of bars of cast steel, some of which were severed in the centre, and showed a fine, dense grain. Besides these were a chisel and several rivets, the latter being crushed flat against the head while cold, complete without breaking the piece, which was so

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* *Vide* paper "On Civilisation and Cerebral Development," read at the Birmingham meeting of the British Association, and published in vol. iv. of the *Transactions of the Ethnological Society of London*, 1866.

ductile that it crushed up like lead without cracking. The whole of the specimens were produced from Cleveland iron.

Several specimens of Warton iron ore, nearly pure peroxide of iron, which was much commended, were exhibited by Mr. H. J. Walduck and Company, Manchester.

A large collection of samples of steel, made at the works of Hopkins, Gilkes, and Company, Middlesborough, were shown on the next stall. They comprised a sample of rolled round bars, rolled square bars, forged square bars, showing fracture, sample of round rolled bar, one end doubled hot, and the other end drawn out and punched in a cold state. Mr. Gjers, of the Linthorpe Ironworks (Lloyd and Company), is the patentee of the process adopted in the manufacture of the articles enumerated: alongside which were a sample of a 24lbs. per yard flat bottomed colliery rail—the first rolled from Cleveland iron—on an ordinary steel rail of the Stockton and Darlington Railway (Guisborough Section) manufactured by the same firm, and weighing 65lbs. per yard. The latter rail, at a weight of 47 tons, showed a permant deflection of 3in. The excellent quality of these rails has been certificated by M. Van Kuth and Van der Heyden, inspectors to the Dutch Government; Mr. Gjers has not yet made his process known to the public. Three circular saws, a number of carving-knives, and other cutlery, manufactured at the Thames Steel Works, Sheffield, from Cleveland pig, were exhibited by Messrs. Lloyd and Company, Linthorpe; as also several samples of rolled round bars, one end punched cold, and the other doubled hot. A forged round bar turned and polished; a billet drawn out from an ingot showing fracture; the end of a forged plate, from which a sample was taken for analysis; and round and square forged bars made up the complement from the Linthorpe Works.

Mr. Charles White, of Newport, Monmouthshire, exhibited two models of a patent rolling mill invented by himself. His system consists in the use of several pairs of rolls combined in one mill, some of the rolls being vertical and others horizontal, and so arranged that the bloom is compressed alternately, flatways and edgeways through as many pairs of rolls as may be required for reducing the iron to its proper size. By this principle manual labour is altogether done away with, excepting a man to throw the pile into the first pair, and another to take the bloom or bar away One important feature of this process is that the iron is allowed little time to cool; and the quantity of work of which the mills are capable will be best learned from the fact that the Aberdaid Company are making from 90 to 100 tons of iron in twelve hours from one mill.

A patent hot blast stove, made entirely of fire brick, for heating blast furnaces, was exhibited by Mr. Thomas Whitwell, the patentee. These stoves will stand any amount of heat, from 2,000 to 3,000 degrees, without damage; and in the economy of fuel are much superior to the metal stove, which they will doubtless ultimately supersede. A plan of Wilson's patent puddling furnace was also shown by Mr. Thomas Whitwell.

The firm of Hawkesley, Wild, and Company, of the Brightside Boiler Works, Sheffield, were represented by a model of a ball, tyre, or bar puddling furnace. This is an invention not less remarkable for its apparent utility than its novelty. The flue of the boiler is lined with fire brick, which by preventing the air from being drawn into the furnace, secures a more regular yield in the quality of the metal. This can be got up much quicker than an ordinary furnace, on account of its drawing no air; and no heat can radiate from the furnace except through the water in the boiler. As soon as the heat is got up, the flue of the boiler acts as the neck of the furnace, which is reduced by means of a patent flanged flue, with cross tubes inserted to absorb the waste heat, before it passes out of the boiler. Messrs. Hawkesley and Company likewise exhibited plans and sections of an improved patent flanged boiler with combustion chambers. By flanging the smaller rings, the iron is secured in a manner which prevents the flue from collapsing. Each flange in the boiler is an expansion joint, which allows the separate rings to expand and contract, without increasing the strain upon the ends or shell of the boiler.

To revert once more to the steel exhibitors. Mr. J. Heaton, of Langley Mill Ironworks, Nottingham, showed two cases of samples. Mr. Heaton's process of steel manufacture consists simply of running the metal direct from the cupola into the converting vessel, into the bottom of which is placed a layer of nitrate of soda covered with a cast iron plate. After the lapse of five or seven minutes, the ingredients having amalgamated, are taken out of the vessel as steel. It is then put into a re-heating furnace, for ordinary steel purposes and wrought under the hammer into blooms, from which it is rolled into bars, or any other form of steel that may be wanted. The samples produced by this system included three links, 2½ diameter: an ingot or steel direct from the converter; a 3-in. square bar of very superior mild steel, showing fracture; a bar of inch octagon, bent cold, broken under the forge hammer, and showing a very superior fine grain; a bar 5½in. broad, and ½in. thick, suitable for shears for cutting iron; four coils of steel, bent cold, without showing any fracture; a bar 10ft. long, one portion of it tilled down to a quarter-square, and another portion ⅝ square octagon.

Mr. Jones, (of Fox, Head, and Co.'s works), brought a number of specimens produced by his process from the works of Bolckow, Vaughan, and Co., Middlesborough. Amongst these were a fine cast steel flange rail, and another rail, with a cast steel head, and wrought iron web and flange; also bars and plates, punched, and bent, and fractured; and bars rolled and hammered, with fractures and cold bends. The composition of these specimens was 90 per cent. Cleveland ore, fine hematite, and fine Swedish ore.

A varied and superior collection of samples, manufactured at the West Hartlepool Ironworks, from No. 4. Cleveland pig, worked at the furnaces of Messrs. Bell Brothers, Port Clarence, was exhibited under the superintendence of the patentee, Mr. Charles Sanderson, Worksop, Notts. This quality of iron has been manufactured into puddled bars, the fracture of which shows Mr. Sanderson's improvement in the toughness and texture of the metal. The patentee has had the same description of iron manufactured into merchant bars, of various dimensions, in which the bright and elongated fracture showed the high quality attained in the second process of manipulation. Amongst the other specimens exhibited by Mr. Sanderson are specimens of hoop iron and split rods for nails. The hoops are very smooth on the edges, and the slit rods are twisted in every possible form, to show their toughness. Samples of iron manufactured exclusively for steel purposes, one of which has been converted into steel by the common process of cementation, is also exhibited by Mr. Sanderson. This iron so converted into steel at a cost of 16s. to 18s., is rolled into bars suitable for the manufacture of railway carriage springs. But what attracted most attention in this lot were the large and small ingots of steel—the largest weighing 600lbs. There is a very fine and even fracture in this ingot, which is broken in two, and is suitable for manufacture into rails. Similar ingots of cast steel of various tempers were shown; as also small railway axles and square shafts, also of cast steel; several samples of cast steel plates, bent and punched in various ways; several samples of cutlery; and a coil of steel wire, pronounced by London electricians to be of first-rate quality.

## LONDON ASSOCIATION OF FOREMAN ENGINEERS.

The members of this institution met on Saturday, the 4th inst., at the George Hotel, Aldermanbury. The chair was occupied by Mr. Joseph Newton, president, and the attendance was large. After the disposal of matters of a routine character, Mr. J. Matthias Hart, of Cheapside, and other gentlemen, were elected as honorary and ordinary members. A discussion followed as to the propriety of relaxing the rule which constitutes "a hard and fast line" against the admission of members over fifty years of age. Several gentlemen slightly beyond that period of life, but otherwise thoroughly eligible, desired admission. Their cases were finally referred to the committee.

The Chairman next took occasion to refer to the munificent conduct of Mr. Whitworth in proposing the foundation of thirty scholarships for the promotion of technical education and the study of mechanical science. The proposed use of the princely donation made by that gentleman, Mr. Newton said he considered was as admirable in conception and intention as it was important in a material sense. Their own association had certainly rendered good service both to employers and employed, and in presiding at its anniversary lately, and then joining it as an honorary member, Mr. Whitworth had evinced his appreciation of its value to both those classes He trusted it would go forth to the world that the associated foremen engineers of London gladly recognised the noble conduct of Mr. Whitworth in founding the scholarships in question, and that they yielded to no section of the community in the sincerity of their gratitude to that gentleman.

A short description was then given of a new speed and distance indicator, or counter. As the apparatus itself was also exhibited, it may not be improper to state that it appeared to be in every way well adapted for its purpose—that of registering the speed of machinery, or the distance travelled by vehicles. It is small in size, simple in construction, contains no springs, and is not costly. Mr Hay, of 83, Lombard-street, is the agent for its introduction. The apparatus consists of a combination of several series of repeating discs. The first, cut in the form of a Maltese cross, has ten concave sides, on which are inscribed the numbering figures. The second disc has ten teeth which catch into the preceding, and the third has a single tooth on its circumference, the radius of which is equal to the concavity of the sides of the first disc. The second and third discs are joined together, their united thickness being equal to that of the first disc. This latter is slipped on an axle at a convenient distance, so as to allow the first disc to catch in with the two others. Disc No. 1 in making one revolution carries round Nos. 2 and 3, and when disc No. 1 has checked off the ten numbering figures, No. 3, which has only one tooth, has only travelled one-tenth, or a single space on the circumference of disc No. 1 of the second series of discs, and so on. The small apparatus shown on Saturday, and which is moved by a ratchet and pawl, registers up to 999,000,000, and is easily returned to zero.

## INSTITUTION OF CIVIL ENGINEERS.

### THE CITY TERMINUS OF THE CHARING-CROSS RAILWAY.

By Mr. John Wolfe Barry, M. Inst. C.E.

This line was authorised by Act of Parliament, dated June 28th, 1861, and the works comprised (1) a bridge over the river Thames, (2) the Cannon-street Station, and (3) viaducts south of the river, for connecting the bridge over the Thames with the main line of the Charing-cross Railway.

The bridge over the Thames had been constructed to carry five lines of way from the south abutment to the pier next to the Middlesex shore, at which point the five lines branched out, and were connected with nine lines of way in the station. There were two footpaths, one on each side of the bridge, intended for the use of the public on payment of a small toll, but they had not yet been opened for traffic. The extreme length of the bridge between the abutments was 706 feet. This length was divided into five spans, the two side openings being each 125ft., and the three centre openings being each 136ft. in the clear on the centre line. The width of the straight portion of the bridge outside the footway parapets was 80ft., and the width of the railway portion between the inside parapets was 61ft. 8in. The fan, which extended over the Middlesex opening, was widened out to 202ft. at the abutment, and accommodated, in addition to the lines of way, portions of two passenger platforms, engine sidings, foreman's offices, &c. The height of the soffit of the bridge above Trinity high-water level varied from 24ft. 8in. at the abutments to 25ft. 4in. in the centre span. The object of this arrangement was to prevent the bridge appearing depressed at the centre. The height of the rails above the soffit of the bridge was 9ft. 10in.

The southern abutment was built on cast-iron caissons, sunk side by side, partly by means of divers working in helmets, and partly by dredging inside the caissons with a bag and spoon dredger. In the case of the north abutment, neither caissons nor cofferdams were used; short lengths of ground were excavated at low water, a small "stank" dam of clay was employed, and the water being pumped out as the tide ebbed, the excavation was continued and the footings were got in. The piers were each formed of four cast-iron cylinders, placed in a line at right angles to the longitudinal axis of the bridge, and connected by two wrought-iron transverse girders at the top. The outside diameter of the cylinders was 18ft. below and 12ft. above the bed of the river; a conical reducing ring being introduced to effect the junction between the two diameters. The cylinder plates were fluted from 5ft. below Trinity high-water mark up to the level of the ornamental cap mouldings. In sinking the cylinders, the bed of the river was first smoothed by dredging; then the two bottom rings, together 13½ft. in height, which was equivalent to the greatest depth of water at low tide, were put together on timbers, between strong timber guides, exactly over their destined position. This portion of the cylinder was next raised by a travelling crane so as to permit the removal of the supporting timbers, and was afterwards lowered into position. A third ring of plates was then added, and a bag and spoon dredger was employed inside the cylinder, to take out the mud and gravel. As the cylinder descended additional rings were bolted on until the London clay was reached, when the sinking was continued by ordinary excavation until the final depth was attained, which was from 59 to 65½ft. below Trinity high-water mark. The cylinders were filled with Portland cement concrete up to the level of the bottom of the reducing ring, and on this brickwork, also in Portland cement, was carefully built for the full height of each column, being capped with large bed stones 2ft. thick. Each of the cylinders was weighted at the testing line with 850 tons of iron. This weight was calculated to represent the dead weight of the structure above that line, a rolling line of one ton per lineal foot for each line of way supported by the cylinder, and a moving load on the footpaths. The order to remove the load was not given until it was ascertained that no subsidence had taken place for seven days. The greatest subsidence under the full test load was 2⅜in., and the least ⅛in. The heaviest weight on the London clay at the bottom of any of the cylinders was 5.84 tons per superficial foot, with a rolling load as stated; and the heaviest weight on the brickwork in the cylinders was about 9 tons per superficial foot.

The particulars were next given in detail of the bed-plate girders, of the outside main girders, and of the intermediate main girders. The girders for the two side openings were independent of the other spans, but those for the three centre spans were continuous over the three openings. The flooring of the bridge was composed of flat plates of wrought iron ½in. thick, which were riveted to the top flanges of the main girders, and were further strengthened by angle or T irons; for as the floor of the bridge formed the station yard, and was occupied by cross roads, as well as by the through lines, it was necessary that it should be capable of carrying the rolling load in any direction. Upon the flooring plates asphalte was laid, which was covered with an average thickness of 5in. of ashes, as ballast, and on this the ordinary permanent way was placed.

The piers of the bridge, from the bottom of the cylinders to the bed-plate girder, contained in all about 2,500 tons of cast and wrought iron. The superstructure contained about 4,200 tons of wrought-iron in girders, floor-plates, &c., and about 1,100 tons of ornamentsl castings. The cost of the Cannon-street Bridge, including the abutments, signal bridge, and all things connected with the work, with the exception of the permanent way, signals and signal apparatus, gas and water mains, amounted to £193,000. This sum gave £2 15s. as the cost per superficial foot, and £250 per lineal foot, or £50 per lineal foot for each way of line, including the fan and footpaths.

The length of ground occupied by the Cannon-street Station, between the river Thames and Cannon-street, was 855ft., distributed as follows:—The forecourt was 90ft. wide, the booking-offices were 85ft. wide, and the length of the covered portion of the station south of the booking-offices was 680ft. The width of the station outside the walls was 202ft., and inside the walls, at the platform level, it was 187ft. The whole of the station was built on a substructure of brick piers and arches, except the booking-offices and the part which was over Upper Thames-street. At the crossing of this street, which passed underneath the station at about midway of its length, wrought-iron girders were used. Openings were left in all the piers, to allow tramways to be worked throughout the basement if necessary; and provision had been made in the arches for an hydraulic lift to raise and lower the waggons. The cross openings north of Upper Thames-street were mostly carried up through the springing of the large arch, and were groined into it. The groining, which was 27in. thick, was built in Portland cement, and the keystone was of Bramley Fall. It was adopted in consequence of the height of the ground not allowing communication between the different main archways, by transverse arches below the springing of the large arch. Without intercommunication the value of the vaults would have been commercially much diminished, and they would not have been available, as they were now, for parcels offices, stores, and railway purposes. The station walls were almost entirely of brickwork in mortar—the only exceptions being the arch over Upper Thames-street, and a few courses at the top of the walls, which were laid in cement.

The main trusses of the roof consisted of segmental ribs with a tie-bar looped up. The clear span of the trusses was 190ft. 4in. The rise of the rib at the centre was 60ft., and the rise of the tie-bar was 30ft. The particulars of the different members were then given in detail. The ordinary distance from centre to centre of the trusses was 33ft. 6in., being the same as the distance between the centres of the piers of the substructure. In crossing Upper Thames-street, however, the distance apart was increased to 35ft. 1½in., in order to suit the abutments of the bridge over that street. The weight of a single truss was 47¼ tons. The parts of the roof not glazed were covered partly with zinc and partly with slating. A lantern, 22ft. wide, extending nearly the whole length of the roof, was glazed on the top, and had the sides fitted with louvres, which afforded means of ventilation. Two movable timber stages, designed by Mr. J. Phillips (Assoc. Inst. C.E.), were used in the erection of the roof. One was as high as the top of the segmental ribs, and was employed in the erection of the trusses; the other was smaller, being low enough to pass under the tie-bar, and used for painting, glazing, and finishing. The cost of the roof of the Cannon-street Station had amounted to £49 10s. per square of 100 superficial feet of area covered, measured between the walls. The cost of the roof of the Charing-cross Station was £39 per square. In both instances the price of iron was high, the contract price for wrought iron in place in the roof being £24 5s. per ton.

The booking-offices, waiting-rooms, refreshment-rooms, &c., were at the north end, at right angles to the lines of way, and were chiefly situated on the ground floor of the building which, above and below them, formed the City Terminus Hotel.

The parcels offices, stores, cellarage, &c., were in the basement of the station, access from the rail level being given by means of stairs; while hydraulic lifts were provided for raising and lowering the parcel trollies. There were nine lines of way in the station, of which eight lines were alongside platforms, one line being set apart for spare stock and standing room. The eastern and western platforms were each 13½ft. wide at the centre, the general departure platform was 19ft. wide, and the general arrival platforms were 12½ft. wide opposite the cab road, and about 30ft. wide beyond. The principle of having a line of railway on each side of the platform, instead of a platform on each side of a line, was believed to be the most economical in space, and, relative to the space occupied, the most economical in working. The area of the platforms which were alongside trains was 43,877 superficial feet, and the length of the trains accommodated was 4,778 lineal feet, giving about 9 superficial feet of platform for each lineal foot of train.

The station-yard and signals were then described; and it was stated that the arrangement adopted was, that every line should approach every platform without back-shunting, excepting only the platform on the western side, which was to a great extent devoted to the short traffic to and from Charing-cross. This principle had been carried out by means of about forty pairs of points. The signal-box was 42ft. long by 9ft. wide; there were four posts, with twenty-four semaphore arms, eight arms being for "out" trains, and sixteen for "in" trains. The signal-box contained sixty-seven levers, of which thirty-seven worked signals, and thirty worked points. The signals locked the points and each other, so that no contradictory signals could be given; nor could the permission for ingress to or egress from any platform be given until the points were arranged in accordance with the signal for that particular platform. An idea of the duty performed by this apparatus, which was erected by Messrs. Saxby and Farmer, might be formed from the fact, that 775 trains had passed under the signal bridge in a single working day. One morning lately thirty-five trains were signalled and passed in or out of the station in thirty-five minutes. Mr. Walker's electric telegraph apparatus, which worked a miniature semaphore distance-signal in each box, was used for signalling the trains on the block system.

The cost of the works of the City Terminus Extension was £505,336, and of the whole Charing-cross Railway, including the extension, £1,160,118, or including land, somewhat more than three million sterling. In this sum, it was to be remembered, were included about 4½ miles of railway for a double line, two large bridges over the river Thames, a considerable number of expensive street bridges, and two of the most extensive metropolitan termini. The importance of the traffic, which was not at present fully developed, might be gathered from the fact that, during the year ending the 1st of January, 1868, being the first year since the City Terminus Extension Railway was opened, about eight million passengers used the Cannon-street Station, of which number about three million and a-half were local passengers between Cannon-street and Charing-cross. At the present time about twenty-six thousand passengers used the Cannon-street Station daily, and the South-Eastern Railway now conveyed about fifteen million passengers annually.

## ON THE EXPERIMENTAL DETERMINATION OF THE STRAINS ON THE SUSPENSION TIES OF A BOW-STRING GIRDER.

By Mr. W. Airy, Assoc. Inst. C.E.

Although in this communication the case of a bow-string girder, as ordinarily constructed, only was considered, yet the author believed that the principle, on which the strains had been ascertained, was equally applicable to all mechanical structures with complex bracing, as, for instance, station roofs, where the labour and uncertainty of a theoretical calculation rendered an experimental investigation exceedingly desirable.

The model on which the experiments were made was composed of a bow of steel, and had a span of 6ft. with a rise of 1ft.; the string being constructed of two slips of oak, and the suspension ties being of steel wire, gauge No. 26 (96ft. to the oz.).

The process by which the tensions were ascertained was the following: the ties, on being sounded, gave a good resonant musical note, and advantage was taken of this to compare the note of any string with that of a free string suspended in a frame, and cut off by a sliding bridge to the length of the string under comparison. The free string supported a small scale-pan, and this scale-pan was loaded with weights till the note of the free string and that of the string under comparison exactly coincided. This was determined by ear with the greatest accuracy, the effect of ½oz. in 80oz. being clearly perceptible. The tension of the string on the girder was thus measured by the weight in the scale-pan of the free string; and this was done for every string in every case.

The determination of the thrusts was arrived at by a differential process, thus:—A uniformly distributed weight was applied on the girder, and the tension of every string was taken; then a travelling weight was introduced in addition, and hung at any one point, and the tension of every string was again taken: the difference of the tensions in the two cases of each string being regarded as the thrust, or tension, of that string produced by the travelling load.

The reduced results of the experiments, comprising the effect of every possible arrangements of loads that could come on a girder, were given in diagrams. It was verified by experiments: 1°, that the tension, or thrust, of every string was proportional to the weight causing it; and 2°. that when several weights were applied at the same time, the effect on every string was that due to the sum of the effects which would be produced by each of the weights separately.

The rules by which the strength of ties should be regulated, as deduced from the experiments, were, for an evenly distributed stationary load, that all the bars were in tension, that the end uprights were most strained and the middle ones least, and that, with respect to the diagonals, those were most strained which radiated outwards from the points where they met the string—the strain on each of which might be taken at one-half the load due to a bay—those that radiated inwards from the points where they met the string being strained to the extent of one-fourth the load due to a bay. In the case of a single moveable load, the uprights were liable to a tension of from $\frac{19}{34}$ to $\frac{1}{6}$ of the weight, as the load advanced from either end towards the middle, and the greatest tension to which the diagonals were liable was one-fourth, and the greatest thrust two-thirteenths of the weight.

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## MANCHESTER ASSOCIATION FOR THE PREVENTION OF STEAM BOILER EXPLOSIONS.

The last ordinary monthly meeting of the Executive Committee of this Association was held at the offices, 41, Corporation-street, Manchester, on Tuesday, March 31st, 1861, Wm. Fairbairn, Esq., C.E., F.R.S., LL.D., &c., President, in the chair, when Mr. L. E. Fletcher, chief engineer, presented his report, of which the following is an abstract:—

During the past month 273 visits of inspection have been made, and 612 boilers examined, 421 externally, 21 internally, 18 in the flues, and 152 entirely, while in addition 12 have been tested by hydraulic pressure. In these boilers 130 defects have been discovered, 12 of them being dangerous, thus:—Furnaces out of shape, 2; cases of fracture, 25—5 dangerous; blistered plates, 8; cases of internal corrosion, 25—5 dangerous; external corrosion, 6—1 dangerous; internal grooving, 10; external grooving, 6—1 dangerous. In addition to which the following fittings have been found defective: water guages, 4; blow-out apparatus, 5 safety-valves, 4; pressure guages 3; while in 13 cases feed back pressure valves have been omitted where they should have been supplied.

Many of the defects enumerated in the previous list proved of a serious character, but they were of a class so similar to those frequently referred to on similar occasions, that a detailed notice is hardly necessary, and therefore it need only be stated briefly that several of the cases of fracture occurred at the seams of rivets at the bottom of externally-fired boilers, and not only in those fired by hand, but also in those fitted with Juckes's furnaces, while one of the cases of fracture was due to defective staying of the flat end plates of a double-flued boiler. Other dangerous defects were met with, arising from internal corrosion, the rivet heads being seriously wasted, the plates thinned, and the edges of the overlaps eaten away, while boilers resting on midfeathers were seriously corroded, though this could not be detected till the brickwork was removed, which shows the importance of sight holes being ploughed out in preparation for inspection, as previously recommended.

### Explosions.

Only one explosion has occurred during the past month, and, happily, no one has been either killed or injured. I have, however, to report on No. 7 Explosion, particulars of which were not received in time for the last report, though it occurred in the preceding month. Not one of the exploded boilers was under the inspection of this association.

In addition to these, I may perhaps make brief reference in passing to the bursting of a hot water boiler, and four cases of scalding, by which three persons were killed, and three others injured. The mention of these may prove serviceable as a caution.

The explosion of the hot water boiler occurred on Thursday, Jan. 9th, when one person was injured, but fortunately no one killed.

The first case of scalding took place on Friday, Jan. 17th, at a printworks, at which two lads were engaged inside a kier, either cleaning it out or arranging the goods, when a stop tap in the pipe connecting it to a range of boilers was suddenly opened, and the steam turned in upon them, in consequence of which one of the poor fellows was so severely scalded that he died the same day. These taps are now fitted with padlocks to prevent their being tampered with when anyone is inside.

Another case of scalding occurred on Wednesday, January 22nd, through the bursting of a steam pipe at a rolling mill. It appears that the engineman was about to start his engine the first thing in the morning, when just as he was in the act of opening the steam-valve close to the engine, the pipe was shattered in pieces, and the poor man so seriously scalded that he died the same day. The explosion has been attributed to the engineman's not having drained off all the water formed by condensation in the steam pipe before opening the steam valve. The engine had been standing all night and was situated at a considerable distance from the boilers, at least 100 feet, the steam pipe being carried in an underground tunnel. Under these circumstances no doubt a good deal of water would be formed in the pipe, and it has been thought that as soon as the valve was opened the water was carried along by the rush of steam, when, on arriving at the steam-valve box, it acted as a water-ram or hammer, and thus split the valve-box in pieces. If this view of the matter be correct, it is clearly very important that all long ranges of steam pipe should be thoroughly freed of water before the column of steam with them is set in motion.

The third case occurred on Thursday, February 6th, at a dye works, at which it appears two men were engaged in tightening the cover of a steam dye pan, when it was blown up through the roof of the building, and one of the men killed and the other injured. Full particulars have not been obtained, but it may be remarked that, as a rule, it is not wise to tighten joints with steam up.

The fourth case of scalding was due to the blowing off of the mudhole cover of a small vertical portable boiler, 7ft. 6in. in height, and 3ft. in diameter, employed in driving a crane on some large public works in process of erection. It appears that on the morning of Monday, March the 9th, the attendant got up steam in this boiler for the first time after it had been cleaned out, and when he had raised the steam to a pressure of 40lb., perceiving that the joint of the mudhole cover began to leak, he attempted to tighten it by screwing up a central bolt three-quarters of an inch in diameter, by which it was held, when the bolt snapped in two, and the cover, which was an external one, was blown off, and the poor man so seriously scalded by the rush of steam and hot water that he still lies in the hospital in a very dangerous state. It is extremely unwise to trust external covers merely to a single bolt. There should always be a series, while, as shown by past experience, it is dangerous to tighten up such covers when under steam pressure.

Explosion No. 7, which resulted in the death of two persons, occurred at six o'clock on the morning of Wednesday, Feb. 12th, at a paper mill.

The boiler was one of a series of three, connected together and working side by side at a pressure of about 42lb. on the square inch. The exploded one was of different construction to the others, and of a type sometimes used in tug boats. It had two cylindrical internal furnace tubes running into oval-shaped flues, between which a return flue was introduced which had to be squeezed up into a flat-sided shape, in order to be got into the confined space. The length of the boiler was 20ft. 3in., the diameter of the shell 7ft. 3in., and of the furnace tubes 2ft. 9in., while the return flue in question measured about 10ft. 6in. in length, 2ft. 8in. vertically by 1ft. 8in. horizontally, and the plates in the shell, as well as in the furnace and flue tubes, three-eighths of an inch in thickness. To strengthen this oval return flue, the flat sides were connected to the flues on each side by a single row of five short bolt stays 1⅛in. in diameter, spaced about 1ft. 9in. apart, and screwed into the plates at each end, but not riveted securely over.

The boiler failed at this oval return flue tube, the right hand side of which collapsed laterally from end to end, and rent at a transverse seam, when the steam and hot water rushed out through the furnace mouths, carrying away the firebars, bridge, mouthpiece, and door from the left hand furnace, and projecting them with so much violence that they penetrated through the wall of the mill, at a distance of about 20ft., and so severely scalded and injured a man working inside, that he died shortly after, while the fireman also, who was standing near the front of the boiler at the time, was scalded to death.

The cause of the explosion was clearly the malconstruction of the boiler. The form was weak, and the stays altogether defective; those on the right-hand side of the flue, which collapsed, all gave way, four of them stripping the threads, and tearing out of the holes, while the fifth broke short off through the thread, leaving the screwed stump still in its place.

The coroner's jury brought in the usual verdict of "Accidental death;" but this boiler was clearly ill-adapted for the general run of land service. Such a form of construction is only admissible where want of room, as on board a ship or other peculiar circumstances, render it imperative, and then the boiler should only be worked at a low pressure, while the stays should be much more numerous, and more thoroughly secured, and the whole subjected to frequent and searching examination. It is to be regretted that steam users should lay down boilers on which the lives of their workpeople depend without competent advice, and though it is stated that the makers examined this boiler but two months before it exploded, the fact of their having done so and passed it as sound, only shows that makers are not always to be relied on either as boiler inspectors or boiler constructors, and that the only safety for steam users lies in a system of competent independent periodical inspection.

No. 8 Explosion occurred at five o'clock on the afternoon of Tuesday, March 3rd, at a small iron foundry. Fortunately, however, though the premises were altogether disorganised and an adjoining building brought down, yet no one was either killed or injured.

The boiler was of horizontal cylindrical construction, externally-fired, 18ft. in. long, 4ft. in diameter, made of plates three-eighths of an inch thick, and worked at a pressure of about 50lb. on the square inch. Both of the ends were flat, or very nearly so, and stayed with only a single longitudinal tie rod, measuring 1¾in. square, and connected to them at the centre by means of a round pin 1¼in. in diameter, which passed through the end of the rod, and a couple of angle irons riveted to each end of the boiler.

The boiler failed at the flat ends, both of which were blown out, rending through the root of the angle iron attaching them to the shell, the front end being thrown into the workshops, and the back into a pond at a distance of about 50 yards, while the shell, though lifted from its seat, was moved but a few feet. Bricks and other *debris* were shot to a considerable distance, some as far as 150 yards, while the foundry was brought to a standstill, an adjoining coach-house and stable, in which a horse as well as a gig were standing, were demolished, the gig crushed to pieces, and the horse buried in the ruins.

The cause of the explosion is simply the malconstruction of the boiler. The pressure of steam on each of the flat ends amounted to about 40 tons, and for this they were not adequately stayed. The pin at the back of the boiler, passing through the eye of the longitudinal tie bar, already described, broke short across, when boths ends were suddenly left unsupported, and must have been blown out almost simultaneously.

This explosion may prove a useful caution to those of our members who have boilers fitted with diagonal or other bolt stays attached with pins. It is frequently my duty to point out the danger of this mode of connection, but the warning is too generally considered as unnecessary. These pins, however, are often taken out by the attendants and forgotten to be replaced, when the stays become worse than useless, and lead to false confidence. One of the association's inspectors, on recently examining a boiler, found that three stay-pins had been removed, and were lying loose at the bottom, while the explosion reported above is by no means a solitary one resulting from the failure of these stay-pins, either through omission or fracture, so that it is trusted the members will see that the warnings given with regard to these pins are not unnecessary.

## INSTITUTION OF NAVAL ARCHITECTS.

### ON THE ENGLISH MEASUREMENT OF TONNAGE.

By M. Ananias Dekke, of Bergen, Norway, M.I.N.A.

As there appears to be a general desire among several of the Western nations to adopt an universal standard of weights, measures, coins, and so forth, throughout the world, and as the English rules for measuring ships seem the most likely to be accepted, at least as groundwork for an uniform system, I think it may not be unreasonable to seek the opinion of the Institution upon some points in the Merchant Shipping Act of 1854 respecting the measurement of tonnage. In raising this question, I am very far from any idea of venturing to propose anything different from the present English rules as best suited to England, but I am desirous to do all in my power to facilitate the adoption in my own country of the English rules, in order to secure the benefit of an international system.

The Norwegian rule for the measurement of ships was established in 1845, and is as follows:—

"Measure the length of the ship on the deck from inside of stem, or inner edge of hawse timbers placed alongside stem (if this gives a greater length) to the after edge of sternpost, both measures at the height of the deck line. From this measure deduct 1½ per cent., and the remainder is to be reckoned as the length of the ship, called D E. Divide this length into four equal parts, and set them off from the stem. Then find the tranverse areas of the three different points of division called F for the foremost, M for the middle one, and A for the aftermost (the first and last points at the stem and sternpost going for nothing), as follows:—

"1. In ships with only one deck.

"Take the upper breadth, called C C, from inside of ceiling of one side to the other close below the deck; then take a horizontal breadth, A A, at 0·75in. above the lowest point of the ship's bottom of the ship D E, divide the product by 3, and the quotient is the cubical content of the ship.

"2. In ships with two decks.

"In the lower hold the measures are to be taken, as in a single-decked ship; but in the upper hold, at the three points of division, F, M, and A, there must only be taken the height between the decks and the breadth at half the height. These two measures are then to be multiplied together, and the content of the three areas are added to the respective areas of the lower hold before the calculation of the cubical content of the whole ship is commenced. The cubical content is divided by 165, and the quotient is the burden in Norwegian commercelæsters."

From this it will be observed that the Norwegian rule of 1845 is based on the same principle as the present English, this last one being only different in a few details, and that mostly in having the numbers of measurements that are to be taken increasing in proportion to the size of the ships. Although it might be thought the most just way of measuring to have the numbers of measures to be taken alike for all ships, of whatever size, because it is not easy to see why a large ship should be measured in a more strict manner than a small one; still I shall not speak any more about this, because it is made for the sake of getting the cubical content as accurate as possible; and, further, has the advantage that it prevents bad forms of ships being made to evade dues upon tonnage; but what I think ought to be altered in the English rule is the standards upon which the increased numbers of areas are to begin.

The English rule states the stations of areas as follows:—

| | | | | | |
|---|---|---|---|---|---|
| Class 1. | Length of 50ft. and under | | | into 4 | parts. |
| „ 2 | „ above | 50 | „ 120ft. | „ 6 | „ |
| „ 3 | „ „ | 120 | „ 180 | „ 8 | „ |
| „ 4 | „ „ | 180 | „ 225 | „ 10 | „ |
| „ 5 | „ „ | 225 | „ ... | „ 12 | „ |

These, I think, are too many areas, particularly for the smaller ships; and although it is made to secure the greatest possible accuracy, it gives, on account of the great number of areas, in many cases quite a contrary result, because it cannot be carried through in all ships, but makes the use of Rule II. necessary for a great number of them; and I need not say how inaccurate and unjust this rule is, but shall only call attention to the following list of ship-drawings of the different forms, that I enclose, and which I have measured for the purpose, not only with the numbers of areas as presented in Rule I., but but also divided in four parts with only five areas (including the one at stem and stern), and further with the English Rule II., the Norwegian Rule I. and Norwegian Rule II., which last one, like the English Rule II., is an outside one, namely:—

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Difference between English Rule I. and English Rule II. | Per cent. | + 7·87 | + 5·15 | + 2·94 | +27·13 | +12·09 | + 21·5 | + 44·2 |
| Difference between English Rule I. and Rule I. with only four parts. | Per cent. | + 2·32 | + 1·11 | + 0·16 | + 0·96 | + 0·53 | + 0·74 | + 0·99 |
| Proportion between Norwegian Commercelæster and Tons from English Rule I. | | 1·8383 | 1·8733 | 1·8625 | 1·8626 | 1·8418 | 1·8560 | 1·8378 |
| Rule I., Norwegian Head-rule in Commercelæster. | | 412·5 | 297·3 | 262· | 249· | 170·03 | 98·79 | 46·49 |
| Rule II., present Norwegian, made out in Tons. | | 788·8 | 566·4 | 492· | 554·44 | 339·12 | 218·8 | 126·1 |
| Rule II., English. | | 817·93 | 585·6 | 502·5 | 589·6 | 350·9 | 222·9 | 123·23 |
| Rule I., with only four equal parts. | | 775.91 | 550·72 | 488·78 | 468·25 | 314·69 | 184·72 | 86·22 |
| Rule I. | | 758·30 | 556·92 | 487·99 | 463·79 | 313·04 | 183·36 | 85·44 |
| Dead Rise of Midship Frame, Degrees. | deg. | 7 | 8 | 8 | 8 | 13 | 17½ | 28½ |
| Angle of Water-line in Degrees. | deg. | 31 | 40 | 31½ | 22 | 35 | 27 | 24 |
| $\frac{\text{Displacement.}}{L \times B \times \frac{2}{3} H.}$ | | 0·6173 | 0·6413 | 0·61125 | 0·5344 | 0·6022 | 0·4936 | 0·3954 |
| | | Lina<br>two-deck ship .................. | Constance<br>flat bottom, full ends ............ | Bergenseren<br>flat bottom, sharper ends ......... | Hebe<br>flat bottom, very sharp ends ...... | Nordlyset<br>medium, sharp bottom and ends | Cuba<br>sharp bottom and sharp ends ... | Hagleik<br>extremely sharp bottom and ends |

And anyone, I think, will confess that there is a much greater injustice done to all those ships which are obliged to be measured by Rule II., than advantage gained by taking the great number of areas in ships whose fittings in the hold permit it. It is true that the difficulty of using Rule I. only exists with ships that are already in use at the time when the new system is introduced, and that it can be carried out in all new ships before the fittings in the hold are made up, and I should therefore not have any objection against it for all new ships; but on a very great number of our present shipping it is impossible to use Rule I., on account of their having cabin and forecastle below deck, which interferes with the foremost and aftermost sections in the hold. The average size of the commercial fleet of Norway is about 64 commercelæsters, or about 120 register tons, and it will easily be seen that when, as is often the case, the cabin and forecastle are below deck, and ships of this average size, of between 50 and 120ft. length, are to be divided into six parts, then there will be only from 8½ to 20ft. from the points at the stem and stern to the nearest sections, and in almost all these cases the cabin and forecastle will interfere with Rule I., when below deck, and thereby make Rule II. necessary.

The loss is not only either the unjust increase of *higher* dues that are paid by those ships that are measured by Rule II., but a certificate for tonnage measured by Rule II. probably has no international value. Then these ships are also obliged to be measured again and again in the different ports at different times, and with such operations money as well as time is lost; and of course they have no benefit at all from an international system, if the English Rule I. is to be carried out in its present form as a standard for an international certificate.

Now, the increase of tonnage by the adoption of Rule II. averages 17·25 per cent. in all classes, and *may* reach 44 per cent., as shown in my comparative list of measurements by both hulls, taken from drawings of actually existing ships, and not of fancy ones. When these classes (including the one which loses 44 per cent. Rule II.) are measured by Rule I. with the full number of sections, or by the same rule with only four parts or three intermediate stations the difference in only one case exceeds 2 per cent. It reaches 2·32 per cent. in the case of a two-decked ship, while in another case it is 1·11 in defect; in five cases difference does not reach 1 per cent., and in all the seven classes taken the together, the aggregate error is not more than 0·81 per cent. I hope, therefore, that it will be admitted that some reduction may be advantageously made in the number of sections, and that this reduction will help to secure a fair and just system applicable to all ships, seeing that it will render it possible to measure by the same rule (No. I.), ships having cabins and forecastles between decks.

The saving of time in measuring with less sections I do not care so much about, and I should not propose reductions in the number of sections for that reason, although loss of time and thereby expense is also a thing to be considered; but, as before said, it is the consequence arising from the impossibility of carrying Rule II. through in a great many cases that I think most about. I should therefore wish that the number of sections should at least be reduced to

| | | | |
|---|---|---|---|
| | 150ft. length and under | in | 4 parts |
| from 150ft. | to 200ft. | „ | 6 „ |
| „ 200ft. | „ 250ft. | „ | 8 „ |
| and above 250ft. | ... ... | „ | 10 „ |

by which two the above-named vessels, the *Lina* and the *Hebe*, would be measured with 6 sections, and the result would then, for these two, be:

| | Rule I. | Rule I with 6 sections only. | Difference. |
|---|---|---|---|
| *Lina* ......... | 758·30 ........ | 765·37 ......... | 0·93 per cent. |
| *Hebe* ......... | 463·79 ........ | 464·68 ......... | 0·19 per cent. |

and when the sum of these two differences is added to the sum of the differences in the other five cases, which remain unaltered, then the average difference would only be 0.34 per cent.

I now ask the Institution to be so kind as to pronounce their opinion about this, not because with reference to the use of English rules in England, as I have said before, but because I think upon the possibility of introducing the English rules into Norway, and because I think Norway would so much more readily accept them when the worst consequences of the system were no more. I think it also, of course, quite sufficient for my country if England would only say that it, for already existing ships, approved a cercertificate of tonnage, measured with this proposed reduced number of sections in cases where Rule I., as now consisting, could not be carried through, and I think that this object would be facilitated (if Norway desired to adopt the plan) if the Institution would give an opinion in favour of my proposal.

About taking the length of the ship, I should also wish to see an alteration, although it is of no importance at all, compared with the question about the number of sections, because it is not quite an easy task for a custom-house officer, without any knowledge of shipbuilding, to determine with accuracy the point at the stern. There is generally a thick strake or waterway across the stern that exceeds the height of the deck several inches, and the officer has then to calculate not only the rake of the stern timber in the height of the waterway, but also the shape of the stern timber below deck, and the rake in the thickness of deck and one-third round of beam. This is, I think, really too minutious and, in many cases, impossible to determine with absolute accuracy, and at the same time I do not see why this very small piece, which generally is of no use at all worth mentioning, should be reckoned in the tonnage. Moreover, this addition in length gives not either a result proportional to its increase, because it brings the sections so much further aft, where the ship of course is sharper; and with all this I think it better to fix the length as that between stem and sternpost as points that are much easier to be found with accuracy, and to take the length at the upper side of the deck, and not care about the deductions for rake in thickness of deck and one-third round of beam.

I should also wish that the deductions for the one-third round of beam were entirely omitted in the rules, because it goes a great way to make the operation more tedious, and the increased tonnage that would result from taking the height close to the deck amidship would perhaps be about counterbalanced by the loss of tonnage on account of the shorter length if taken only from stem to stern-post, and in no case could the difference be anything to speak about.

## ON TESTING IRON BY MAGNETISM.

By S. M. Saxby, Esq., R.N., Associate.

I have the pleasure of offering some remarks on a mode of testing iron both as to condition and quality, by means of magnetism. Its main feature is, that articles made of iron can be rapidly tested without damage to them or defacement. Our only present means of ascertaining the condition of iron is one which often causes the evils we wish to avoid. We have only an imperfect and destructive system, and this only applies to quality, not to condition.

By "condition" I mean the state of the metal whether as regards adventitious and accidental combinations, either chemical or mechanical, or with regard to faults and accidents in the process of forging, welding, and so forth.

To prevent misconception it is better at the outset to declare that I do not profess—I never have professed—to be able to do more than test forged articles or castings, whether of iron or steel. Whatever comes off the anvil (with an exceptional case or two which I will explain presently) falls within the scope of my powers; but I wish it to be distinctly understood that hollow iron (iron purposely made hollow) excepting guns and small arm barrels, have scarcely had any of my attention beyond a casual testing at the desire of parties whose anxiety to witness the possible limits of a novel and interesting operation could scarcely, with any consistency on my part, have been treated with indifference. Nor am I, consequently, responsible for any unexpected results in my first in my first attempts. It is one thing to study results of testing a bar of iron, the particulars respecting the preparation of which have been previously communicated to me, and in which known facts could be compared with results of testing; and quite another thing to have placed before one a suspected bar, the tamperings with which I had reason to imagine to be the work of some of the ablest smiths in the kingdom, and devised on purpose to mislead and deceive me. My experiences have been chiefly derived from these severe ordeals, which surely are better calculated to confuse and discourage than to instruct and explain. In the former case we can profitably and calmly investigate, but in the latter—and especially where we are expected to explain every step of what we are doing—even if we are accumulating facts, they are only heaped together without connection or time for arrangement.

Now, without occasion for entering into minute speculations as to the connection between iron and magnetism, it will perhaps suffice to assume (what I believe is fully admitted) that a mass of iron is an aggregate of distinct particles, each of which has polarity; that these particles are (among themselves) not in immediate contact. I also assume that what we call "pure" iron, as used in commerce, is that which is best adapted for manufacturing purposes generally, so far as regards strength in every direction, and that a test of the goodness and purity of iron is reasonably supposed to be its capability of being tied up cold into a compact knot. As an illustration of this I produce a sample of iron, which, when pulled into this form cold, only broke at a strain of 43 tons per square inch.

I also assume that tensile strength, however useful for some purpose, is but an insufficient test of what is called goodness in iron; inasmuch as it only indicates strength in one direction, and is not incompatible with brittleness.

I further assume that if each particle of iron has polarity, the whole mass made up of any number of such particles is a magnet inductively so, if the iron is pure and soft: and permanently so, if in the state of steel or cast iron; the magnetic force having a decided connection with the presence of the carbon. Hence I assert that the old notion of magnetism existing only on the surface iron is an error, and one that I will presently overturn by direct experiment.

I assume still further that strength in iron is a consequence of a certain molecular condition resulting from magnetic causes.

Now the above form the groundwork of my system of testing, and if conceded enable me at once to proceed to illustration, but I would first suggest that it will be necessary to further concede that we never know when we have put a piece of iron into a blast heat (as in a forge fire) whether it will come out thereof in an altered or unaltered condition. Last year in this room an eminent steel manufacturer, Mr. Rochussen, told us that he had doubted whether, in the process of forging, a shaft of steel as put into the furnace did not come out an iron one. His words were: "if in a puddled steel shaft, when it is finished, we have reached perfect homogenity it may also follow that by the frequent reheating which it has required in order to become a perfectly weldable mass, it has been reduced to iron. If a shaft made on that principle is sound it is iron, if it is steel it has all the elements of weakness from not being prepared. Steel which will work well, which will equal iron in all its virtues, and which will excel in its working strength, cannot be made beyond 34 to 36 tons per square inch." My experiments and observations on a small scale had convinced me of the same thing, and I arrived at my opinion in the following manner:—

We may describe steel as iron, plus certain other ingredients. Now to remove any part of these other ingredients is to alter the whole character of the steel, and to remove them almost entirely is to leave the iron in a state of greater or less purity in the place of steel.

The other ingredients are the fluid particles which fly off under the blows of the hammer; these blows when given at a welding heat are essentially a purifying process. On examination we find that the squeezed-out portions are not iron, for iron has a specific gravity of about 7·7, while these globules have a specific gravity of at most 5·5, generally less. And again, this oxide, dross and impurity as we may call it, is easily pulverised in an agate mortar. I have a sample here in the state of an almost impalpable powder; it has not the tenacity of the metal iron at all, so that the conversion of steel into iron by the mere process of forging is but reasonably to be expected. But admit this—and where are we? We are calling things by wrong names—we call that steel which was once steel, and where we are thinking we have the qualities of steel we have absolutely those of iron; and whether iron purified in the manner just alluded to has superior qualities remains to be proved.

I can only say that Bowling iron (of which I shall speak presently) when subjected to my magnetic testing, shows many characteristics of steel. With so great a variety then in this condition of forged articles, without at present any means excepting a destructive one of knowing this condition of detecting it, I submit that if I can offer you a ready method of examining iron articles I may with confidence appeal to your kindness to receive my imperfect demonstrations with indulgence. Let us ask a smith the quality of a piece of iron, and what does he do? If he may cut it, or file it, or break it, he will tell you; but ask as to its soundness and he can only prove that by the testing machine. This is what I propose to remedy.

We are told that if we take a magnetised bar of iron or steel and divide it we shall have two separate magnets, each having its north and south poles; further divisions of these produce smaller and smaller magnets, until our powers of further mechanical division are exhausted. It is easier thus to bring the mind to recognise the minuteness of the polar particles of a mass of iron held together by means of such polarity. That this "holding together" differs from what is commonly called cohesive force (which belongs to all solids) is a peculiar and distinctive characteristic of a few metals, such as iron, cobalt, nickel, and so on, and it is thus illustrated: Take the well-known experiment of suspending a series of small steel pins at the end of a powerful bar magnet (*vide* diagram). If the end be the north pole, the upper end of each needle will be a south pole, and the lower end a north pole. The pins are, of course, sustained in position by magnetism, which in this case is a cohesive force. Whatever may be its nature let us imagine its action to be analagous to that which exists amongst particles or molecules of iron, as favourably placed when north and south poles alternate, as they do in the diagram; let us, in fact, for the occasion, view the mass made up of bar and pins as a solid, its parts simply held together by cohesion. If we reverse or interrupt the force which connect the needles and bar (and we can easily do it) separation instantly follows; cohesion is destroyed, but the so-called cohesion which we are using is magnetism—magnetic force—and that cohesion constituted the tensile strength of the solid; therefore who can say that magnetic force in iron is not strength in iron. This, then, is the main point.

If we interfere with that favourable condition which is the element of strength in iron, viz., north pole to south pole, and so on, we cause weakness in the metal. We derive hence an axiom that—"Continous polarity in iron and steel constitutes strength, while its disruption or solution is weakness, and flaws and fault are examples of such weakness." Now, the amount of magnetism in a piece of iron, or rather the amount and peculiarities of polar condition in a piece of iron, are measurable; therefore if strength in iron is magnetism, so is strength in iron measurable; and as any common compass is a magnetometer, so ought we, by the use of the compass, to be able to measure strength in iron and to detect its weaknesses.

This is a wooden model of a piece of round bar iron (to full scale), 14in. long, and of 4in. diameter. The piece of iron which this represents was prepared as to size under my directions in order to test the power of a magnet over the interior of a solid mass; and as I am not aware of any direct experiment having been recorded on the subject, I would ask permission to give some rather important, perhaps interesting, details. By leave of the captain-superintendent, I requested a most able and intelligent master smith at Sheerness to heat the mass to a bright heat; to slit a hole in the side of it at the middle, and while hot to drive in a piece of steel, so that it might lie exactly in the axis of the bar. Instead of complying, he thought it better (as it undoubtedly was) to drill a ½in. hole in the axis from one end of the bar; drop in a steel pin, and then carefully weld the whole together, solid; so that I should have what I wanted, viz., a piece of steel imbedded in a solid coating of iron in every direction, quite away from the surface. but in such a manner that neither the situation, nor size, nor shape, nor condition of the steel should be previously known to me—nor had I the least idea of either; indeed, I tested under the impression that he had complied with my request.

I mention these details to show the actual value of this experiment, and they will convey to you those insights into the power of magnetic testing which without them would need a great deal of illustration. It is better to describe in detail one experiment than to imperfectly glance at many. I naturally felt with my compass about the centre of the bar in this way, but could find no steel there, and at once said so—fully suspecting some trick—but the master smith declared that he *had* enclosed the steel. Under some very natural but momentary perplexity—for it was a very severe trial—I carefully ran my compass up and down the side of the bar, thus, placed the iron *in* the meridian, *out* of the meridian, in the line of dip, and until corroborations of compass disturbance near one end (just here) advised me of evident local interference with, or disruption of, that molecular alternate polar continuity to which I have called attention. Placing as I now do a chalk mark, saying, "The pin is here—am I right?" He replied, "Not exactly." I requested him to lay off with his rule the exact position of the pin, instead of which he merely said, "That is only one end of it—where is the other?" I could not at first with any certainty find it, and here my experiments might have ended; but I had noticed that the needle showed diminishing unsteadiness as it approached the one end of the bar. A moment's consideration, therefore, convinced me, and I confidently declared that the one end of the steel pin, as at first detected, could not have been properly welded into the mass of iron—that the other end must have been thoroughly combined with the iron.

The master smith then accurately measured off the position of the pin (as seen in the diagram), and punched in both my chalk marks and his own marks so fix them. Perhaps, however, I have yet to state the most extraordinary and most significant results of this examination, the consequences of which I believe, if followed up in a right spirit, will prove an immense saving of public money. With all brevity I will say that next morning I obtained leave from the Colonel-Commandant of the Sheerness garrison (Colonel Crofton) to try my hand at testing a large gun; and supposing an Armstrong to be the more complicated in its form than others, I obtained permission to test a 40lb. Armstrong for flaws and fractures. Within half a minute's testing I had exclaimed to Lieut. Goienes (gunnery instructor), who had kindly placed the gun for me in the magnetic equatorial plane, E. and W., "Something wrong here; I can trace something wrong, and a fault of some sort runs half round the circumference of the gun." I had then no idea that the barrel was made up of coils. On his sending his sergeant for the gun's register (No. 133), he read in it the word of a flaw just where I had worked it, and not far from the muzzle. On the same occasion, and with equal success, I tested two 32-pounders and three small-arm gun-barrels, in each case pointing out defects, which had been previously known to the sergeant-armourer to exist, the lieutenant watching with much interest the action of my testing compass, and confirming the accuracy of my deductions from its motions. Thus, sir, I presume to indulge a hope that I shall in due time contribute not only towards a source of great national economy, but add an additional safeguard to the gallant hearts who man our guns both at sea and on shore. I was soon afterwards describing my success with the steel pin in the mass of iron, when it was kindly hinted to me that it was all very well to state my opinion as to the condition of the pin, but that with strangers some ocular demonstration was necessary. I therefore had the bar cut, and to avoid the destruction of the precise end of the unwelded part, had my first cut made so as, if possible, to show it. It proved that I had been correct, for one end is not welded and the other is welded; and I have the pleasure of producing an unimpeachable proof of the soundness of the principles on which I found my test by magnetism in showing you the specimen itself.

To use this magnetic test effectually a fair knowledge of the main points of terrestrial magnetism is indispensable; but where, at the present day, is the master smith or his assistants who are equal to a comprehension of it? Let it even be that, in due time, an officer be attached to a testing-room in every factory where iron articles are forged or iron made, and it will amply remunerate. And further, if we consider for a moment the importance, which I now beg to suggest, of more attention being given to the mode of casting iron, &c., we shall secure more strongly a better acquaintance with the method in which we can secure the greatest strength from the least quantity of metal. My early experiments showed me that in this the generally prevailing process is defective. The want of a convenient and better mode of testing (in fact, the want of a better estimation of what I have called the continuity of alternate polarity), has been a source of much weakness in iron castings. It has, moreover, been a source of much waste. Customary fractures occurring at particular parts of an article naturally lead to the strengthening of those parts with additional metal; whereas, according to my observations, I believe in many cases that such weakness arises from the imperfect manner in which the molten metal is run into the mould, for unless the junctions of the surfaces of the hot metal occur at the same temperature the molecular condition is defective. It is nothing uncommon with me to find opposite polarities occurring in castings within the space of small portions of an inch. Now these are equivalent to flaws in wrought iron; they are absolute weaknesses, and in most cases easily remediable. Irregularity of cooling causes molecular disruptions, There is but little difficulty in the testing of many articles, such as shafts, spindles, girders, braces, knees, railway wheels, and so on, and especially such articles as revolve in a lathe during manufacture. Among these in particular are gun barrels; and perhaps I cannot better employ a few remaining minutes than in adding a few further remarks on this, I believe, nationally important branch of my subject, and especially as bearing on the safety of sailors working guns between decks or in a turret. I believe guns upon the large scale are being built of a stout iron or steel internal cylinder, and various outer cylinders. The two 32-pounders which I tested were of this kind, and yet I found no difficulty in testing them. But how much more conveniently could I have tested each part separately before being put together—how much more thoroughly? Had I been permitted to practice for a day or two (as I volunteered to do) at Woolwich a few months since, I should have increased my experience. In the case of smallarm gun barrels, how much easier to test them before the addition of staples and portions of iron or steel which complete the barrel with all the complications they afterwards cause in testing by magnetism. I scarcely doubt that we shall before long be able in a great measure to dispense with gunpowder testing to the proving of those guns only which give satisfactory results with the magnetic test. We should thus be substituting in magnetism a perfect method of proof for an imperfect—because that by gunpowder is only partial, and limited to the quantity of powder used.

A very few brief remarks as to the power of testing by compass will convey ample information as to its value. I have a piece of iron which was brought to me for my opinion (it is marked *n*). It was said to be good, but I marked it as faulty, and on cutting it at the part I marked at was found to be the case. It was the same with the piece marked *m*. I have dozens of similar specimens. The two bars marked *s m s* are samples of good and bad iron—the round one good, the square one bad.

My few examinations of rolled plate have led me to suspect that electricity, of which magnetism is, of course, a mere condition, possesses a property in some measure analogous to that pertaining to light when passing through media of different densities; if so, this would explain the difficulty I experience in testing plate iron known to be laminated. At Chatham I pronounced a plate to be "good" in quality, as it proved to be, which had very extensive laminations, and this called my special attention to some peculiarities I had not before witnessed. Now in penetrating a substance, light is subject to three different laws, viz., reflection, refraction, and dispersion. Viewing electricity as but another imponderable influence, if it be right to speak of it as a distinct influence, it is easy to conceive that electricity may in like manner be subject to a law of dispersion. If it be so it would account for the distortion of what, when rolled plate stands vertically east and west, ought to be the place of the equatorial planes, namely, at right angles to the line of magnetic dip. This law of dispersion, if applicable to electricity, is possibly evidenced by, and may be the cause of, the zigzag progress of a flash of lightning, as seen on a large scale as it passes through atmospheric stratifications of different densities, and on a small scale may be seen in the examination of a powerful electric spark by means of a photographic paper. But a passing word or two as to this suspected law of magnetic dispersion, as illustrated in the diagram, which I will explain. Now we are accustomed to associate in our ideas light, heat, and electricity as identical. But it is as easy to suppose that light and electricity are the same as that light and heat are so. But Professors Stokes and Tyndall have each already demonstrated that light and heat are the same thing. May we not, then, when obscure facts point to some novelty in the use of magnetism, and lead us directly to notice an unsuspected divergence—may we not, I say, reasonably suspect the cause to be that property of divergence which is known to exist in light, and which, if light be identical with electricity, may also exist in magnetism?

It is remarkable that, in general, we know less of the condition of iron than of its quality. The best of iron when in bad condition is virtually bad iron. I can give a striking example of the necessity for greater attention to condition, when I allude to what is called Bowling iron; it is costly, and bears the highest character. I did not specially select it for scrutiny, and if I noticed what would appear an imperfection in it, such imperfection is not, I am bound to say, confined to Bowling iron, as specimens, on the table, of iron of high repute will prove.

But Bowling iron is certainly that which has caused me surprise in testing, and as it is used wherever great tensile strength is called for, my magnetic examinations might possibly be turned towards their own interest by its manufacturers. Certainly we need some means of arriving at the condition in which accidental circumstances may have placed the best of iron.

The characteristic of Bowling iron seems to be its great "toughness," its tensile strength; but my experience in testing points prominently to the fact that such toughness is in connection with great aptitude for lateral separation of its fibres, and a strong tendency to partial crystallisation; and as absolute and perfect strength is incompatible with a want of uniformity of condition, I cannot, in my humble judgment, avoid the conclusion that much of what iron I examined at Chatham Dockyard as "Chatham Iron" is, for general purposes, and from the absence of the tendency in its fibres to separate laterally, even, if possible, superior to Bowling.

I wanted to procure at Chatham the very best sample of iron which experience could select for me as a standard of purity. The master smith selected a sample, and one of his best workmen was employed to work it into a ½in. square bar. But what was our astonishment when we found the testimony borne by my compass to be depreciating. My compass showed the condition to be unsound, and I marked the spot condemned, and on cutting the bar it was found to be partly crystallised and partly fibrous (here it is marked "C"), and therefore it is of different strengths in portions of the same section. What other test could have detected this?

And again, the specific gravity of Bowling iron varies very considerably. Taking for comparison the specific gravity of the best Swedish to reach 7·86, I find in one sample of Bowling the specific gravity to be 7·878; in another it was 7 874 (diagram 13); in another 7·775 (diagram 29); while another gives as low as 7·613.

I should be exceedingly sorry to be misunderstood in my remarks as to Bowling iron, and will now show a sample which can scarcely be surpassed for toughness (marked "E,") although on cutting it where it disturbed my magnet I detected a fault. Perhaps Dr. Percy is not far wrong when he tells us that "the occasional, perhaps accidental introduction of bad ores, and other causes, may at times produce inferior qualities of iron." I can only appeal to fact; I may have been unfortunate in the selection of samples, but the majority have been selected for me. Here are several on the table.

A few noteworthy defects on the common mode of forging iron have been detected by the magnetic test. For instance, the upsetting of a piece of iron should always be done at as near a welding heat as possible. If otherwise done it causes flaws perceptible to the magnet; and let us here remark that many faults in condition might be remedied by annealing. As an instance: At Chatham my attention was called to the fracture of a long piece of 4in. square iron, which was being forged out of best scrap. During manufacture it broke in two near the slings, certainly from vibration having caused it to crystallise; I believe it to have been very carefully worked and very good in quality, but the condition, had it not been broken, would doubtless have been greatly benefited by subsequent annealing.

And again, experiments have shown me that whether iron be forged in one direction or another, as regards the magnetic meridian, so will its strength vary. Samples on the table illustrate this. Hence we may reasonably question whether all testing machines should not be placed in a direction east and west, and for chain cables especially, in the iron of which we wish to avoid destruction of elasticity.

And again, in welding iron it is bad to use the ends bevelled, laying pieces of filling up iron across them. This crossing of fibres, even after a sound weld, is an element of weakness, and it has been clearly proved by the magnet test to be very objectionable. We have already, therefore, seen some benefits from testing by the simple pocket compass; and such as they are, I beg to offer to the public.

# ON THE TREATMENT OF STEEL PLATES IN THE SHIPBUILDER'S YARD.

By T. A. Rochussen, Esq., Associate.

The use of iron for the conveyance of goods and passengers on roads, and the consequent application of large quantities of wrought iron to rails and bridges, stimulated a facility for the production of a material which, almost at the same time when railways became in use, entered into the construction of ships.

The iron manufacture of that period was limited to a comparative small number of makers, who, trained to good work, supplied a metal the excellency of which we see illustrated by rails of more than twenty-five years' life on some of our leading railways, and the hulls of iron steamers such as the *Lord John Russell*, and the *Sir Robert Peel*, sailing from London, and others in the north, who, notwithstanding a hard-worked career of thirty years, still enjoy a green old age. The railway system, under the impulse of a very rapid development, encroaching chiefly upon landed property, fortunately found only one controller of its organisation—in the different Acts of Parliament regulating expropriation and compensation, and the infliction of a very slight and inefficient supervision of the Board of Trade, and was thus enabled to select the best material for the working of its traffic.

It stimulated the production of the finest locomotive engines, and when these heavy messengers of commerce destroyed the iron rails upon which they ran, railways as far as their finances would allow substituted steel rails. The traffic on land therefore accommodated itself to circumstances, and the genius of man rose to the requirements which man had created.

The human being, born and living on *terra firma*, appears from time immemorial to have looked upon the sea as an element where existence was extra dangerous, and thus almost every nation except the bold sailor population of Holland and Scandinavia, allowed itself, in the matter of shipping, to be guided and coerced by governments or by corporate bodies especially invested with conventional authority, such as English Lloyds or French Bureau Veritas. The interference of both, especially the former, has in its time done an immense amount of good, and while defining equitable averages of sea risks they have at the same time endeavoured by the accumulated experience of generations to establish wholesome rules for the construction of wooden ships offering the greatest security to man and merchandise.

When iron entered into the construction of ships the material was not well understood by those who, by force of habit, had to determine the mode of its application, but who were simply accustomed to the dumb strength of wood, viz., resistance to the pulling strain on a fibre, and thus sought in iron only one equivalent, that is, a high figure of breaking strain. This was fixed by Lloyd's at twenty tons, and subsequently by the Admiralty, following in its wake, at twenty-two tons per square inch with and eighteen tons across the so-called fibre. Never was the adge of a "little knowledge being a dangerous thing" more true than in the instance of this single Admiralty test. It was established in deliberate ignorance of the intelligent iron industry not only of this country but of Europe in general, at a time when the splendid qualities of such iron as Yorkshire, Sweden, and Westphalia produces ought to have been appreciated because they were known. It gave rise to the manufacture of an iron—responding to the demand for one element of strength only—to the construction of ships, many of which have gone down or broken up under circumstances where no injury ought to have been caused, more of which are still floating with the false hall-mark of a high class and sea-worthiness, and finally this Admiralty test has failed to educate the shipbuilder into the knowledge of good material, and given him the temptation to use the cheapest and worst iron provided it tested up to twenty-two tons.

It was but natural that common sense would at last emancipate itself from the trammels of absurdity, and therefore, while those merchants who had simply an insurable interest at heart continued to own ships built of regulation test iron there were others who, independent of insurance, sought security in the material of their ships rather than in policies; and thus we find that, beginning with the large steam tugs on the Rhine as early as 1851, private yachts, channel and shallow river steamers, steel was already recognised as the best material for shipbuilding. When the American Confederate war and the consequent blockade running called into life a fleet of steel steamers, three ships were built with a total disregard of the conditions of ordinary insurance—a sort of ocean butterflies—the thickness of their plates bordered upon the bounds of imprudence, and yet, I believe, only one, the Lelia, was lost in a teritic gale of wind going out of the Meresy.

While the yards of the Clyde and Mersey were full of blockade-runners, it was natural that the material came under more general notice, and thus at that period several steel vessels were built for the ordinary long passage trade, which, although classed "A1 excellent twenty years" in the Liverpool book, did not, in the definition of Lloyds, rank higher than iron.

It so happens fortunately that no official control has been exercised over the material of masts and other spars, and thus, while the owner had no interest in improving upon iron for the hull of his ship, he could with direct benefit to himself, rig his vessel with steel spars, which in the China clippers of modern build are now almost universally adopted. It would be folly to waste time in demonstrating why a light and strong material should take the place of a heavier and weaker, or to calculate the time when steel in shipbuilding will receive its official recognition as distinguished by various tests from ordinary iron. It already takes part in the most important armaments of the country, and in this instance, at least, the administration of the War-office and the Admiralty, if not on a par with that of other countries, is more alive to improvement than the more pacific authorities.

I am justified in looking upon steel as the material which our period requires and will adopt as soon as the community is technically free to use it to the best advantage; and here we enter upon the consideration of the material itself.

We are aware that steel is made from different irons by different processes, so it presents almost as many varieties as wrought iron, and whether made by puddling or Bessemering every make will in time obtain a distinct qualification of merit, such as in iron we apportion to Sweden, Westphalia, and Yorkshire. Notwithstanding this we have to deal with the general properties of steel applying to all makes, which if well understood, will facilitate its treatment in the builder's yard, as distinguished from the handling of iron, and the absence of this knowledge of the nature of steel demands the more urgently supplying, since even in this hall well-wishing friends have stumbled over bad material or good material badly handled.

We often hear, and probably with justice, that steel is not reliable—that it is not homogeneous, and people who have spent a life in successfully treating iron point with scorn at a steel plate which has split or snapped under circumstances where iron would not have sustained any injury. Thus steel yards have snapped in the truss, topmasts split in the fid-hole, plates cracked on sharp curves, and, saving the possibility of bad material inherent to all human production, the quality of the steel may for all that originally have been unimpeachable.

Steel, as many a young beginner in life, had to be saved from its friends. The belief in its breaking strain was at first unfortunately based upon the knowledge of tool steel, and it was not uncommon to specify in constructions steel equal to forty-two or forty-five tons per square inch. That metal, supplied by ambitious or sanguine makers, did not work well, or committed suicide after working, and the effect of such failures has taken some time to work off. The fault did not always arise from want of homogeneity, because of all the varieties of iron manufacture that of making steel ensures more than any other an even distribution of component particles. Having split upon the rock of hardness, and knowing what steel could not do, it seems to be agreed by makers and ship constructors that we are within bounds of safety by exacting a tensile strength of thirty-two tons per square inch.

The mild steel is adapted to every purpose intended by the builder, viz., bending to curve and punching, but with greater care than would be observed with iron, inasmuch that we have not the free command of heat which iron allows with impunity.

And it is just this important point of heat which has to decide the part which steel can play in shipbuilding, and the careless application of which has been the primary cause of such mishaps as may have occurred.

Heating for the purpose of bending through rolls when the material does not receive any elongating pressure under all circumstances entails a loss of tensile strength both in iron and steel. But with steel we run two risks, either the steel may become over-heated and slowly cooling after bending remain very soft and weak, or on the passage of the heated plate from the furnace through the rolls, a keen draught of wind, a shower of rain, or dragging over wet ground, may chill the metal, and while making it wholly or in part hard, render it unfit for a construction requiring elasticity.

Building yards are, as a rule, constructed for the requirements of wooden ships, viz., plenty of room for bulky timber; there is free access to wind and weather, and almost every operation of iron and steel is carried on in the open fair. The bending rolls are seldom roofed over, the reheating furnaces are fired from the back or sides, thus when opening the door there is a rush of cold air upon the hot plate, which then getting a chill cracks when bending through the rolls, or when hammered to a curve. Above all things it is therefore necessary either so to control the heat given in the yard within a limit which cannot be exceeded, or to dispense with heat altogether. Previous annealing has been suggested as the sovereign cure for overheating hard steel, or as affording indemnity against the danger of cracking when steel is worked too cold in the building yard. But looking at this question from an economical point of view, it must be settled whether the shipbuilder is expected to erect furnaces sufficient for the annealing of a large number of plates, and devote attention to the careful issue of an operation on a metal to which he is a stranger, or is the annealing to be done by the steel manufacturer.

Experience teaches that the annealing of cast steel gun barrels, cannon, &c., in furnaces of from 10ft. to 18ft. long, with charges of from two and a-half to seven tons, takes five to seven days. Assuming that ship-plates from ¼in. to $\frac{9}{16}$in. thick, in sizes up to 30ft. long and 6ft. wide, will require only half day firing, and a day and a-half cooling down, the annealing of 300 tons of plates per week would entail such an extension of plant and labour as materially to effect the price of the steel, independent of which the annealed plate always has a rougher surface, unsightly to the eye, and decidedly to be avoided in a ship's skin.

Annealing of large masses, therefore, being impracticable, the builder must have furnaces which cannot be overheated, or he must work the steel cold.

In order to settle both points I have conducted a number of experiments with 127 plates of all thicknesses, of the quality usually supplied to shipbuilders.

Collecting opinions on the Clyde and in England, I found that in the different yards the same steel in one yard heated simply to a temperature touchable by hand, in the other yard to a cherry red, was reported to yield the same result and that therefore a low temperature, say of molten lead, would be sufficient for all purposes.

Operating with plates, equal to a breaking strain of 38 tons and an elasticity modulus of 21 tons, the dipping into a bath of molten lead made no difference in the strength of the steel, while it worked well in punching and bending, and I therefore conclude that while this heat could not possibly hurt a good material it may serve to let down the temper of hard steel, while the expense of a lead bath, involving scarcely any consumption of that metal, would be only a trifling increase to the plant of a building yard, the more so since the heat communicated by molten lead is instantaneous, though limited to an unvarying temperature, while a coal furnace is less certain and the heating of one plate takes from eight to ten minutes. We now proceeded to treat the same steel perfectly cold, taking care to reserve from every plate a length which afterwards was to be handled with a cherry red heat. The cold plates, indiscriminately taken from stock during cold winter weather, withstood bending and punching to perfection, and I have put on the table pieces of a ⅜in. plate bent to a 9in. circle across the fibre, of a 1½in. steel plate bent to a 5ft. circle, of a $\frac{3}{16}$in. plate rolled up like a sheet of paper, of plates punched near the edge, all treated quite cold.

The corresponding halves of these plates, treated hot, of course permitted shaping and tooling equally well, but not better.

Looking at the subject superficially, it would have appeared that both heated and cold plates yielded the same result. But in order thoroughly to sift the question the different plates were put on the testing machine and gave the figures of merit illustrated by the diagrams on the wall.

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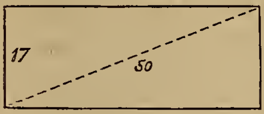

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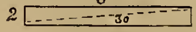

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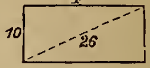

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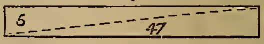

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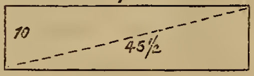

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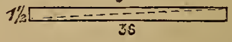

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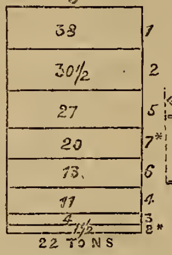

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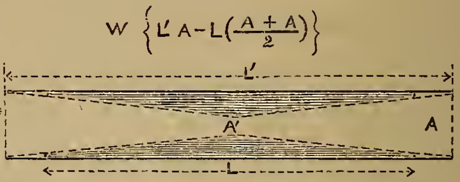

In diagram 10 we have a bar or strip L with a section A, elongating under pulling strain to $L^1$, and at the same time reducting its area at the point of greatest distress to $A^1$.

$A^1$ will be large and $L^1$ small in hard metal, and *vice versâ* in ductile material, and thus the shaded portion of this diagram represents the ductility or power of steel to contract and elongate; in other words, the faculty to distribute strength to adjoining parts. The area of this shaded portion grows with the decrease of $A^1$ and the increase of $L^1$, and it determines exactly the value of resistance to ultimate breaking strain.

By assuming the sides of the plate to the straight instead of parabolical, we arrive with sufficiently approximative truth at the formula—

$$W\left\{ L^1 \times A - L\left(\frac{A + A^1}{2}\right)\right.$$

W being the breaking weight applied per square inch. But we have to consider an equally important element in steel constructions, viz., the amount of strength which the material possesses after its elasticity has been overcome, and it is here that steel treated cold showed immense superiority over that which has been wrought at a red heat.

*Fig. 9, No. 1 represents cold worked steel which lost its elasticity at 21 tons and broke at 38 tons, showing a difference between the point of elasticity and breaking point of 17 tons. No. 2, the same metal treated hot produced the respective figures of 20 tons, 30½ tons, and 14 tons. No. 7, the same steel purposely overheated, but gradually cooled lost its elasticity at 15 tons, broke at 25 tons, with a contraction of area of 45 per cent. No. 8, the same steel heated and purposely chilled, did not elongate till 34 tons, but broke at 35 tons with a contraction of only 2 per cent.

This tenacity of the steel temporarily to hold together after its elasticity has been conquered is a useful adjunct of what I term "stored strength," and represents the power which an injured material may still exercise in a moment of supreme danger. And in order to illustrate this stored strength more fully I have added diagrams resulting from a few varieties of well-known iron.

The dotted diagonal is the ascertained ultimate breaking strain in tons per square inch, and the parallelogram of forces sufficient equally to balance this resultant of destroying forces has for its one side the ascertained difference of elasticity and breaking strain, and the area of this parallelogram is thus represented by the formula:—Difference of elasticity, multiplied by the square root of the square of ultimate strain minus the square of the difference of elasticity—

$$DE\sqrt{\left\{US^2 - DE^2\right\}}$$

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* Overheated.

Thus No. 1 is the stored strength of cold steel No. 1, the ultimate breaking strain of which, with a contraction of 24 per cent. is 50 tons per square inch, a difference of elasticity of 17 tons equal to 833. No. 2, the same steel worked hot, contracting 30 per cent. with a breaking strain of 34 tons, gives an ultimate strain of 50 tons, which, with a difference of elasticity, gives a relative value of stored strength of 672. No. 3, hard east coast iron yielding elasticity at 25 tons, breaking at 28 tons, with a contraction of 7 per cent., giving a stored strength of 89 tons. No. 4, S.C. Crown iron, breaking strain 23 tons, with 12 per cent. contraction, difference of elasticity 10 tons, gives a stored strength of 240. No. 5, Lowmoor iron with a breaking strain of 27 tons, contracting 41 per cent., yielding elasticity at 15 tons, gives a stored strength of 528. No. 6, very hard steel, not yielding elasticity till 39 tons, breaking with 45 tons at a contraction of 4 per cent. only, gives a stored strength of 276. No. 7, overheated steel before quoted, gives a stored strength of 440 tons, and lastly, No. 8, heated but chilled steel leaves but a figure of 36.

And now, reconstructing all my parallelograms as in diagram No. 9 on the base of the Admiralty test of 22 tons, we see at once how for extreme power of endurance the different metals occupy an order of merit, the mild steel at the top, the hard steel and iron lowest in the scale, showing that these metals although possessing a nominally high tensile strength, have no power in reserve to resist a sudden excessive strain. This portion of the diagram at a glance exemplifies the metal which we can star with the blow of a rivet hammer, or snaps when a vessel takes an uneven bottom.

The thickness of the plates operated upon proves that every portion of a ship of 1,500 tons or 2,000 tons builders' measurement (excepting rivets) can be worked cold, that heat is not required, may be injurious or even dangerous, and the weakening by heat of a few plates destroy the calculated strength of the ship, while at all times the fact of a steel plate working cold is a conclusive test of its good quality.

I have purposely abstained from analysing the different methods by which steel is produced—sufficient be it to mention that as the mere cost of melting crucible steel, both in England and Prussia is £9 per ton, the choice for the present lies between puddled and Bessemer steel. An experience of many years has taught me to prefer puddled steel for plates, as possessing a greater amount of stored strength. On the other hand angle bars, T, double T, and bulb beams of Bessemer steel show a much higher figure of merit than Bessemer steel plates; and this arises probably from the fact that the metal, passing through a series of rolling of different sections, gets a thorough kneading, and thus gains in homogeneity and ductility more than the plate, which is simply elongated from the bloom.

The Bessemer process certainly offers the advantage of satisfying a demand for very large blooms without weld, which the puddled steel makers endeavour to approach by making puddle balls of from 2 cwt. to 7 cwt.; and it is remarkable that blooms, made solid from these balls, instead of piling hammered slabs, produce a material of immense strength. I have laid on the table a specimen of this manufacture, taken from a cold bent plate, and testing up to 51 tons on the original area of fracture.

The time has now arrived when failures through heat need not longer occur; by manipulating all steel cold the builder will effect a considerable amount of saving in fuel and furnace appliances, practically test in work almost every plate passing through his yard, and while emancipating himself from the risk attending rough and somewhat unskilled labour, unite with the steel maker in producing a perfect structure.

## ROYAL INSTITUTION OF GREAT BRITAIN.

### ON ALLOYS AND THEIR USES.

By Professor Augustus Matthiessen, F.R.S.

The object of this discourse was to show experimentally why alloys are used in preference to their component metals.

Alloys may be, chemically considered, divided into three classes:—

1. Chemical combinations.
2. Mechanical mixtures.
3. Solutions of the one metal in the other which has become solid, or, for shortness sake, solidified solutions of the one metal in the other.

Under the term chemical combination such alloys may be considered which are the result of the combination of two metals when these unite together with great energy and evolution of heat, producing an alloy the physical and chemical properties of which we cannot foresee. As an example of such alloys, those of gold, with tin, lead, or zinc, may be quoted; for if to melted tin, lead, zinc, or gold be added, the two metals unite together with great energy, and produce an alloy which is exceedingly brittle and totally unfit for practical purposes.

It is for this reason that the more expensive metals, silver and copper, are used for alloying gold for the purpose of coinage, &c.

With regard to such alloys, which may be looked upon as mechanical mixtures, like oil and water, or rather as ether and water, for no two metals are known which, like oil and water, do not dissolve at all in one another, but a few metals are known which, like ether and water, dissolve slightly in one another, for ether will dissolve a certain amount of water, and water a certain amount of ether. If ether and water be mixed together, say in equal parts, two layers will be formed, the top one being ether, containing a little water, the lower one water, containing a little ether. Two metals, for instance, which behave in exactly a similar manner to ether and water are lead and zinc, for lead, when fused with zinc, will dissolve 1·6 per cent. zinc, and zinc in its turn will take up 1·2 per cent. lead.

If these two metals be fused together, say in equal parts, they will separate into two layers, like ether and water, the top one, being the specifically lighter, zinc, with a small percentage of lead, the lower one lead, with a small percentage of zinc. If such an alloy be made and cast in a mould, the difference in the behaviour of the two ends may be easily shown; for the top one is so brittle that it cannot be bent without breaking, whereas the lower one can be bent with ease.

Such chemical combinations and mechanical mixtures are, however, comparatively rare; and for alloys in common use, practice has almost invariably chosen such alloys as may be considered as belonging to the third class, rejecting those of the first and second as worthless for practical purposes.

Under the term solidified solutions of the one metal in the other, such alloys may be considered, which, like the chlorides of potassium and sodium when fused together, produce a mass having some of the physical properties totally different from those of the component salts. It cannot be assumed that the chloride of sodium enters into chemical combination with the chloride of potassium. One important property of a solidified solution is, that the components are homogeneously diffused in one another, so that even under the most powerful microscope, they can be no longer distinguished from one another.

Alloys are used because they possess certain physical properties to a far greater extent than their component metals. The physical properties may be divided into two classes.

1. Those which in all cases are imparted to the alloy, approximately in the ratio in which they are possessed by the component metals.

2. Those which in some cases are, and in others are not, imparted to the alloy in the ratio in which they are possessed by the component metals.

To the first belong specific gravity, specific heat, and expansion due to heat. It is easy to show this experimentally; the specific gravity of an alloy may be shown to be equal to the mean of those of its component metals, by hanging on the one side of a balance the alloy, and on the other side the metals composing it unalloyed, and then placing them both in water.

The specific heat of an alloy may be proved equal to that of its components by placing the alloy and its components in boiling water, and then in equal volumes of cold water; when the rise of temperature in the two cases will be found the same as may be shown by a differential-air thermometer.

A brass bar placed in any apparatus for showing expansion by heat is seen to expand exactly as much as a composite bar, of which one portion is of copper, the other of zinc. The length of the zinc portion being proportioned to the amount of zinc in brass.

To the second class of physical properties belong conduction for heat and electricity, hardness, tenacity, &c.

As a basis for the conclusion which will be drawn, the electric conducting power for alloys may be taken. Researches into this subject have shown that when tin, lead, zinc, or cadmium are alloyed together, such alloys conduct electricity in the ratio of the relative volumes of the component metals, whilst in all other cases no such simple relation exists between the conducting power of the metals and their alloys. If, for instance, gold be alloyed with silver, say in equal volumes, the conducting power of an alloy will be 15, that of silver being 100, and that of gold 80.

If curves be drawn to represent the conducting power of different series of alloys, three typical forms will be observed: the first represented by nearly a straight line, the second by the letter *L*, and the third by the letter U.

Wiedemann and Franz have proved experimentally that the values obtained for the conducting power of metals and alloys, for heat and electricity, are identically the same; and the truth of this statement may be shown by the following experiments:—If bars of gold and silver and some gold-silver alloys be fixed so that one end of all of them is in a hot-water box, and the other end in the bulb of a small air-thermometer, the depression in the columns of the liquid in the tubes of the air-thermometers will indicate the relative conducting powers (approximately) of the several bars; and if through the tops of the columns of liquid be drawn, such line will form a curve similar to that referred to as obtained for the electric conducting power.

That this is true is thus shown:—

By the side of this apparatus is placed another of this construction: Into the bulbs of several air-thermometers are fixed wires of the same size and length, and of the same materials as were used in the heat-conducting experiment. One end of each wire is soldered to one thick copper wire, and the other end to another similar wire. These two wires are connected to the poles of a battery. The current will then divide itself, and a portion will pass through every wire proportional to the conducting power of that wire. This current will heat the wire and cause the liquid in the tubes connected with the air-thermometers to descend, and the line drawn through the top of the columns will be nearly similar to the curve already mentioned, which is formed by the bulbs in which the heat-conducting bars are fixed.

The analogy between the relation existing in this case and in some others may be shown experimentally as follows:—

*Sonority.* When bars of alloys and their component metals are struck, a great difference will be found in the note produced; and in almost every case where the experiment has been made, the most sonorous alloy was found to correspond in composition approximately with that at the turning point of the electric conducting power curve.

*Tenacity.* When wires of the same diameter of metals and alloys are broken by traction, those of the alloys will require a much greater force than their component metals; and it may be deduced from what is known, that those alloys the composition of which corresponds to the turning point of the conducting power curve are more tenacious than any other alloy composed of the same metals.

*Elasticity.* When spirals of wires of metals and their alloys are weighted to an equal extent, the alloys will be found on removing the weights to possess the property of resuming their original form in a much higher degree than their component metals. Here again the alloys corresponding in composition to those of the turning point of the conducting power curves are the most elastic.

From what has been said, and from the experiments described, the conclusion may be drawn that the chemical composition of the practically-used two metal alloys correspond to those situated at the turning points of the heat and electric conducting power curves, and that if a two-metal alloy of a special physical property be required, it would be as well to try that alloy the composition of which would correspond to the turning point of the curve representing the electric conducting power of the alloys of the two metals.

## ON FARADAY AS A DISCOVERER.

By John Tyndall, Esq., LL.D., F.R.S., Professor of Natural Philosophy Royal Institution.

(*Continued from page* 90.)

And then his thoughts suddenly widen, and he asks himself whether the rotating earth does not generate induced currents as it turns round its axis from west to east. In his experiment with the twirling magnet the galvanometer wire remained at rest; one portion of the circuit was in motion relatively to another portion. But in the case of the twirling planet the galvanometer wire would necessarily be carried along with the earth; there would be no relative motion. What must be the consequence? Take the case of a telegraph wire with its two terminal plates dipped into the earth, and suppose the wire to lie in the magnetic meridian. The ground underneath the wire is influenced like the wire itself by the earth's rotation; if a current from south to north be generated in the wire, a similar current from south to north would be generated in the earth under the wire; these currents would run against the same terminal plate, and thus neutralise each other.

This inference appears inevitable, but his profound vision perceived its possible invalidity. He saw that it was at least possible that the difference of conducting power between the earth and the wire might give one an advantage over the other, and that thus a residual or differential current might be obtained. He combined wires of different materials, and caused them to act in opposition to each other; but found the combination ineffectual. The more copious flow in the better conductor was exactly counterbalanced by the resistance of the worst. Still though experiment was thus emphatic he would clear his mind of all discomfort by operating on the earth itself. He went to the round lake near Kensington Palace, and stretched 480 feet of copper wire, north and south, over the lake, causing plates soldered to the wire at its ends to dip into the water. The copper wire was severed at the middle, and the severed ends connected with a galvanometer. No effect whatever was observed. But though quiescent water gave no effect, moving water might. He therefore worked at London Bridge for three days during the ebb and flow of the tide, but without any satisfactory result. Still he urges, "Theoretically it seems a necessary consequence, that where water is flowing there electric currents should be formed. If a line be imagined passing from Dover to Calais through the sea, and returning through the land, beneath the water, to Dover, it traces out a circuit of conducting matter one part of which, when the water moves up or down the channel, is cutting the magnetic curves of the earth, whilst the other is relatively at rest. . . There is every reason to believe that currents do run in the general direction of the circuit described, either one way or the other, according as the passage of the water is up or down the Channel." This was written before the submarine cable was thought of, and he once informed me that actual observation upon that cable had been found to be in accordance with his theoretic deduction.

Three years subsequent to the publication of these researches, that is to say on the 29th of January, 1835, Faraday read before the Royal Society a paper "On the influence by induction of an electric current upon itself." A shock and spark of a peculiar character had been observed by a young man named William Jenkin, who must have been a youth of some scientific promise, but who, as Faraday once informed me, was dissuaded by his own father from having anything to do with science. The investigation of the fact noticed by Mr. Jenkin led Faraday to the discovery of the extra current, or the current induced in the primary wire itself at the moments of making and breaking contact, the phenomena of which he described and illustrated in the beautiful and exhaustive paper referred to.

After he had proved to his own satisfaction the identity of electricities, he tried to compare them quantitatively together. The terms quantity and intensity, which Faraday constantly used, need a word of explanation here. He might charge a single Leyden jar by twenty turns of his machine, or he might charge a battery of ten jars by the same number of turns. The quantity in both cases would be sensibly the same, but the intensity of the single jar would be the greatest, for here the electricity would be less diffused. Faraday first satisfied himself that the needle of his galvanometer was caused to swing through the same arc by the same quantity of machine electricity, whether it was condensed in a small battery or diffused over a large one. Thus the electricity developed by thirty turns of his machine produced, under very variable conditions of battery surface, the same deflection. Hence he inferred the possibility of comparing, as regards quantity, electricities which differ greatly from each other in intensity.

His object now is to compare frictional with voltaic electricity. Moistening bibulous paper with the iodide of potassium—a favourite test of his—and subjecting it to the action of machine electricity, he decomposed the iodide, and formed a brown spot where the iodine was liberated. Then he immersed two wires, one of zinc, the other of platinum, each $\frac{1}{13}$th of an inch in diameter, to a depth of $\frac{5}{8}$ths of an inch in acidulated water during eight beats of his watch; and found that the needle of his galvanometer swung through the same arc, and coloured his moistened paper to the same extent, as thirty turns of his large electrical machine. Twenty-eight turns of the machine produced an effect distinctly less than that produced by his two wires. Now, the quantity of water decomposed by the wires in this experiment totally eluded observation; it was immeasurably small; and still that amount of decomposition involved the develment of a quantity of electric force which, if applied in a proper form, would kill a rat, and no man would like to bear it.

In his subsequent researches "on the absolute quantity of electricity associated with the particles or atoms of matter," he endeavours to give an idea of the amount of electrical force involved in the decomposition of a single grain of water. He is almost afraid to mention it, for he estimates it at 800,000 discharges of his large Leyden battery. This, if concentrated in a single discharge, would be equal to a very great flash of lightning; while the chemical action of a single grain of water on four grains of zinc would yield electricity equal in quantity to a powerful thunderstorm. Thus his mind rises from the minute to the vast, expanding involuntarily from the smallest laboratory fact till it embraces the largest and grandest natural phenomena.

On the 23rd of May, 1833, he read a paper before the Royal Society "On a new Law of Electric Conduction." He found that though the current passed through water, it did not pass through ice:—why not, since they are one and the same substance? Some years subsequently he answered this question by saying that the liquid condition enables the molecule of water to turn round so as to place itself in the proper line of polarization, while the rigidity of the solid condition prevents this arrangement. This polar arrangement must precede decomposition, and decomposition is an accompaniment of conduction. He then passed on to other substances; to oxides and chlorides, and iodides, and salts, and sulphurets, and found them all insulators when solid, and conductors when fused. In all cases, moreover, except one—and this exception he thought might be apparent only—he found the passage of the current across the fused compound to be accompanied by its decomposition. Is then the act of decomposition essential to the act of conduction in these bodies? Even recently this question was warmly contested. Faraday was very cautious latterly in expressing himself upon this subject; but as a matter of fact he held that an infinitesimal quantity of electricity might pass through a compound liquid without producing its decomposition. De la Rive, who has been a great worker on the chemical phenomena of the pile, is very emphatic on the other side. Experiment, according to him and others, establishes in the most conclusive manner that no trace of electricity can pass through a liquid compound without producing its equivalent decomposition.

Faraday has now got fairly entangled amid the chemical phenomena of the pile, and here his previous training under Davy must have been of the most improtant service to him. Why he asks, should decomposition thus take place? what force is it that wrenches the locked constituent of these compounds asunder? On the 20th of June, 1833, he read a paper before the Royal Society "On Electro-Chemical Decomposition," in which he seeks to answer these questions. The notion had been entertained that the poles, as they are called, of the decomposing cell, or in other words the surfaces by which the current enters and quits the liquid, exercised electric attractions upon the constituents of the liquid and tore them asunder. Faraday combats this notion with extreme vigour. Litmus reveals, as you know, the action of an acid by turning red, turmeric reveals the action of an alkali by turning brown. Sulphate of soda, you know, is a salt compounded of the alkali soda and sulphuric acid. The voltaic current passing through a solution of this salt so decomposes it, that sulphuric acid appears at one pole of the decomposing cell and alkali at the other. Faraday steeped a piece of litmus paper and a piece of turmeric paper in a solution of sulphate of soda: placing each of them upon a separate plate of glass, he connected them together by means of a string moistened with the same solution. He then attached one of them to the positive conductor of an electric machine, and the other to the gas-pipes of this building. These he called his "discharging train." On turning the machine the electricity passed from paper to paper through the string, which might be varied in length from a few inches to seventy feet without changing the result. The first paper was reddened, declaring the presence of sulphuric acid; the second was browned, declaring the presence of the alkali soda. The dissolved salt, therefore, arranged in this fashion, was decomposed by the machine exactly as it would have been by the voltaic current. When instead of using the positive conductor he used the negative; the positions of the acid and alkali were reversed. Thus he satisfied himself that chemical decomposition by the machine is obedient to the laws which rule decomposition by the pile.

And now he gradually abolishes those so-called poles to the attraction of which electric decomposition had been ascribed. He connected a piece of turmeric paper moistened with the sulphate of soda with the positive conductor of his machine; then he placed a metallic point in connection with his discharging train opposite the moist paper, so that the electricity shall discharge through the air towards the point. The turning of the machine caused the corners of the piece of turmeric paper opposite to the point to turn brown, thus declaring the presence of alkali. He changed the turmeric for litmus paper, and placed it, not in connection with his conductor, but with his discharging train, a metallic point connected with the conductor being fixed at a couple of inches from the paper; on turning the machine, acid was liberated at the edges and corners of the litmus. He then placed a series of pointed pieces of paper, each separate piece being composed of two halves, one of litmus and the other of turmeric paper, and all moistened with sulphate of soda, in the line of the current from the machine. The pieces of paper were separated from each other by spaces of air. The machine was turned; and it was always found that at the point where the electricity entered the paper, litmus was reddened, and at the point where it quitted the paper, turmeric was browned. "Here," he urges, "the poles are entirely abandoned, but we have still electro-chemical decomposition." It is evident to him that instead of being *attracted* by the poles, the bodies separated are *ejected* by the current. The effects thus obtained with poles of air he also succeeded in obtaining with poles of water. The advance in Faraday's own ideas made at this time is indicated by the word "ejected." He afterwards reiterates this view: the evolved substances are *expelled* from the decomposing body and "*not drawn out by an attraction.*"

Having abolished this idea of polar attraction, he proceeds to enunciate and develop a theory of his own. He refers to Davy's celebrated Bakerian Lecture given in 1806, which he says "is almost entirely occupied in the consideration of electro-chemical decompositions." The facts recorded in that lecture Faraday regards as of the utmost value. But "the mode of action by which the effects take place is stated very generally; so generally indeed, that probably a dozen precise schemes of electro-chemical action might be drawn up, differing essentially from each other, yet all agreeing with the statement there given."

### LAWS OF ELECTRO-CHEMICAL DECOMPOSITION.

No man ever felt the tyranny of symbols more deeply than Faraday, and no man was ever more assiduous than he to liberate himself from them and the terms which suggested them. Calling Dr. Whewell to his aid in 1833, he endeavoured to displace by others all terms tainted by a foregone conclusion. His paper on Electro-chemical decomposition, received by the Royal Society on the 9th of January, 1834, opens with the proposal of a new terminology. He would avoid the word "current" if he could. He does abandon the word "poles" as applied to the ends of a decomposing cell, because it suggests the idea of attraction, substituting for it the perfectly neutral term electrodes. He applied the term electrolyte to every substance which can be decomposed by the current, and the act of decomposition he calls electrolysis. All these terms have become current in science. He called the positive electrode the Anode, and the negative one the Cathode, but these terms, though frequently used, have not enjoyed the same currency as the others. The terms Anion and Cation, which he applied to the constituents of the decomposed electrolyte, and the term ion, which included both anions and cations, are still less frequently employed.

Faraday now passes from terminology to research; he sees the necessity of quantitative determinations, and seeks to supply himself with a measure of voltaic electricity. This he finds in the quantity of water decomposed by the current. He tests this measure in all possible ways, to assure himself that no error can arise from its employment. He places in the course of one and the same current a series of cells with electrodes of different sizes, some of them plates of platinum, others merely platinum wires, and collects the gas liberated on each distinct pair of electrodes. He finds the quantity of gas to be the same for all. Thus he concludes that when the same quantity of electricity is caused to pass through a series of cells containing acidulated water, the electro-chemical action is independent of the size of the electrodes. He next proves that variations in intensity do not interfere with this equality of action. Whether his battery is charged with strong acid or with weak; whether it consists of five pairs or of fifty pairs; in short, whatever be its source, when the same current is sent through his series of cells, the same amount of decomposition takes place in all. He next assures himself that the strength or weakness of his dilute acid does not interfere with this law. Sending the same current through a series of cells containing mixtures of sulphuric acid and water of different strengths, he finds, however the proportion of acid to water might vary, the same amount of gas to be collected in all the cells. A crowd of facts of this character forced upon Faraday's mind the conclusion that the amount of electro-chemical decomposition depends, not upon the size of the electrodes, not upon the intensity of the current, not upon the strength of the solution, but solely upon the quantity of electricity which passes through the cell. The quantity of electricity he concludes is proportional to the amount of chemical action. On this law Faraday based the construction of his celebrated voltameter, or measurer of voltaic electricity.

But before he can apply this measure he must clear his ground of numerous possible sources of error. The decomposition of his acidulated water is certainly a direct result of the current; but as the varied and important researches of MM. Becquerel, De la Rive, and others had shown, there are also secondary actions, which may materially interfere with and complicate the pure action of the current. These actions may occur in two ways: either the liberated ion may seize upon the electrode against which it is set free, forming a chemical compound with that electrode; or it may seize upon the substance of the electrolyte itself, and thus introduce, into the circuit chemical actions over and above those due to the current. Faraday subjected these secondary actions to an exhaustive examination. Instructed by his experiments, and rendered competent by them to distinguish between primary and secondary results, he proceeds to establish the doctrine of "definite electro-chemical decomposition."

Into the same circuit he introduced his voltameter, which consisted of a graduated tube filled with acidulated water and provided with platinum plates for the decomposition of the water, and also a cell containing chloride of tin. Experiments already referred to had taught him that this substance though an insulator when solid, is a conductor when fused, the passage of the current being always accompanied by the decomposition of the chloride. He wished now to ascertain what relation this decomposition bore to that of the water in his voltameter.

Completing his circuit, he permitted the current to continue until "a reasonable quantity of gas" was collected in the voltameter. The circuit was then broken, and the quantity of tin liberated compared with the quantity of gas. The weight of the former was 3·2 grains, that of the latter 0·49742 of a grain. Oxygen, as you know, unites with hydrogen in the proportion of 8 to 1 to form water. Calling the equivalent, or, as it is sometimes called, the atomic weight of hydrogen 1, that of oxygen is 8; that of water is consequently 8 + 1, or 9. Now if the quantity of water decomposed in Faraday's experiment be represented by the number 9, or in other words by the equivalent of water, then the quantity of tin liberated from the fused chloride is found by an easy calculation to be 57·9, which is almost exactly the chemical equivalent of tin. Thus both the water and the chloride were broken up in proportions expressed by their respective equivalents. The amount of electric force which wrenched asunder the constituents of the molecule of water was competent, and neither more nor less than competent, to wrench asunder the constituents of the molecules of the chloride of tin. The fact is typical. With the indications of his voltameter he compared the decomposition of other substances both singly and in series. He submitted his conclusions to numberless tests. He purposely introduced secondary actions. He endeavoured to hamper the fulfilment of those laws which it was the intense desire of his mind to see established. But from all these difficulties emerged the golden truth, that under every variety of circumstances the decompositions of the voltaic current are as definite in their character as those chemical combinations which gave birth to the atomic theory. This law of electro-chemical decomposition ranks, in point of importance, with that of definite combining proportions in chemistry.

### Origin of Power in the Voltaic Pile.

In one of the public areas of the town of Como stands a statue, with no inscription on its pedestal save that of a single name, "Volta." The bearer of that name occupies a place for ever memorable in the history of science. To him we owe the discovery of the voltaic pile, to which, for a brief interval, we must now turn our attention.

Volta himself knew nothing of the chemical phenomena of the pile; but as soon as these became known, suggestions and intimations appeared that chemical actions, and not metallic contact, might be the real source of voltaic electricity. This idea was expressed by Fabroni in Italy and by Wollaston in England. It was developed and maintained by those "admirable electricians," Becquerel, of Paris, and De la Rive, of Geneva. The contact theory, on the other hand, received its chief development and illustration in Germany. It was long the scientific creed of the great chemists and natural philosophers of that country, and to the present hour there may be some of them unable to liberate themselves from the fascination of their first-love.

After the researches which I have endeavoured to place before you, it was impossible for Faraday to avoid taking a side in this controversy. He did so in a paper "On the Electricity of the Voltaic Pile," received by the Royal Society, on the 7th of April, 1834. His position in the controversy might have been predicted. He saw chemical effects going hand-in-hand with electrical effects, the one being proportional to the other; and, in the paper now before us, he proved that when the former were excluded, the latter were sought for in vain. He produced a current without metallic contact; he discovered liquids which, though competent to transmit the feeblest currents—competent therefore to allow the electricity of contact to flow through them if it were able to from a current—were absolutely powerless when chemically inactive.

One of the very few experimental mistakes of Faraday occurred in this investigation. He thought that with a single voltaic cell he had obtained the spark before the metals touched, but he subsequently discovered his error. To enable the voltaic spark to pass through air before the terminals of the battery were united, it was necessary to exalt the electro-motive force of the battery by multiplying its elements; but all the elements Faraday possessed were unequal to the task of urging the spark across the shortest measurable space of air. Nor, indeed, could the action of the battery, the different metals of which were in contact with each other, decide the point in question. Still as regards the identity of electricities from various sources, it was at that day of great importance to determine whether or not the voltaic current could jump as a spark across an interval before contact. Faraday's friend, Mr. Gassiot, solved this problem. He erected a battery of 4,000 cells, and with it urged a stream of sparks from terminal to terminal, when separated from each other by a measurable space of air.

The memoir on the "Electricity of the Voltaic Pile," published in 1834, appears to have produced but little impression upon the supporters of the contact theory. These indeed were men of too great intellectual weight and insight lightly to take up, or lightly to abandon a theory. Faraday therefore resumed the attack in a paper communicated to the Royal Society, on the 6th of February, 1840. In this paper he hampered his antagonists by a crowd of adverse experiments. He hung difficulty after difficulty about the neck of the contact theory, until in its efforts to escape from his assaults it so changed its character as to become a thing totally different from the theory proposed by Volta. The more persistently it was defended, however, the more clearly did it show itself to be a congeries of devices, bearing the stamp of dialectic skill rather than that of natural truth.

In conclusion, Faraday brought to bear upon it an argument which, had its full weight and purport been understood at the time, would have instantly decided the controversy. "The contact theory," he urged, "assumes that a force which is able to overcome powerful resistance, as for instance that of the conductors, good or bad, through which the current passes, and that again of the electrolytic action where bodies are decomposed by it, can arise out of nothing: that without any change in the acting matter, or the consumption of any generating force, a current shall be produced which shall go on for ever against a constant resistance, or only be stopped, as in the voltaic trough, by the ruins which its exertion has heaped up in its own course. This would indeed be a creation of power, and is like no other force in nature. We have many processes by which the form of the power may be so changed, that an apparent conversion of one into the other takes place. So we can change chemical force into the electric current, or the current into chemical force. The beautiful experiments of Seebeck and Peltier show the convertibility of heat and electricity; and others by Oersted and myself show the convertibility of electricity and magnetism. But in no case, not even in those of the Gymnotus and Torpedo, is there a pure creation or a production of power without a corresponding exhaustion of something to supply it."

His first great paper on frictional electricity was sent to the Royal Society on the 30th of November, 1837. We here find him face to face with an idea which beset his mind throughout his whole subsequent life, the idea of action at a distance. It perplexed and bewildered him. In his attempts to get rid of this perplexity he was often unconsciously rebelling against the limitations of the intellect itself. He loved to quote Newton upon this point: over and over again he introduces his memorable words, "That gravity should be innate, inherent, and essential to matter, so that one body may act upon another at a distance through a vacuum and without the mediation of anything else, by and through which this action and force may be conveyed from one to another, is to me so great an absurdity, that I believe no man who has in philosophical matters a competent faculty of thinking can ever fall into it. Gravity must be caused by an agent acting constantly according to certain laws; but whether this agent be material or immaterial I have left to the consideration of my readers."

Faraday does not see the same difficulty in his contiguous particles. And yet by transferring the conception from masses to particles we simply lessen size and distance, but we do not alter the quality of the conception. Whatever difficulty the mind experiences in conceiving of action at sensible distances, besets it also when it attempts to conceive of action at insensible distances. Still the investigation of the point whether electric and magnetic effects were wrought out through the intervention of contiguous particles or not, had a physical interest altogether apart from the metaphysical difficulty. Faraday grapples with the subject experimentally. By simple intuition he sees that action at a distance must be exerted in straight lines. Gravity, he knows, will not turn a corner, but exerts its pull along a right line; hence his aim and effort to ascertain whether electric action ever takes place in curved lines. This once proved, it would follow that the action is carried on by means of a medium surrounding the electrified bodies. His experiments in 1837, reduced, in his opinion, this point to demonstration. He then found that he could electrify by induction an insulated sphere placed completely in the shadow of a body which screened it from direct action. He pictured the lines of electric force bending round the edges of the screen, and reuniting on the other side of it; and he proved that in many cases the augmentation of the distance between his insulated sphere and the inducing body, instead of lessening, increased the charge of the sphere. This he ascribed to the coalescence of the lines of electric force at some distance behind the screen.

Faraday's theoretic views on this subject have not received general acceptance, but they drove him to experiment, and experiment with him was always prolific of results. By suitable arrangements he places a metallic sphere in the middle of a large hollow sphere, leaving a space of something more than half-an-inch between them. The interior sphere was insulated, the external one uninsulated. To the former he communicated a definite charge of electricity. It acted by induction upon the concave surface of the latter, and he examined how this act of induction was affected by placing insulators of various kinds between the two spheres. He tried gases, liquids, and solids, but the solids alone gave him positive results. He constructed two instruments of the foregoing description, equal in size and similar in form. The interior sphere of each communicated with the external air by a brass stem ending in a knob. The apparatus was virtually a Leyden jar, the two coatings of which were the two spheres, with a thick and variable insulator between them. The amount of charge in each jar was determined by bringing a proof-plane into contact with its knob, and measuring by a torsion balance the charge taken away. He first charged one of his instruments, and then dividing the charge with the other, found that when air intervened in both cases, the charge was equally divided. But when shell-lac, sulphur, or spermaceti was interposed between the two spheres of one jar, while air occupied this interval in the other, then he found that the instrument occupied by the "solid dielectric" took more than half the original charge. A portion of the charge was absorbed in the dielectric itself. The electricity took time to penetrate the dielectric. Immediately after the discharge of the apparatus no trace of electricity was found upon its knob. But after a time electricity was found there, the charge having gradually returned from the dielectric in which it had been lodged. Different insulators possess this power of permitting the charge to enter them in different degrees. Faraday figured their particles as polarized, and he concluded that the force of induction is propagated from particle to particle of the dielectric from the inner sphere to the outer one. This power of propagation possessed by insulators he calls their "Specific Inductive Capacity."

Faraday visualizes with the utmost clearness the state of his contiguous particles; one after another they become charged, each succeeding particle depending for its charge upon its predecessor. And now he seeks to break down the wall of partition between conductors and insulators. "Can we not," he says, "by a gradual chain of association carry up discharge from its occurrence in air through spermaceti and water to solutions, and then on to chlorides, oxides, and metals, without any essential change in its character?" Even copper, he urges, offers a resistance to the transmission of electricity. The action of its particles differs from those of an insulator only in degree. They are charged like the particles of the insulator, but they discharge with greater ease and rapidity; and this rapidity of molecular discharge is what we call conduction. Conduction then is always preceded by atomic induction; and when through some quality of the body, which Faraday does not define, the atomic discharge is rendered slow and difficult, conduction passes into insulation.

In the researches now under review the ratio of speculation and reasoning to experiment is far higher than in any of Faraday's previous works. Amid much that is entangled and dark we have flashes of wondrous insight and utterances which seem less the product of reasoning than of revelation. I will confine myself here to one example of this divining power:—By his most ingenious device of a rapidly rotating mirror, Wheatstone had proved that electricity required time to pass through a wire, the current reaching the middle of the wire later than its two ends. "If," says Faraday, "the two ends of the wire in Professor Wheatstone's experiments were immediately connected with two large insulated metallic surfaces exposed to the air, so that the primary act of induction, after making the contact for discharge, might be in part removed from the internal portion of the wire at the first instance, and disposed for the moment on its surface jointly with the air and surrounding conductors, then I venture to anticipate that the middle spark would be more retarded than before. And if those two plates were the inner and outer coatings of a large jar or Leyden battery, then the retardation of the spark would be much greater." This was only a prediction, for the experiment was not made. Sixteen years subsequently, however, the proper conditions came into play, and Faraday was able to show that the observations of Werner Siemens, and Latimer Clark, on subterraneous and submarine wires were illustrations, on a grand scale, of the principle which he had enunciated in 1838. The wires and the surrounding water act as a Leyden jar, and the retardation of the current predicted by Faraday manifests itself in every message sent by such cables.

Faraday, you have been informed, endeavoured to improve the manufacture of glass for optical purposes. But though he produced a heavy glass of great refractive power, its value to optics did not repay him for the pains and labour bestowed on it. Now, however, we reach a result established by means of this same heavy glass, which made ample amends for all.

In November, 1845, he announced his discovery of the "Magnetization of Light, and the Illumination of the Lines of Magnetic Force." This title provoked comment at the time, and caused misapprehension. He therefore added an explanatory note; but the note left his meaning as entangled as before. In fact, Faraday had notions regarding the magnetization of light which were peculiar to himself, and untranslatable into the scientific language of the time. Probably no other philosopher of his day would have employed the phrases just quoted as appropriate to the discovery announced in 1845. But Faraday was more than a philosopher; he was a prophet, and often wrought by an inspiration to be understood by sympathy alone. The prophetic element in his character occasionally coloured and even injured the utterance of the man of science; but subtracting that element, though you might have conferred on him intellectual symmetry, you would have destroyed his motive force.

But let us pass from the label of this casket to the jewel it contains. "I have long," he says, "held an opinion almost amounting to conviction, in common I believe with many other lovers of natural knowledge, that the various forms under which the forces of matter are made manifest have one common origin; in other words, are so directly related and mutually dependent, that they are convertible, as it were, into one another, and possess equivalents of power in their action. . . . . This strong persuasion," he adds, "extended to the powers of light." And then he examines the action of magnets upon light. From conversation with him and Anderson, I should infer that the labour preceding this discovery was very great. The world knows little of the toil of the discoverer. It sees the climber jubilant on the mountain-top, but does not know the labour expended in reaching it. Probably hundreds of experiments had been made on transparent crystals before he thought of testing his heavy glass. Here is his own clear and simple description of the result of his first experiment with this substance:—"A piece of this glass, about two inches square, and 0·5 of an inch thick, having flat and polished edges, was placed as a diamagnetic between the poles (not as yet magnetized by the electric current), so that the polarized ray should pass through its length; the glass acted as air, water, or any other transparent substance would do; and if the eye-piece were previously turned into such a position that the polarized ray was extinguished, or rather the image produced by it rendered invisible, then the introduction of the glass made no alteration in this respect. In this state of circumstances, the force of the electro-magnet was developed by sending an electric current through its coils, and immediately the image of the lamp-flame became visible, and continued so long as the arrangement continued magnetic. On stopping the electric current, and so causing the magnetic force to cease, the light instantly disappeared. These phenomena could be renewed at pleasure, at any instant of time, and upon any occasion, showing a perfect dependence of cause and effect."

In a beam of ordinary light the particles of the luminiferous ether vibrate in all directions perpendicular to the line of progression; by the act of polarization, performed here by Faraday, all oscillations but those parallel to a certain plane are eliminated. When the plane of vibration of the polarizer coincides with that of the analyzer, a portion of the beam passes through both; but when these two planes are at right angles to each other, the beam is extinguished. If by any means, while the polarizer and analyzer remain thus crossed, the plane of vibration of the polarized beam between them could be changed, then the light would be, in part at least, transmitted. In Faraday's experiment this was accomplished. His magnet turned the plane of polarization of the beam through a certain angle, and thus enabled it to get through the analyzer; so that "the magnetization of light and the illumination of the magnetic lines of force" becomes when expressed in the language of modern theory, the rotation of the plane of polarization.

To him, as to all true philosophers, the main value of a fact was its position and suggestiveness in the general sequence of scientific truth. Hence, having established the existence of a phenomenon, his habit was to look at it from all possible points of view, and to develop its relationship to other phenomena. He proved that the direction of the rotation depends upon the polarity of his magnet; being reversed when the magnetic poles are reversed. He showed that when a polarized ray passed through his heavy glass in a direction parallel to the magnetic lines of force, the rotation is a maximum, and that when the direction of the ray is at right angles to the lines of force there is no rotation at all. He also proved that the amount of the rotation is proportional to the length of the diamagnetic through which the ray passes. He operated with liquids and solutions. Of aqueous solutions he tried 150 and more, and found the power in all of them. He then examined gases; but here all his efforts to produce any sensible action upon the polarized beam were ineffectual. He then passed from magnets to currents, enclosing bars of heavy glass, and tubes containing liquids and aqueous solutions within an electro-magnetic helix. A current sent through the helix caused the plane of polarization to rotate, and always in the direction of the current. The rotation was reversed when the current was reversed. In the case of magnets, he observed a gradual, through quick, ascent of the transmitted beam from a state of darkness to its maximum brilliancy when the magnet was excited. In the case of currents, the beam attained at once its maximum. This he showed to be due to the time required by the iron of the electro-magnet to assume its full magnetic power, which time vanishes when a current without iron is employed. "In this experiment," he says, "we may I think, justly say that a ray of light is electrified, and the electric forces illuminated." In the helix, as with the magnets, he submitted air to magnetic influence "carefully and anxiously," but could not discover any trace of action on the polarized ray.

Many substances possess the power of turning the plane of polarisation without the intervention of magnetism. Oil of turpentine and quartz are examples: but Faraday showed that, while in one direction, that is, across the lines of magnetic force, his rotation is zero, augmenting gradually from this until it attains its maximum, when the direction of the ray is parallel to the lines of force, in the oil of turpentine, the rotation is independent of the direction of the ray. But he showed that a still more profound distinction exists between the magnetic rotation and the natural one. I will try to explain how. Suppose a tube with glass ends containing oil of turpentine to be placed north and south. Fixing the eye at the south end of the tube, let a polarised beam be sent through it from the north. To the observer in this position the rotation of the plane of polarisation, by the turpentine, is right-handed. Let the eye be placed at the north end of the tube and a beam be sent through it from the south: the rotation is still right-handed. Not so, however, when a bar of heavy glass is subjected to the action of an electric current. In this case if, in the first position of the eye, the rotation be right-handed, in the second position it is left-handed. These considerations make it manifest that if a polarised beam, after having passed through the oil of turpentine in its natural state, could, by any means, be reflected back through the liquid, the rotation impressed upon the direct beam would be exactly neutralised by that impressed upon the reflected one. Not so with the induced magnetic effect. Here it is manifest that the rotation would be doubled by the act of reflection. Hence Faraday concludes that the particles of the oil of turpentine which rotate by virtue of their natural force, and those which rotate by virtue of their induced force, cannot be in the same condition. The same remark applies to all bodies which possess a natural power of rotating the plane of polarisation.

And then he proceeded with exquisite skill and insight to take advantage of this conclusion. He silvered the ends of his piece of heavy glass, leaving, however, a narrow portion parallel to two edges diagonally opposed to each other unsilvered. He then sent his beam through this uncovered portion, and by suitably inclining his glass caused the beam within it to reach his eye, first direct, and then after two, four, and six reflections. These corresponded to the passage of the ray once, three times, five times, and seven times through the glass.

(*To be continued.*)

## LAUNCH OF THE "KONIG WILHELM."

One of the largest and strongest ironclads ever built in this country for any foreign government, the *König Wilhelm*, was launched on the 25th ult., from the dockyard of the Thames Ironworks at Blackwall.

The history of the *König Wilhelm* is somewhat peculiar. A little more than three years ago the Turkish Government wished for an ironclad that was to eclipse all ironclads then afloat. Unfortunately, however, for the Turkish Government, its Cretan difficulties soon developed into financial difficulties. Its promises of payment kept no sort of pace with the work done, and payment, at last, altogether failing, the frigate was left on the hands of the Thames Company to get rid of it as best they could. As in duty bound, the company offered it to the Admiralty for the price the Sultan had agreed to pay for it. But the Admiralty, while admitting the excellence and strength of the vessel—as, indeed, they could not well do otherwise, seeing it was then considered the masterpiece of their own chief constructor—hesitated about its purchase under different pleas. The company, therefore, after a time offered it to the Prussian Government, which instantly replied by agreeing to take it at a price considerably higher than that at which it was offered to the English Admiralty. No sooner had this offer been accepted and the agreement signed than the English Admiralty, in a brief lucid interval, wished to purchase the vessel without further delay. It was, however, then too late.

In her armament will rest the great strength of *König Wilhelm*, for she is built to carry no less than 26 300-pounders, all made of Krupp's hammered steel, and all, it is said, capable of being fired with 75lb. charges as often as twice in a minute. The length of this formidable ship is 356ft., do., of keel for tonnage, 320ft.; breadth for tonnage, 60ft.; depth amidships from top of keel 41ft.; burden in tons, $6{,}127\frac{63}{94}$. The engines are being made by Messrs. Maudslay, and are to be 1,150-horse power nominal, and capable of working up to a power of 7,000 horses. With this power, and guided by the ordinary calculations, it is believed she will realise from 13 to 14 knots an hour. There will be 40 furnaces required to keep her going at full speed, and these will use more than 80 tons of coal a day, and her coal bunkers only hold 700 tons. Her construction is on the longitudinal system—a series of very stiff wrought-iron girders, or frames, being laid at intervals of 7ft. apart, and passing along her completely from stem to stern. Between these frames the ribs are bolted, below the water-line, at intervals of 4ft. apart; but above it, and behind the armour, they are bolted as close as to be within 2ft. of each other. Within both frames and ribs comes another iron skin an inch thick, the inner one being 4½ft. apart from the outer. Side passages, or wings, running the whole length of the structure, continue this double form up to the main deck. The inner side of these wings forms the wall of the coal bunkers, so that even were it possible for a shot to pass through the armoured sides of the *König Wilhelm*, it would still have to penetrate the iron coal bunkers, and pass through 8ft. of coal before it could do any mischief to the fighting crew of the ship. The armour is 8in. thick amidships, tapering gradually downwards to a thickness of 7in., at 7ft. below the water line. It also tapers off in the same manner towards the bow and stern, diminishing from 8in. to 6in., and then to 4in. The latter thickness, however, is only used in places where it is almost impossible a shot could strik, such as under the counter or under the bows. Wherever it is probable a shot could strike there is never less than 6in. of armour, and nearly always 8in., with a 10in. teak backing and double iron skin. About 40ft.aft of the bowsprit, and forward of the stern two bulkheads, each of 6in. armour and 18in. of teak, are continued from the lower deck up through the main deck, and rise 7ft. above the spar deck. On this spar deck these are curved into the form of slightly semicircular shields, each pierced with four portholes for cannon and loopholes for musketry. Within these shields are to be carried four 300-pounders, which can be used to fire straight fore and aft, or as broadside guns.

## LAUNCH OF THE "SIRIUS."

The screw sloop Sirius, built at Portsmouth-dockyard from the designs of the present Chief Constructor of the Navy, was launched from No. 1 building slip of that yard on the 24th ult. The *Sirius* is one of the vessels built or building of the improved Amazon type. She measures between perpendiculars 212ft.; length of keel for tonnage, 185ft. 8in.; extreme breadth, 36ft.; breadth for tonnage, 35ft. 10in.; breadth moulded, 35ft. 2in.; depth in hold, 19ft. 4·75in.; burden in tons, o.m., $1{,}268\frac{8}{94}$. Her machinery will consist of a pair of Maudslay, Sons, and Field's patent compound engines of a power of 350-horse, driving a Griffiths-Maudslay screw. The *Sirius* is a wood-built vessel with rolled-iron deck beams, iron stringer plates under the upper deck at the water ways, and iron diagonal strap fastenings. She will carry no armour, in common with all others of her class. Her armament will consist of two 6½-ton 7in. muzzle loading rifled guns, mounted on iron carriages and slides, and two rifled and "converted" 64-pounders. The official estimate of the cost of the ship fitted for sea, but exclusive of machinery and armament, is £43,000.

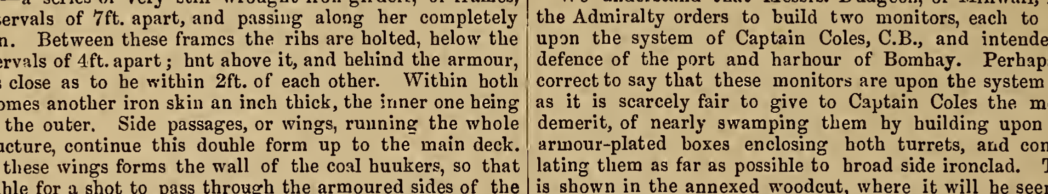
## LEAD PIPES LINED WITH TIN.

We have received a sample of lead pipe lined with tin, a process which appears to be remarkably well adapted for water supply pipes. It is well known that lead oxidises and injures the water, and consequently lead-lined cisterns have to a great extent been abolished; lead pipes, however, are still almost universally used, from the ease with which they can be fitted to any required situation. In order to overcome the objections to the use of lead pipes and still retain all its advantages, M. Hamon of Paris has invented a method of lining lead pipes with tin, in such a manner that, while they are equally strong, they may be made much lighter, and consequently cheaper than lead pipes of the same bore, and at the same time the water is kept from contact with the lead, and is as pure after passing through the pipe as it was when it entered. Another advantage may be mentioned, viz., that by the system used for drawing the pipes, the inside is perfectly smooth and polished, offering a minimum of friction to the water.

## MONITORS FOR BOMBAY.

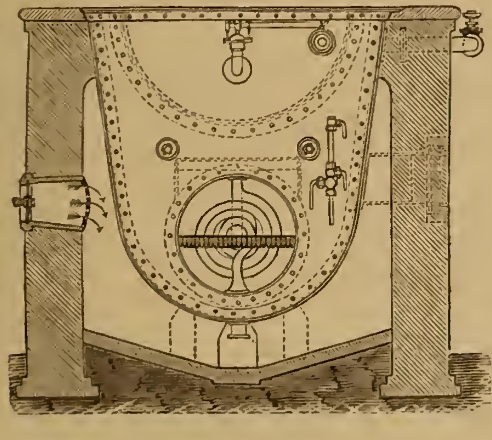
We understand that Messrs. Dudgeon, of Millwall, have received from the Admiralty orders to build two monitors, each to have two turrets, upon the system of Captain Coles, C.B., and intended to serve for the defence of the port and harbour of Bombay. Perhaps it would be more correct to say that these monitors are upon the system of the Admiralty, as it is scarcely fair to give to Captain Coles the merit, or rather the demerit, of nearly swamping them by building upon their decks huge armour-plated boxes enclosing both turrets, and consequently assimilating them as far as possible to broad side ironclad. The style of vessel is shown in the annexed woodcut, where it will be seen that instead of a simple breakwater, as proposed by Captain Coles, and intended only for the purposes of navigation, there is a species of raised deck amidships, the turrets being required to be similarly raised. Thus, instead of the vessel having to carry the weight of the turrets only, it is required by these Admiralty improvements (?) to carry about three times as much. We have heard of things being "improved off the face of the earth;" perhaps the Admiralty are endeavouring to "improve monitors off the surface of the ocean."

The following are some of the leading dimensions, &c., viz.:—Length between perpendiculars, 225ft.; extreme breadth, 42ft.; depth of hold 12ft. 3in.; burden in tons, 1,849; load draught, 15ft.; area of midship section, about 600 square feet; displacement, about 3,000 tons; engines, 200 horse-power nominal; thickness of armour on sides, 6in.; do. upon turrets and breastwork, 8in.; width of armour on sides, 6ft. (2ft. above and 4ft. below load-water line); height of breastwork, 6ft. 9in.; wood backing, 10in. thick. The vessel will be fitted with independent engines for ventilating and working the turrets.



## DUNN'S PATENT CHEMICAL PAN.

In various manufacturing processes, such as dissolving chemicals, boiling preserves and gluten, preparing asphalte, brewing, &c., it is very desirable and sometimes absolutely necessary that the heat should be perfectly under control. Pans with a simple fire underneath are for these purposes very difficult to manage, and often dangerous, consequently there have been many schemes proposed for transmitting the heat of the furnace through some medium. Thus steam has been very generally used for this purpose, the furnace generating steam in a suitable boiler, which is then made to heat the pan, either by means of a coil of pipes or a jacket. In some cases a particular liquid is employed, whose boiling point is exactly the required temperature, such as oil, tallow, quicksilver, or fusible alloys. In all these cases, however, there is a considerable amount of complication involved, besides a large amount of space taken up. The chemical pan which has been devised by Mr. Thomas Dunn, the well known engineer of Manchester, and of which we give an engraving, appears to be exceedingly simple and convenient. It is, in fact, a steam boiler and chemical pan in one; the fire being lighted under the pan, but having between the two a stratum of water and steam, whereby the temperature may be regulated. The heating vessel or boiler is about half full of water, having a furnace flue similar to a Cornish boiler running through it, which, for the more perfect abstraction of heat from the flue, is provided with a spiral water-heater; the heat also passes round the bottom of this vessel, as shown in the engraving. Into the top of this vessel is fitted the chemical pan, which is thus heated by the steam underneath it. A safety-valve is provided, not only to prevent accidents, but also in order that the heat may be regulated to the required temperature. It will thus be seen that by this arrangement the whole apparatus is self contained, and all pipes, cocks, condense-boxes, &c., with their various connections, are entirely obviated.



## SAN FRANCISCO MECHANICS' INSTITUTE.

### ANNUAL ELECTION OF OFFICERS.

The annual election for officers of the Mechanics' Institute was held on March 2nd. Two tickets were in the field, and a most spirited and active contest took place between the friends of the rival candidate, the supporters of both tickets being out in large numbers. Although personal issues were to some extent brought into the contest, the best of feeling prevailed throughout, and the canvass resulted in bringing into the treasury a round aggregate of back dues, most of which might otherwise never have been realised. The large proportion of 717 votes were cast, out of a total membership of about 1,000. The officers elected are especially pledged to economy in the matter of a building and the general management of the forthcoming fair. The result of the balloting was as follows: A. S. Hallidie, president; J. Wilcox, vice-president; H. L. Davis, treasurer; H. D. Dunn, corresponding secretary; J. T. Holmes, recording secretary; D. R. Coleman, W. C. Pease, N. D. Arnott, A. Doble, D. Farquharson, J. Browning, and John Hancock, directors.

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The United States coal-fields are stated to be thirty-seven times larger than our own, and there are coal-fields on the continent not inconsiderable, though much smaller in the aggregate than our own, and yet we probably raise nearly two-thirds of the total quantity now being extracted over the whole surface of the globe.

## REVIEWS AND NOTICES OF NEW BOOKS.

*The Mineralogist's Directory, or a Guide to the Principal Localities in the United Kingdom of Great Britain and Ireland.* By Townshend M. Hall, F.G.S., London: Edward Stanford, Charing-cross.

This work will be found to supply a great want of the mineralogist, geologist, and mining engineer, and will facilitate considerably their investigation. It contains in alphabetical order a list of British minerals and sub-species, with their chemical composition attached, and then an immense number of places in Great Britain are given with a list of the various minerals, or the general composition of the earth in each locality. For convenience of reference the counties of England are given first in alphabetical order, and any place in any particular county similarly arranged; Wales, Scotland, Ireland, &c., being also divided in the same manner. It will thus be seen that the mineralogical peculiarities of any place may be found with the greatest ease, as also the chemical composition of such minerals.

*Nevada and California processes of Silver and Gold extraction.* By Guido Kustel. Frank D. Carlton, San Francisco.

This work is designed to supply the necessary information, both practical and theoretical, to persons engaged in the various mining enterprises in California. Of late years, in addition to gold, numerous discoveries have been made of rich and extensive silver bearing lodes in that province, and especially in Nevada Territory, and consequently a large amount of enterprise and capital has been directed to that part of the country. Mr. Kustel's treatise appears to be remarkably well adapted for the assistance, both of those already engaged, and for such persons as are proposing to engage in developing the resources of this magnificent country. The engravings are exceedingly good and very interesting, not only as illustrating that species of industry, but also the excellence with which such a work can be turned out in San Francisco.

*Etudes sur l'exposition de* 1867. Eugène Lacroix, 15, Quai Malaquais Paris.

We would again call the attention of our readers to this most useful work, which continues to be published monthly. The information it contains is as varied as were the contents of the French exhibition. Nothing of interest appears to be neglected but as might be expected, the engineering department receives the principle share of attention. The monthly parts for this year include some very good treatises upon the manufacture of gas, agricultural engineering, civil engineering, wood machinery, cotton, woollen, &c., manufactures; and the engravings with which the treatises, are plentifully interspersed, are very good. The plates which accompany the various treatises are also very excellent, and will be found very useful for reference. When completed the whole work will form a complete encyclopedia of information respecting the latest improvements in civil and mechanical engineering, and also upon almost every conceivable science and art which was represented at that magnificent exhibition.

*Engineering facts and figures for* 1867. A. Fullarton and Co., London and Edinburgh.

This is the fifth volume that has been issued under the above title, and appears to be considerably superior to any of the former. The principal reason for this improvement is no doubt owing to the great opportunity offered by the French Exhibition, of which full advantage has been taken. In fact the editors seem to have laboured under an *embarras de richesse* from this cause, and the chief difficulty thus imposed has been to condense within the limits of some 400 pages, the voluminous reports made upon the various objects there exhibited. In addition to the information thus afforded, notices are given of the various improvements that have taken place in the different branches of engineering during the past year; the "facts and figures" respecting steam boilers and liquid fuel, being especially interesting. In additions to descriptions of all the most interesting inventions, wood cuts, and engravings are given where necessary, to convey a correct idea of the peculiarity of form or method of carrying into practice such inventions.

*Sanitary Siftings, or results of sewage systems compared.* By a Naval Officer. E. and F. N. Spon, 48, Charing-cross.

A naval officer in this pamphlet endeavours to show that all sewage systems are both imperfect and injurious, and that there is nothing equal to Moules earth closets. It is, in fact rather a lengthy advertisement of that system.

## NOTES AND NOVELTIES.

### MISCELLANEOUS.

The Thames Embankment is to be carried on piers from the Temple Gardens to Blackfriars Bridge, with entrances for barges to the existing wharves underneath the road.

It appears that the total quantity of earth extracted in connection with the Suez Canal works amounted in the month ending February 15th, 1868, to 1,466,428 cubic metres, showing an increase of 336,000 cubic metres upon the preceding month. When all the dredgers collected are in operation it is expected that the rate of extraction will be still further increased.

The quantity of coal exported from Belgium last year was 3,564,364 tons, as compared with 3,971,772 tons in 1866, and 3,567,687 tons in 1865. Nearly the whole of the Belgian coal exported goes to France, which took 3,442,226 tons in 1867, against 3,818,712 tons in 1866, and 3,350,782 tons in 1865.

Great Yarmouth.—A considerable sum is about to be expended in the improvement of of Great Yarmouth. On the report of Mr. Beardmore, C.C., the Public Works Loan Commissioners have agreed to make a first advance of £10,000. Probably an additional sum of £20,000 will be advanced and expended.

Extensive freshets and much damage to railways, bridges, and the portions of cities bordering on watercourses are reported from all parts of America. The past winter has been more severe than any for several years, and the sudden thaw has swollen the rivers almost beyond precedent.

A Russian contract for iron and steel rails, with their accessories, is stated to have been secured by MM. de Dorlodot, of Acoz; but precise details on the subject have not yet transpired. The duty hitherto levied on pig iron imported into Russia is expected to be removed.

The Black Diamond Drill.—The Windsor (Vt.) U.S., Manufacturing Company are making a diamond drill quite different from the annular or tube drill (which formed a large central core and proved a failure). The new one has a solid drill head, cutting the full size of the hole. This gives it greater strength and better facility for setting the diamonds, so as to hold their position with less liability to loosen. The diamonds used are dark, opaque, and imported for the purpose. They are worked by a small oscillating engine attached to the drill-carriage, and connected with a flexible supply tube. Two men can carry one. It is quickly adjusted for work. The proprietors state that after boring over 500ft. in granite, quartz, talc, and marble, with one drill-head, the diamond points showed no wear.

New Sensitive Compound.—M. Prat, who claims to have isolated fluorine, forms a fluoride of silver insoluble in water and soluble in ammonia, from which it is precipitated by nitric acid. It is altered by light more rapidly than chloride of silver. The ordinary soluble fluoride of silver known to chemists is, according to Prat, an oxy-fluoride.

Exports of Machinery.—During the past year the foreign and colonial demand for British steam-engines was tolerably good, the value of the exports in the eleven months ending November 30th being £1,829,578, as compared with £1,611,442 to the corresponding date of 1866, and £1,797,435 in the first eleven months of 1865. It is worthy of note that a decrease, instead of an increase, would have been observed in the demand for British steam-engines last year, but for the very large deliveries of locomotives to the Indian railway companies. Thus, the value of the steam-engines sent to British India to November 30 last year was no less than £857,627, as compared with £457,987 in the coreesponding period of 1866, and £271,298 in the corresponding date of 1865. The exports of other British machinery remained about stationary last year, having attained a total of £2,781,928 to November 30, as against £2,785,908 in the first eleven months of 1866, and £3,015,249 to the corresponding date of 1865. In the ten years ending 1866 inclusive the value of the steam-engines exported from the United Kingdom was as follows:—1857, £1,069,249; 1858, £1,097,278; 1859, £973,340; 1860, £1,238,333; 1861, £1,258,164; 1862, £1,624,876; 1863, £1,595,036; 1864, £1,617,117; 1865, £1,958,533; and 1866, £1,750,492. The value of the exports of other machinery during the same period is subjoined:—1857, £2,814,420; 1858, £2,502,074; 1859, £2,757,961; 1860, £2,599,488; 1861, £2,955,506; 1862, £2,467,797; 1863, £2,772,976; 1864, £3,231,475; 1865, £3,264,100; and 1866, £2,998,692.

The Foreign Coal and Iron Trades.—There are continued complaints of depression in the French iron trade, but some good orders have been obtained by French mechanical firms. Thus Messrs. Schneider and Co., of Creusot, are about to proceed with a great bridge over the Danube for the Austrian State Railways. Creusot has also been ordered to supply 15,000 tons of rails for lines which the Hungarian Government is about to carry out. Messrs. Cail and Co., of Paris, have obtained an order for the iron work required for a large viaduct on the Austrian State Railways. We may also note that the Paris, Lyons, and Mediterranean Railway Company has ordered 20,000 tons of Bessemer steel rails from the Terre-Noire works. The quotation at St. Dizier for rolled iron from coke-made pig is £8 4s. per ton; ditto from mixed pig, £6 16s. per ton. The tendency of the Belgian iron trade is considered to be in the direction of improvement.

Galvanised Iron Roofing.—It has been necessary to recover the metal portion of the vast roof over the New-street station, Birmingham. The corrugated galvanised iron which had been used, is completely worn out after thirteen years' use. The zinc surface has long since disappeared by galvanic action and the oxygen of the rain water, has combined with the now unprotected iron, to be washed away slowly but surely by each succeeding shower of rain. The escaped steam from the entering and leaving locomotives was naturally condensed on the cool surfaces at the sides of the roof, and this increased humidity involved increased destruction there, givng a most dilapidated appearance. This state of things has been progressing during several months; in fact, the south side of the Worcester-street end was necessarily renewed with zinc sheeting some eighteen months ago. Now, the remainder of the roof has been similarly treated by Messrs. Ash and Lacy, the contractors, of Birmingham. We notice the ingenious contrivance by which these sheets are fastened. The purlins, which rest upon the main iron girders of the roof, are about 8ft. apart; across these, other piecce are nailed at about a foot apart. These are grooved on the upper side, and at regulated distances, eyes are fixed in this channel. The zinc sheet is ribbed to correspond with these channels, and has soldered to the under side of the corrugation, corresponding hooks, which shoot firm and fast into the slotted and sunk eyes, when the sheet of zinc is slipped into position. It will thus be seen that there are no holes made for nails; and though no nails are used no soldering is required, and painting is dispensed with. Each sheet of zinc overlaps, or is overlapped by its neighbour, at the sides and ends, and the result is an unbroken and perfectly water-tight roof. The zinc used is 16 guage, and more than a hundred thousand square feet have been expended in this renewal. That portion which, as noticed, was relaid about eighteen months since, remains intact, and satisfies every requirement.

### NAVAL ENGINEERING.

The twin screw gun vessel *Ringdove*, 160-horse power (nominal), awaiting her commission at Portsmouth, made a second official trial of her speed over the measured mile in Stokes Bay on March 30, and obtained a slightly increased rate of mean speed over the rate obtained on her previous trial. She drew 10ft. 5in. of water aft and 8ft. 8in. forward, with 90 tons of coals on board, and with rig and first-class steam reserve stores all complete. The speeds obtained by the ship and the times occupied in "circling" were as follows:—Full boiler power.—Knots per hour per run.—11·502, 10·405, 12·000, 10·056, 12·329, and 9·730; mean speed of the ship per hour, with full boiler power, 11·103 knots. Half boiler power.—Knots per hour per run.—10·876, 8·018, 11·392, and 7·547; mean speed of the ship per hour, with half boiler power, 9·581 knots. Circling.—With both engines working ahead, half circles made to starboard in 1 min. 45 sec., to port in 1 min. 44 sec.; full circles made to starboard in 3 min. 25 sec., to port in 3 min. 8 sec. With the two engines working in opposite directions, half circles made to starboard in 1 min. 28 sec., to port in 1 min. 23 sec.; full circles made to starboard in 3 min. 11 sec., to port in 3 min. 9 sec. With one engine only, and the rudder left free—half circles made to starboard in 2 min. 15 sec., to port in 3 min. 3 sec.; full circles made to starboard in 4 min. 30 sec., to port in 5 min. 32 secs. With one engine only, and the rudder lashed amidships—half circles made to starboard in 2 min. 27 sec., to port in 2 min. 25 sec.; full circles made to starboard in 4 min. 18 sec., to port in 4 min. 27 sec. The machinery worked admirably.

A contractors' trial of the engines of the double-screw steam gun vessel *Lapwing*, 2, took place outside Plymouth Sound about a month ago. She is of 663 tons burden, and belongs to the new class, of which there are eight vessels, and was constructed at Devonport. Four of them are having their machinery manufactured by the Messrs. Rennie; the *Lapwing* is the first of the four tried, and she is supplied with two pair of engines to work her two propellers. The trials took place under the superintendence of Captain George O. Willes, C.B., of the Steam Reserve, assisted by Mr. William Dinnen, Chief Inspector of Machinery Afloat, and by Mr. Robert Nicoll, of the Keyham factory. Mr. G. B. Rennie was present on the part of the contractors. The mean of six runs, at full power, gave a speed of 10·46 knots at a mean number of 116 revolutions per minute, the mean pressure in boiler being 26lb. The vacuum 25in., giving an indicated power of 830 horses, being five times the nominal power, 160, and 110 horse power more than the contract indicated power. These engines are of the ordinary type, without surface condensers or superheaters, and were tried under the regulations recently issued by the Admiralty. The result may, therefore, be considered satisfactory. The mean speed at half-boiler power was 8·06 knots, the revolutions 97, and the pressure of steam 19lb.

Trial Trip of the New Trinity Yacht "Irene."—On the 16th ult. the *Irene* left Blackwall at 11 a m., on her trial trip, and proceeded to the measure mile on the Maplin Sands. A large committee of the Elder Brethren of the Trinity House were on board, accompanied by Mr. Caird, of Greenock, the builder of this excellent vessel. Her dimensions are as follows:—Extreme length 231ft., length between perpendiculars 210ft., breadth of beam, 26ft., depth of hold 13ft. 10in., gross tonnage, 507½, registered tonnage 319, mean draught of water 9ft. with 140 tons of weight on board, displacement 722 tons, crew (all told), 38. At 1.30 had the two upper beacons in line; made six runs with an average of time per mile, 4 min. 14 sec., and an average distance per hour of 14¼ knots. on a trial of speed with one boiler, and the pressure reduced from 30lbs. to 16lbs., the average obtained was obtained was 11¾ knots.

### STEAM SHIPPING.

Steam Navigation for Russia.—The Russian merchants are yearly continuing to develope the internal resources of that empire by means of steam navigation. The Tyne has largely supplied Russia with steam vessels, and this spring a fair number of orders have been completed. Messrs. Leslie and Co. have finished a fleet of steam lighters of considerable tonnage for river service on the Black Sea; and Messrs. Charles Mitchell and Co. have completed a steamer of 300 tons for the commissioners for improving the Don estuaries; they have also on hand a paddle steamer for the Volga, and a steamer named the *Alexander*, intended for the service between St. Petersburg and the principal towns on Lake Onega. She is 500 tons, will have engines of 120-horse power. will have accommodation for three classes of passengers, and is specially designed for river service and for open water.

The "Great Eastern" Steamship.—It seems as if the misfortunes of the "big ship" were never to be at an end. She is being gradually stripped of everything that can be removed. On Thursday and Friday last all her furniture and fittings were sold by public auction under a bill of sale held by a leading firm in Liverpool, and a very heavy creditor of the company. The effects consisted of an immense quantity of furniture and bedding, which had been supplied by several Liverpool tradesmen on behalf of the French company, by whom the ship was chartered, and who are still unpaid for it. The articles sold comprised about 2,000 hair and wool beds, upwards of 1,000 cushions, about 40 splendid mahogany dining tables, several hundred chairs, more than 1,000 sets of curtains, and an immense number of miscellaneous articles, including all the valuable copper cooking and culinary utensils. Most of the articles sold—more especially the copper utensils—brought their full value, and the sale realised several thousand pounds.

### LAUNCHES.

A fine iron screw steamer was launched recently from Messrs. Denton, Gray, and Co.'s yard, at Hartlepool, of the following dimensions:—Length, 220ft.; breadth, 28-3ft.; depth, 21ft. 8in.; tonnage, 930 gross weight. Her engines will be fitted by Messrs. Richardson and Son, Hartlepool. The vessel is built on speculation.

Messrs. Robertson and Co. have launched on the Clyde a fine saloon paddle steamer of the following dimensions:—125ft. in length, 22ft. in breadth, and 7ft. 6in. in depth. She is named the *Ozorio*, and has been built for Senor Silveira, of Rio Grande, is to be engined by Mr. David Rowan, of Glasgow, and, when finished, is to proceed under steam to her destination, there to run with goods and passengers on the Rio Grande.

### TELEGRAPHIC ENGINEERING.

Telegraph in Abyssinia.—The line of telegraph is completed and in working order to Attegeret, a distance of 101 miles from Tonla, though interruptions constantly occur by breaks in the line, supposed to be caused by the natives of the country stealing the wire. The progress of the line towards Antalo is delayed for want of poles, none suitsable being procurable in the neighbourhood. The 2nd Company Bombay Sappers and 53 Lascars, have been placed at the disposal of Lieut. St. John, R.E., director of the telegraph, to assist in putting up posts and laying the line.

Messrs. Stearns and Smith, of the Franklin Telegraph Company (U.S.), have for some time been engaged in perfecting an apparatus for working in both directions over a single wire at the same time. The method employed is the one originally devised in 1854 by Frischen, inspector of telegraphs in Hanover, but has been improved by the addition of a local circuit attachment to the transmitting apparatus. A wire between New York and Boston has been lately worked in this manner with the greatest success.

## RAILWAYS.

**The** *Opinione* of Florence announces that the Italian Government have come to an understanding with the administration of the railway companies to allow the travellers entering Italy at Susa, and leaving it at Ancona and Brindisi, to have their luggage conveyed in transit, without submitting them to any examination of the Custom-houses, either on coming in or going out. The main object of this measure is to avoid any stoppage or delay to travellers on their way to India, who, even before the completion of the Mont Cenis tunnel, might wish to embark at Brindisi rather than at Marseilles.

**The Nice and Genoa Railway.**—The last section of the Paris and Mediterranean Railway between Monaco and Italy is now about to be terminated with as much rapidity as possible. It is only a few kilomètres in length, but of great difficulty as regards the works required in its construction. It runs parallel with the Cornichi road, principally at the edge of the sea, and crosses the various difficulties of the ground in cuttings or embankments, tunnels or viaducts, but at very different levels from the above road, which in many places is several hundred mètres above the railway. The most important work is the tunnel at Cape St. Martin, which has been commenced at both ends as well as in the middle by means of shafts. The French line terminates at Port St. Louis, about two kilomètres distant from Mentone. On the Italian side the section from Voltri to Savona is now complete, and the locomotive has already passed over it. It will probably be opened to the public towards the end of the present month.

**There** are now 12,000 miles of railway open to travel in France. Every line is remunerative, some paying original stockholders from 20 to 25 per cent., and it is claimed that passengers are conveyed by them with more regularity, safety, and comfort, than elsewhere in Europe. Within eighty years at the farthest all these lines will have reverted to the Government and become, practically, public property.

## ACCIDENTS.

**Frightful Explosion on Board an American Steamer.**—The *Magnolia* (s), which left Cincinnati at noon on the 18th March, with cabin passengers and a large amount of freight, exploded her boilers twelve miles above this city at half-past one o'clock in the afternoon. The greater portion of the cabin was carried away, and the boat afterwards took fire. About forty persons were killed, several of them being burnt to death. The *Magnolia* had one hundred and twenty passengers and a crew of forty. Fifty-seven are known to have been saved. The boat took fire immediately after the boilers exploded, and after the remaining upper works were destroyed some powder exploded, destroying all but the hull, which sank. Many of the passengers jumped overboard and were drowned, and others were burnt, among them the captain.

## DOCKS, HARBOURS, BRIDGES.

**The** corner stone of the great bridge across the Mississippi at St. Louis was laid on Feb. 2nd, with appropriate ceremonies.

**The Alfred Graving Dock at Williamstown, Victoria, Australia.**—The memorial stone of this dock was laid by the Duke of Edinburgh on the 4th of January last. Since the dock was first designed our men-of-war have increased so greatly in size that it was thought necessary to alter its proportions, and when completed it will be capable of taking in the largest vessel afloat excepting the *Great Eastern*. The following are some of the principal dimensions, viz. .—Length over all, 420ft., and 400ft. long on the floor within the entrance. It will be 97ft. in width on the top, and the entrance will be 80ft. wide in the clear. At ordinary spring tides there will be a depth of water of 24ft. 6in. on the sill at low water, and 27ft. at high water. The entrance will be closed by an iron caisson. The dock is built of the basaltic stone of the neighbourhood, known as bluestone, and is estimated to cost, when complete, with pumping engines, &c., £185,000. The dockyard comprises an area of fifteen acres, and includes the present patent slip, which is capable of raising vessels of 2,000 tons; and within this dockyard workshops for the several trades connected with shipbuilding will be erected. The works of the dock were commenced in November, 1864, and its completion is expected by the end of 1869. Engineer, W. W. Wardell, Inspector-General of Public Works, assisted by W. H. Steel and A. C. Todd. Contractor for Works now in progress, J. Leggatt. Resident Inspector, H. Woods.

**Millwall Docks.**—One of the greatest and most important additions to the private dock accommodation of the river was made on Saturday, the 14th March, by the formal opening of these basins and warehouses. The whole space on which the docks and warehouses stand is no less than 104 acres. Of this area there are at present 35 acres of water for dock accommodation, and when the scheme is entirely completed there will be upwards of 52, leaving 152 acres available for wharves and warehouses. The width of the floating dock at Millwall is no less than 350ft., and has two entrance locks, one, the first, of 250ft. long, and the second 290ft., and both with a width of 80ft., and a depth at the sill of the lock of 28ft. below Trinity high water mark. Thus with the inner gate open a vessel longer and broader than any vessel yet built, except the *Great Eastern*, could easily be taken into dock at almost any time of average high water. Near the floating dock is a graving dock for the repairs of vessels. Its length is, inside the sill, 415ft., and its width 65ft., with a depth of water 25ft. below Trinity datum. All the locks are provided with hydraulic power for working the pairs of gates, the bridges, and one three-ton and one five-ton capstan, and hydraulic power is also applied to the drawbridge between the inner and outer dock, and to some of the cranes in connection with the warehouses. Of these latter nine have already been built—namely, two of 300ft. long, four of 100ft. long, and three of 100ft. long. These are fitted with 12 35-cwt. cranes, one 5-ton crane, one of 14 tons, and a sheerlegs equal to a weight of 80 tons is in course of erection. On Saturday little was done in the way of "opening" beyond letting some vessels into the new docks, and in visiting the graving docks, in which the *Arapiles*, a Spanish ironclad, now lies, awaiting her entire completion for sea.

**Mr. Haywood** states that the new viaduct at Holborn Hill will, so far as carriage traffic is concerned, be available for use at the end of this year or the beginning of next.

**The Suez Canal.**—In the month ending March 14th, the total extraction of earth amounted to 1,554,63 cubic mètres, as compared with 1,100,128 cubic mètres in the month ending February 15th, and 1,130,380 cubic mètres in the month ending January 15th. The quantity of earth remaining to be extracted, March 15th, 1869, was estimated at 36,005,131 cubic mètres.

## MINES, METALLURGY, &c.

**In** Tasmania workings have been successfully opened at the north end of the Douglas river coalfields. Coal of good quality for steam purposes has been discovered on the east coast of South Brani Island, at Adventure Bay; and a bituminous coal of fair quality has been discovered near Hamilton. Coal deposits are reported in Trinidad; the finest quality was found at Point Noir: it burnt rapidly with much flame. At Iwanai, also, in the island of Yeddo, in Japan, coal mines have been discovered. An experiment was made with some of the coal picked out from the surface of the seam, in the galley fire of Her Majesty's ship *Salamis*; 79lbs. of coal yielded 17·27 per cent. of ash, 1·5 per cent. of clinker, an average amount of smoke, and a strong durable flame. Another coal-field was found at Yeddo, in the immediate vicinity of the port of Hiogo. The natives have been working it for the last ten years, but not continuously.

## LATEST PRICES IN THE LONDON METAL MARKET.

| | From | | | To | | |
|---|---|---|---|---|---|---|
| | £ | s. | d. | £ | s. | d. |
| COPPER. | | | | | | |
| Best selected, per ton | 83 | 0 | 0 | 84 | 0 | 0 |
| Tough cake and tile do. | 80 | 0 | 0 | 82 | 0 | 0 |
| Sheathing and sheets do. | 84 | 0 | 0 | 85 | 0 | 0 |
| Bolts do. | 83 | 0 | 0 | ,, | ,, | ,, |
| Bottoms do. | 86 | 0 | 0 | 88 | 0 | 0 |
| Old (exchange) do. | 68 | 0 | 0 | 70 | 0 | 0 |
| Burra Burra do. | 83 | 10 | 0 | 84 | 0 | 0 |
| Wire, per lb. | 0 | 1 | 0 | ,, | 1 | 0½ |
| Tubes do. | 0 | 0 | 11½ | 0 | 1 | 0 |
| BRASS. | | | | | | |
| Sheets, per lb. | 0 | 0 | 9 | 0 | 0 | 10 |
| Wire do. | 0 | 0 | 8½ | 0 | 0 | 9½ |
| Tubes do. | 0 | 0 | 10½ | 0 | 0 | 11 |
| Yellow metal sheath do. | 0 | 0 | 7¼ | ,, | ,, | ,, |
| Sheets do. | 0 | 0 | 7 | ,, | ,, | ,, |
| SPELTER. | | | | | | |
| Foreign on the spot, per ton | 20 | 5 | 0 | 20 | 7 | 6 |
| Do. to arrive | 20 | 5 | 0 | 20 | 7 | 6 |
| ZINC. | | | | | | |
| In sheets, per ton | 26 | 0 | 0 | ,, | ,, | ,, |
| TIN. | | | | | | |
| English blocks, per ton | 98 | 0 | 0 | ,, | ,, | ,, |
| Do. bars (in barrels) do. | 99 | 0 | 0 | ,, | ,, | ,, |
| Do. refined do. | 99 | 10 | 0 | ,, | ,, | ,, |
| Banca do. | 94 | 0 | 0 | 95 | 0 | 0 |
| Straits do. | 93 | 0 | 0 | 93 | 10 | 0 |
| TIN PLATES.* | | | | | | |
| IC. charcoal, 1st quality, per box | 1 | 7 | 0 | 1 | 10 | 0 |
| IX. do. 1st quality do. | 1 | 13 | 0 | 1 | 16 | 0 |
| IC. do. 2nd quality do. | 1 | 5 | 0 | 1 | 7 | 0 |
| IX. do. 2nd quality do. | 1 | 11 | 0 | 1 | 13 | 0 |
| IC. Coke do. | 1 | 3 | 0 | 1 | 4 | 0 |
| IX. do. do | 1 | 9 | 0 | 1 | 10 | 0 |
| Canada plates, per ton | 13 | 10 | 0 | ,, | ,, | ,, |
| Do. at works do. | 12 | 10 | 0 | ,, | ,, | ,, |
| IRON. | | | | | | |
| Bars, Welsh, in London, per ton | 6 | 5 | 0 | ,, | ,, | ,, |
| Do. to arrive do. | 6 | 2 | 6 | 6 | 5 | 0 |
| Nail rods do. | 6 | 15 | 0 | 7 | 0 | 0 |
| Stafford in London do. | 7 | 7 | 6 | 8 | 10 | 0 |
| Bars do. do. | 7 | 7 | 6 | 9 | 10 | 0 |
| Hoops do. do. | 8 | 5 | 0 | 9 | 5 | 0 |
| Sheets, single, do. | 9 | 0 | 0 | 11 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. mrch. Tyne or Tees do. | 6 | 10 | 0 | ,, | ,, | ,, |
| Do. railway, in Wales, do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. Swedish in London do. | 10 | 2 | 6 | 10 | 5 | 0 |
| To arrive do. | 10 | 2 | 6 | 10 | 5 | 0 |
| Pig No. 1 in Clyde do. | 2 | 12 | 9 | 2 | 17 | 0 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | ,, | ,, | ,, |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 7 | 0 | 0 | 7 | 10 | 0 |
| STEEL. | | | | | | |
| Swedish in kegs (rolled), per ton | 14 | 5 | 0 | ,, | ,, | ,, |
| Do. (hammered) do. | 14 | 15 | 0 | 15 | 0 | 0 |
| Do. in faggots do. | 16 | 0 | 0 | ,, | ,, | ,, |
| English spring do. | 17 | 0 | 0 | 23 | 0 | 0 |
| QUICKSILVER, per bottle | 6 | 17 | 0 | ,, | ,, | ,, |
| LEAD. | | | | | | |
| English pig, common, per ton | 19 | 10 | 0 | 19 | 12 | 6 |
| Ditto. L.B. do. | 19 | 15 | 0 | ,, | ,, | ,, |
| Do. W.B. do. | 21 | 10 | 0 | ,, | ,, | ,, |
| Do. sheet, do. | 20 | 5 | 0 | ,, | ,, | ,, |
| Do. red lead do. | 20 | 15 | 0 | ,, | ,, | ,, |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 10 | 0 | 23 | 0 | 0 |
| Spanish do. | 18 | 15 | 0 | 19 | 0 | 0 |

* At the works 1s. to 1s. 6d. per box less.

## LIST OF APPLICATIONS FOR LETTERS PATENT.

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

### Dated March 18th, 1868.

914 W. Smale—Machinery for figure weaving
915 C. F. C. Cretinborne—Ventilating mines
916 W. Clarke and E. Walker—Capstans
917 E. Butterworth—Furnaces
918 W. R. Lake—Apparatus for effecting the continuous return into a steam boiler of the water evaporated
919 G. Martin—Treatment of mixed fabrics
920 A. V. Newton—Covering for floors
921 C. J. Appleby and I Riley—Cranes
922 R Townsend—Firearms
923 B E. R Newlands—Treating and obtaining products from spent oxide of iron
924 R. A. Wright—Cutting millstones
925 J. B Linnett—Optical illusions
926 G. Wailes—Safes
927 S. Wenkheim—Combining a shirt and waistcoat

### Dated March 19th, 1868.

928 P. Hill—Brakes for perambulators
929 B. Parks—Separating and crushing breeze
930 C. E. Green and J. Green—Cartridges
931 W. R. Lake—Ventilating windows
932 J. Edwards—Props
933 W. Redman—Cop bottoms
934 E. Rowland—Closing dampers
935 G. Davies—Combing cotton
936 J. E. Lane—Heating apparatus
937 W. Richardson—Bricks and tiles
938 F. Warner and H. Chopping—Windmills
939 W. Hooper—Treating india rubber
940 J. L Geiger—Doubling silk, &c.
841 R. W. J. Truman—Collecting m d
942 L. Encausse—Application of remedial agents to the human frame
943 H. Chamberlain, J. Craven, and H. Wedekind—Burning bricks, &c.
644 H. F. Shaw—Machines for overcoming resistance

### Dated March 20th, 1868

945 R. White—Apparatus for saving 50 per cent of the present steam power
946 J G. Tatters, W. Keeble, and B. Newbery—Cigars
947 C. Mather—Opening wool, &c.
948 W. Pinkney and R. Calvert—Applying jets of steam to blacksmiths' fires
949 R. Meldrum—Steam engines
950 A. Brownlie—Heating air
951 W. Taylor and C. E. Taylor—Stands for sewing machines
952 J. Abraham and T. R. Bayliss—Cartridges
953 J. H. Cooper—Boots
954 C. Gunner—Lifeboats
955 J. H. C. Bade—Ranges
956 G. Twigg and H. Bateman—Corkscrews
957 S. Duer—Stuffing boxes

### Dated March 21st, 18 8.

958 G. Davies—Mill stones
959 E. D. Johnson—Watches
960 I. S. Lister—Hats
961 G. Macdona and O. Hilliard—Appliances for conveyance
966 W. S. Boulton—Lawn mowers
963 J. O. Spong and J. F. Haddaway—Blow-pipes
964 W. G. C. Hudson—Sandals
965 H. Bessemer—Refined iron
966 J. G. Jennings—Waterclosets
967 H. Bessemer—Malleable iron
968 R. G. Greenhow—Firearms

### Dated March 23rd, 1868.

969 E. K. Dutton—Valves
970 V. A. Draubenf—Fuel
971 T. Pope—Braces
972 W. R Lake—Metal ties, &c.
973 S. Holmes—Lamps
974 C. E. Brooman—Lace
975 H. Paulus—Pile-driving engine
976 J. Bronner—Gas burners
977 C. McDermott—Indelible pencil
978 C. F. Guy—Sugar
979 C. N. Leroy—Grease cups
980 A. W. Ramscar and F. W. Wilson—Firearms
981 W. R. Lake—Metal ties
982 C. de Bergue—Locomotive engines
983 E. Vignier—Distilling spirits
984 A. Barclay—Barometers, &c.
985 A. V. Newton—Thrashing machinery
986 H. Treverton and E. H. Fowler—Frames for lamp shades

### Dated March 24th, 1868

987 J S. Farmer—Transmitting railway signals
988 G. B. Paterson—Gasmeter indexes
989 H. Burgess—Rails for railways
990 W. E. Gedge—Smoke-consuming fireplace
991 W. R. Bootbby—Rotary motion
992 T. W. Fuller—Carriages
993 C. D. Abel—Watches, &c.
994 F. Gray—Metal bars
995 E. Gray—Rails, &c.
996 R. A. Hardcastle—Iron and steel
997 J. A. Farrar and B. R. Huntley—Ships' hatches
998 F. W. Crohn—Obtaining power from a fall of water
999 D. Lewis—Portable tables
1000 R. Smith—Winding cotton, &c.
1001 C. Harris—Paper bags
1002 J. Antill—Stench traps
1003 A. V. Newton—Pocket knives
1004 R. Smith—Scouring grain, &c.
1005 M. P. W. Boulton and J. Imray—Aerial locomotion

### Dated March 25th, 1868.

1006 R. Little—Reducing the temperature of air in producing ice, &c
1007 A. Elliott and J. Barker—Lubricating axles
1008 H. A. Bonneville—Distributing prospectuses, cards, &c.
1009 A. McGlashan and J. Hendry—Mashing substances employed in making fermented liquors
1010 A. B. Wollaston and F. Stanbridge—Treatment of mixed fabrics, &c
1011 J. Warburton—Steam engines
1012 G. Hayhurst—Drying cylinders
1013 W. Buck—Working, &c., railway points and signals
1014 T. Lane—Looms
1015 C. E. Brooman—Paper tubes
1016 S. Fisher—Ornamentation of tiles
1017 J. Plant—Dram flasks
1018 A. V. Newton—Spinning machinery
1019 W. Richardson—Burring wool
1020 T. Whitehouse—Blast furnaces
1021 T. Sagar, T. Richmond, and C. Catlow—Looms
1022 J. Anderson—Carding wool
1023 J Jameson—Safety paper
1024 Hon. H. G. P. Meade—Firearms, &c.
1025 A. P. Price—Treatment of ores
1026 W P. Piggott—Transmitting telegraphic messages, &c.

### Dated March 26th. 1868.

1027 E. J. J. Dixon—Reducing, &c., slate
1028 J. T. King—Dressing millstones
1029 W. Oram—Hydraulic presses
1030 M. B. Orr—Drying and preserving vegetable and animal substances
1031 W. H. St. Aubin—Cocks and taps
1032 T. Bettney—Paper cutting machines
1033 H. Davey—Steam engines
1034 W. Clark, jun., and J. Clark—Locomotive engines
1035 M. Havenhand and J. Allen—Pistons
1036 J. Cocks—Trowsers
1037 W. Mauwaring—Reaping machines
1038 W. D. Cliff—Furnaces or kilns
1039 W. S. Page and R. East—Mechanical arrangements applicable to steam boilers
1040 B. Browne—Cuffs, &c.
1041 S. Perry and F. Brampton—Letter clips
1042 J. Lyall—Looms
1043 J. H. Johnson—Lamps
1044 T. Routledge and W. H. Richardson—Bleaching esparto, &c.

### Dated March 27th, 1868.

1045 A. Warner—Cement
1046 S. Holman—Steam pumps, &c.
1047 I. Bates and J. Taylor—Cleaning the flues of boilers
1048 A Scott—Alcoholic fermented, dry, sweet, or effervescent drink
1049 J. Maurice—Optical illusions
1050 F. Bauman—Combination of chemical substances, &c.
1051 G. Hodgkinson—Producing designs
1052 G. Davies—Steam engines
1053 P. Adie—Shearing sheep, &c.
1054 C. E Brooman—Breech-loading firearms
1055 C. B. James—Securing needles
1056 W. E. Newton—Obtaining motive power
1057 H. Jones and W. F. De la Rue—Whist counters
1058 J. G. Jones—Hauling minerals in mines
1059 W. W Hughes—Propelling vessels
1060 S. C. Lister—Cut-pile fabrics
1061 H. Hughes—Locks and keys

### Dated March 28th 1868.

1062 J. G. Fildes—Bearer or support for conveying ladles containing molten metal
1063 T. C. Currie—Preservation of milk
1064 H. G Warren, S. Stuckey, and P. Froud—Revolving iron shutters
1065 J. Macintosh and W. Boggett—Boots
1066 C. Joyner—Water-slide gaseliers
1067 J. C. Coombe and J. Poole—Coating iron, &c.
1068 W. J. Addis—Permanent way of railways
1069 W. E. Gedge—Moistening postage stamps
1070 W. R. Lake—Filters

### Dated March 30th, 1868.

1071 H. Armstrong—Manufacture of steel
1072 O. Ormrod—Washing, bleaching, &c.
1073 C. F. Claus—Iron
1074 C. F. Claus—Malleable iron
1075 B. Mitford—Communicating with deaf and dumb persons
1076 J. H. Johnson—Manufacture of cast steel
1077 J. H. Johnson—Treatment of cork
1078 J. H. Johnson—Manufacture of cast steel, &c.
1079 J. F. Hadland—Metal ties
1080 F. Wirth—Stopping railway trains
1081 J. M. Day—Decorticating seeds, &c.
1082 A. B. Walker—Application of hot blast, &c.
1083 C. S. Tyson—Mechanism for taking up the recoil of heavy ordnance
1084 J. Walker and J. Wharrie—Cast-iron pipes
1085 J. Jordan—Fire-bars

### Dated March 31st, 1868.

1086 W. Austin—Composition, boxes, and surfaces for obtaining instantaneous light from chemically prepared matches
1087 F. Taylor—Fittings of railway carriages
1088 W Allen—Diminishing valves
1089 J. Sinclair—Screw propellers
1090 M. Hawthornthwaite—Taps, &c.
1091 H. B. Woodcock—Metal for axles
1092 J. Lent—Express telegraph
1093 L. F. P. Riviere—Velocipede
1094 J. H. Weston—Lighting and ventilating the interior of buildings
1095 H. Bessemer—Malleable iron
1096 J. H. Johnson—Sewing machines

### Dated April 1st, 1868.

1097 T. Couldrey, jun.—Making pumps
1098 H. H. Doty and G. Graveley—Construction of burners and lamps
1099 A. Scatchard—Aerated bread
1100 A. M. Wier and M. A. Wier—Pneumatic apparatus
1101 W. A. Warner Sleigh and A. Pye—Protecting trousers from mud
1102 W. Smith—Pig iron
1103 L Appleton—Calculating interest
1104 G Davies—Centrifugal ventilators
1105 J. Norris and T. Quaim—Cooking apparatus
1106 J. Walker and J. Caudlin—Flooring, sash, and bench cramps
1107 G. Kynoch and W. Whitehill—Cartridges
1108 W. Clissold—Belt fastenings
1109 R. J. Morison—Cotton gins
1110 W. R Lake—Horse shoe nails
1111 J. H. Dufort and D. Gance—Sewing machines

### Dated April 2nd, 1868.

1112 J. Saxby—Actuating railway points
1113 E. Leahy—Moveable railway
1114 T. Baker—Umbrellas
1115 A. Jackson and J Hartley—Braiding machines
1116 A. Lafone and J. Nichols—Furnaces for burning petroleum
1117 J. G Dale and E. Milner—Producing white pigments from lead
1118 W. Robertson—Shaping and cutting timber
1119 J Napier—Steering ships
1120 W. E. Boardman—Steam and water packing

### Dated April 3rd, 18 8.

1121 J. T. Walmsley—Warping yarns
1122 A. De Metz—Commodes or vessels to be used as waterclosets, &c
1123 J. S. Crosland—Steam engines
1124 C. D. Abel—Refining camphor
1125 J. Wallace—Digging potatoes
1126 J. McCulloch—Utilising old tarpaulin
1127 J. Harwood—Sewing machines
1128 C. W. Baldwin—Device for measuring the amount of a flowing liquid
1129 A Martin—Bonnet shapes
1130 J. H. Johnson—Cast steel, &c.
1131 J. V. Jones and G. J. Williams—Metallic tubes
1132 G. Piggott—Electric telegraphs
1133 W. Williams—Tin plates
1134 J. G. Tongue—Lamps
1135 T. Row—Paper hangings

### Dated April 4th, 1868.

1136 H. C. Butcher—Tobacco pipe
1137 H. Cochrane—Blast furnaces
1138 W. Johnson—Compressing coal, &c.
1139 F A Calvert—Cleaning cotton, &c.
1140 T. Faucheux—Axles of wheels
1141 A. Illingworth and H. Illingworth—Folding worsted
1142 F. A. E. G. De Massas—Cleaning cotton seeds
1143 F. H. Greenstreet—Targets, &c.
1144 R. Nabbs—Locks
1145 C. E. Turnbull—Paper binders or eyelets
1146 G. Davies—Washing and separating ores
1147 D. C. MacIvor—Propelling ships

### Dated April 6th, 1868.

1148 J. Griffiths and J. Jeavons—Piles
1149 H. Bryceson, J. Bryceson, and T. H. Morten—Organs
1150 D. Crichton, W. Doubavand, and D. Crichton—Looms
1151 E Hay—Measuring the flow of liquids
1152 J. Dunbar and R. Nicholson—Inserting coal into gas retorts, &c.
1153 R. Moreland and D. Thomson—Pumping engines
1154 G H. Gardner and J. Bickerton—Lithographic printing machines
1155 M. A. F. Mennons—Reception of typographic or autographic telegrams
1156 J. M. Plessner—Motive power
1157 J. Radcliffe—Iron and steel
1158 J. Perry—Packing bottles
1159 C. Desnos—Permanent way of railways
1160 T. Holt and H Spencer—Spinning cotton
1161 A. V. Newton—Bathing shoes
1162 A. V Newton—Anchors
1163 J. Casson—Planing wood

### Dated April 7th, 1868.

1164 E. Watteau—Screw taps
1165 R. Holiday—Prevention of accidents at facing points on railways
1166 H. J Ditmars—Consumption of smoke
1167 A. L Holley—Iron and steel
1168 W. Nall—Holding and igniting matches
1169 E. H. Newby—Boat detaching apparatus
1170 H. Fisher—Handles of tenpots
1171 F. Simpson and S. Hardwick—Rolling sheets of iron
1172 C. W. Siemens—Application of gas furnaces to evaporating, smelting, &c.
1173 I. Sherwood—Lamps
1174 R. G. Lowndes—Finishing textile fabrics
1175 J. Armstrong—Harrows
1176 P. McMahon—Destroying the decaying principle in animal substances
1177 D. Lane—Floor and other cloth

### Dated April 8th, 1868.

1178 C. G. Spencer—Machine for enabling persons to support, raise, and propel themselves in and through the air
1179 J. Bedford—Washing and drying grain
1180 J. J. Chaudun and J. J. Dexant—Cartridges
1161 J. James and T. Jones—Manufacture of iron into steel
1182 G. H. Palmer—Spring brace
1183 W. R. Lake—Cutting rocks
1 84 W. E. Newton—Salts of soda
1185 E Benningfield—Lifting machine
1166 C. G. Hill—Fringes
1187 V. Gallet—Steel
1185 E Brasier and J. E. Hodgkin—Scutching flax
1189 T. Hunt—Ordnance
1190 C Douglas—Cutting the teeth of wheels

### Dated April 9th 1868.

1191 W. Chapman—Skiving leather
192 J. Fitter—Alarums
1193 J. Plews—Steam engines
1194 J. Rae—Railway wheels
1195 A. H. Still and D. Lane—Gas
1196 W. B. Robins—Garden engines
1197 J H. Whitehead—Removing soot from the surfaces of heating tubes
1198 G. T. Bousfield—Dies
1199 J Leemins—Looms
1200 W. E. Newton—Firearms and cartridges
1201 R. A. Wright—Heating structures
1202 L. Verstraet—Housing burning petroleum

### Dated April 11th, 1868.

1203 J Sutcliffe—Outline maps
1204 J. Marsden—Construction of beams
1205 C Martin, W. Barrett, and T. S. Webb—Treatment of titaniferous iron ores
1206 C. E. Brooman—Photography
1207 T. H Baylis—Cribs, cots, &c.
1208 J. C. Wilson—Hydraulic packing cases
1209 R. Nicholls—Buttons
1210 G. Clark—Explosive compounds
1211 H. A. Archereau—Obtaining heat and light
1212 S. W Huntington—Preparing paper
1213 A. Woodcock—Suspending pictures
1214 M. A. F. Mennons—Carbonated beverages
1215 E. Dubois and E. Casper—Gas meters
1216 A. Barclay—Condensing steam engines
1217 G. Paton—Looms

### Dated April 13th, 1868.

1218 B. J. B. Mills—Bleaching feathers, &c.
1219 J. Rothery—Getting and hewing coal, &c.
1220 R. Ridley and J. Rothery—Getting and hewing coal, &c.
1221 T. F. Shillington—Reaping machines
1222 T Forster—Compounds of india rubber, &c.
1223 G. E. Donisthorpe—Getting coal, &c.
1224 E. Richardson—Stays or corsets
1225 J. Combe—Breaking flax, &c.

### Dated April 14th, 1868.

1226 C. Hargrove and S. Hargrove jun.—Breech-loading actions
1227 T. Smith, T. W. Miller, and T. Don—Manufacturing wheat into meal, &c.
1228 E. Foden—Mowing and reaping
1229 A. Braham and L. Braham—Hats
1230 D. P. H. Vaughan—Ceramic tesseræ, &c.
1231 J. H. Johnson—Saw handles
1232 H. Hughes—Pipings of satin
1233 M. P. W. Boulton—Receiving motion from fluids, &c.
1234 B. Blackburn and A. B. Blackburn—Navigable structures

### Dated April 15th, 1868.

1235 W. Watts—Mangles
1236 A. V. Newton—Breech-loading firearms
1237 G. Glover—Submerged or subaqueous lamps
1238 E. Page—Fixing the tines of harrows, &c.
1239 W. S. Fletcher—Combing silk, &c.
1240 R. Oxland—Treatment of ores
1241 R. Ward—Twisting tobacco
1242 R. Boby—Horse rakes

### Dated April 16th, 1868.

1243 F. A. Leigh—Machine for planting potatoes
1244 C. Burn—Propelling carriages
1245 J. Clarke—Manufacture of paper
1246 E A. Morgan—Glass rings employed in spinning
1247 W. Callender—Filling cartridges
1248 R. Weir and J. Gray—Furnaces
1249 H. S. Evans—Taps, valves, &c.
1250 J. H. Johnson—Heating and ventilating
1251 J. Robinson—Manufacture of paint

### Dated April 17th, 1868.

1252 H. G. Fairburn—Machinery for turning
1253 C. W. Siemens—Electrical apparatus
1254 G. D. Kittoe and P. Brotherhood—Refrigerating worts
1255 H. O. Robinson—Screw propeller
1256 W. Gorman—Manufacture of iron
1257 D. Smith—Securing tubes in steam boilers
1258 W. E. Gedge—New chemical product
1259 W. E. Gedge—Mechanical boot and shoe fitting machine
1260 Lieut. F. Bacon—Firearms
1261 J. Erskine—Firearms
1262 A V. Newton—Machinery for gathering hay
1263 A. P. Price and J. A. Wanklyn—Preparation and use of anæsthetics

### Dated April 18th, 1868.

1264 T. Bradford—Machinery employed for churning, &c.
1265 G. Lister—Feeding slivers of wool, &c.
1266 E. T. Hughes—Hats and bonnets
1267 J. Hargreaves—Phosphates
1268 R. Scholefield—Brick-making machinery
1269 A. Ashley, E. Rawnsley, and W. Pearson—Lubricating spindles
1270 W. Lund—Turning off crosshead wrist-pins
1271 N. Ager—Fastenings for window-sashes
1272 H. W. Widmark—Governors for steam engines
1273 J E. F. Ludeke—Motive power
1274 R. Hill and J. F. D'Oyly—Paddle wheels
1275 A. B. Childs—Grinding the surface of millstones, &c.

# THOMPSON AND NOBLE'S IMPROVED SLIPWAY.

Fig. 1.

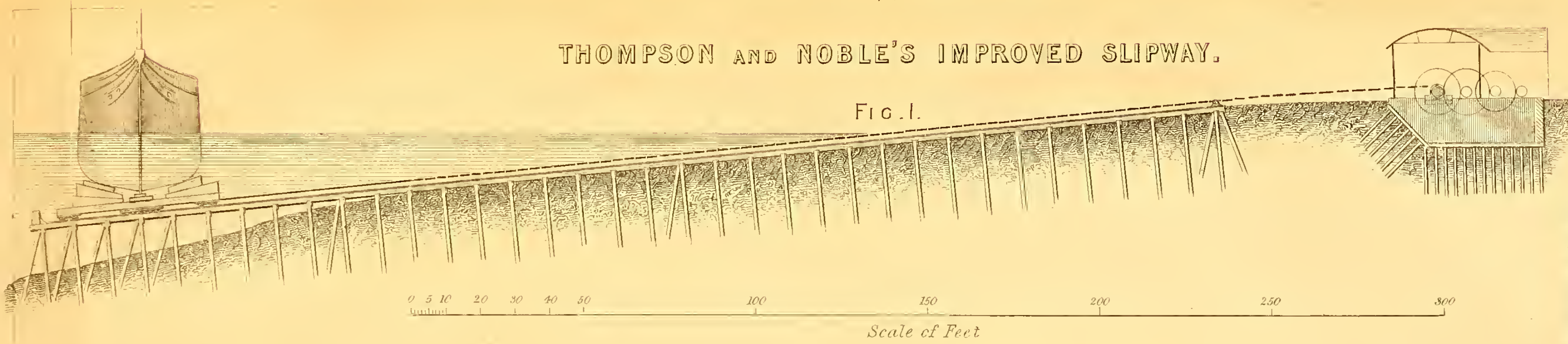


Fig. 2.

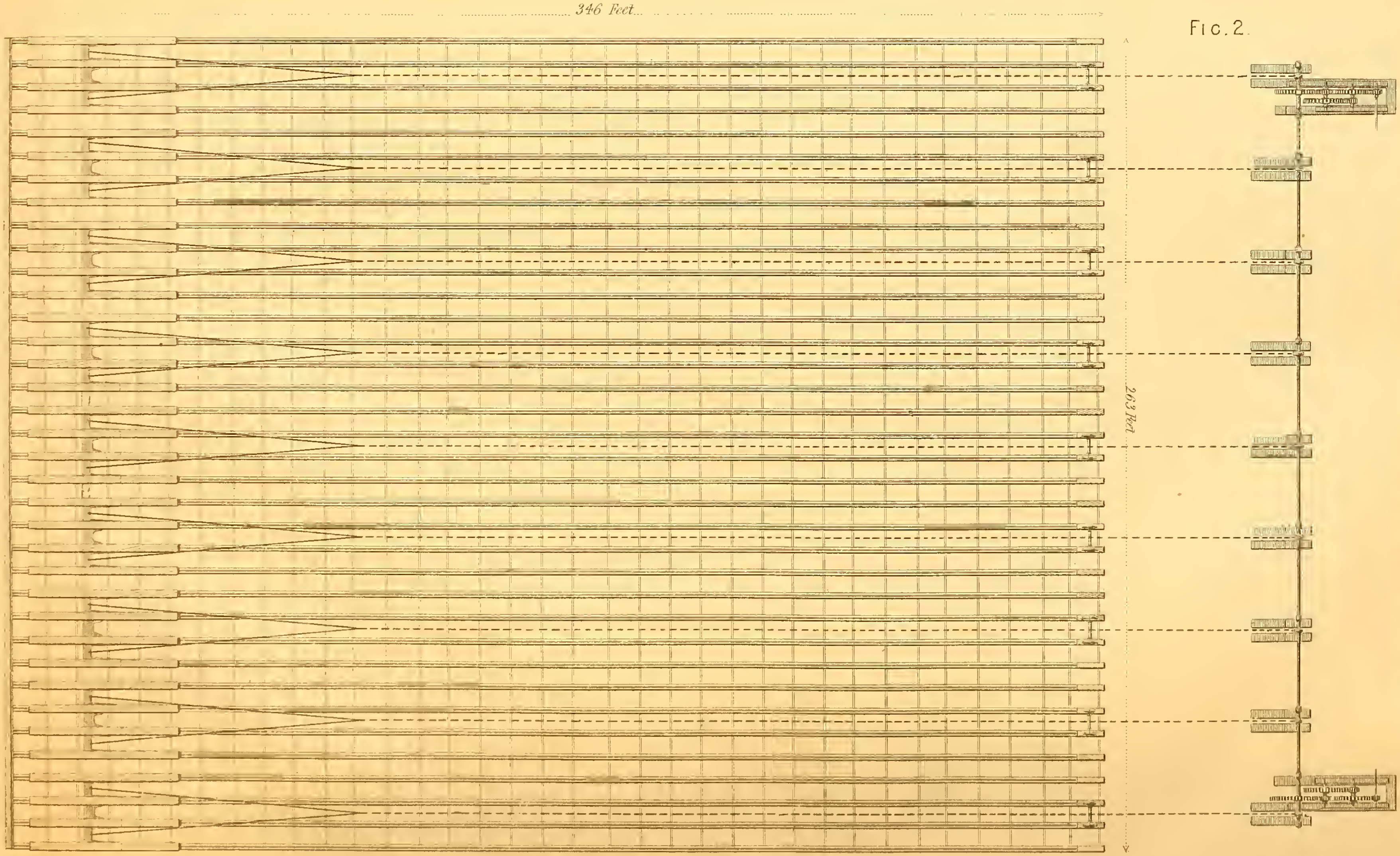
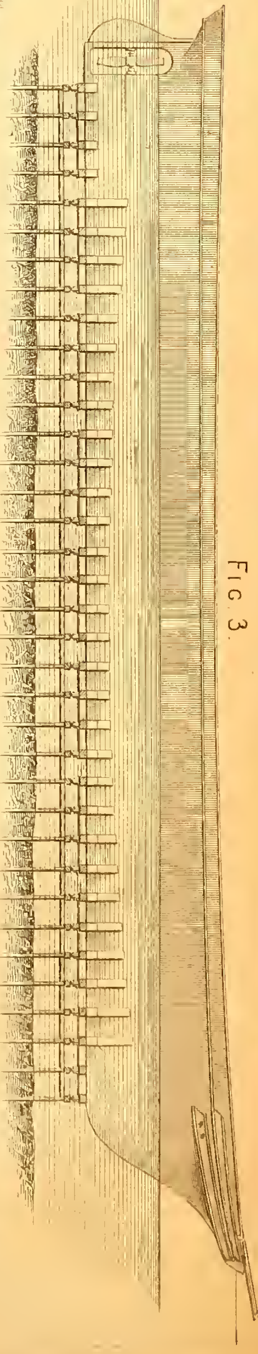


Fig. 3.



W. Smith, C. E. direx.

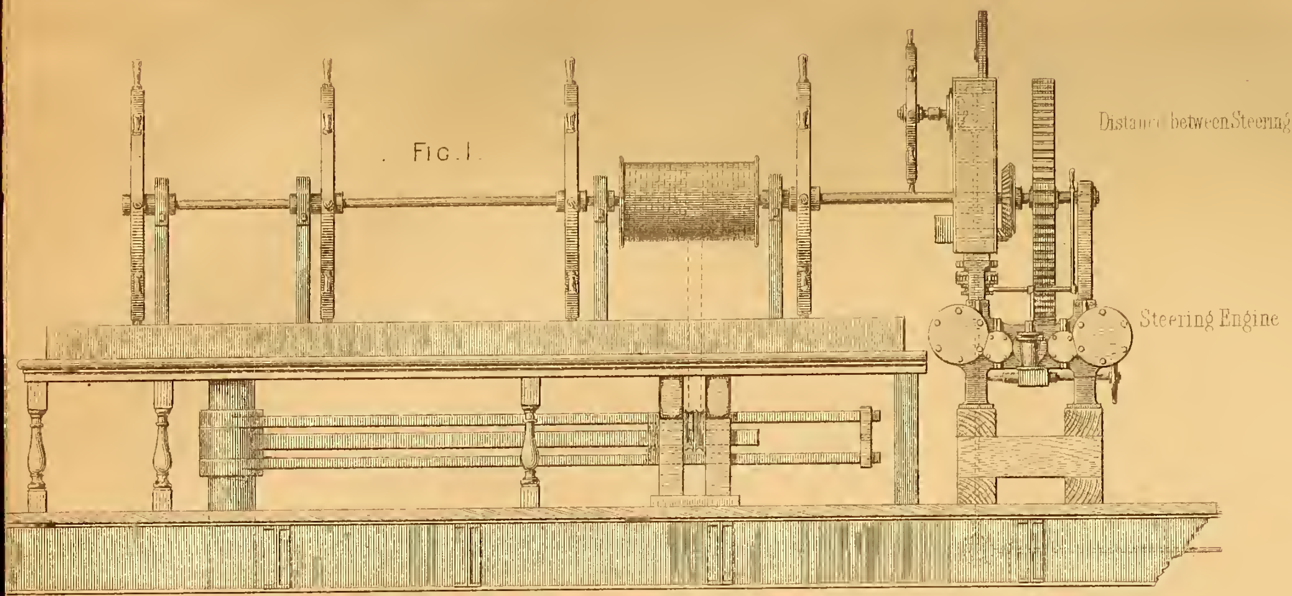


FIG. 1.

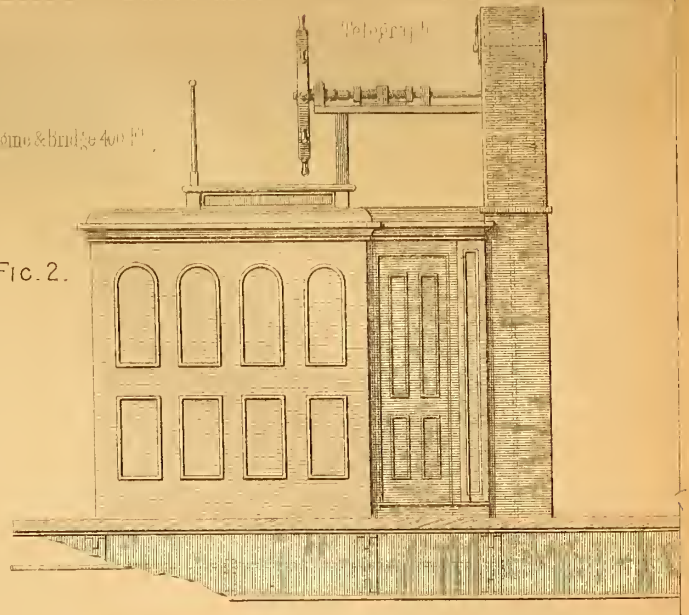


FIG. 2.

# THE "GREAT EASTERN" S. S.

## STEAM STEERING GEAR

*FITTED BY MESSRS GEO. FORRESTER & Co LIVERPOOL*

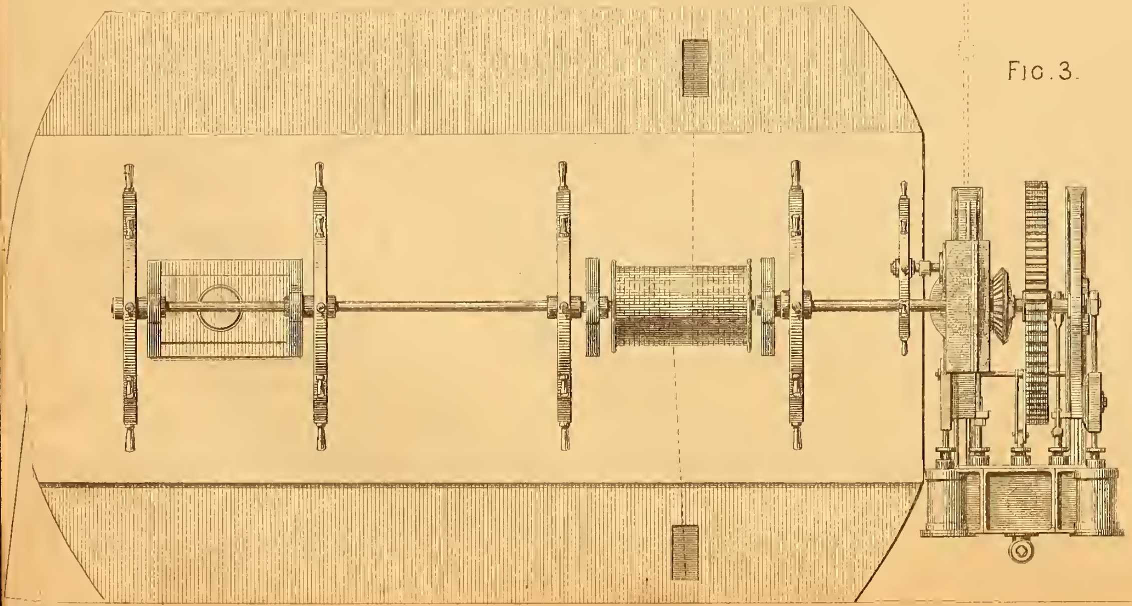


FIG. 3.

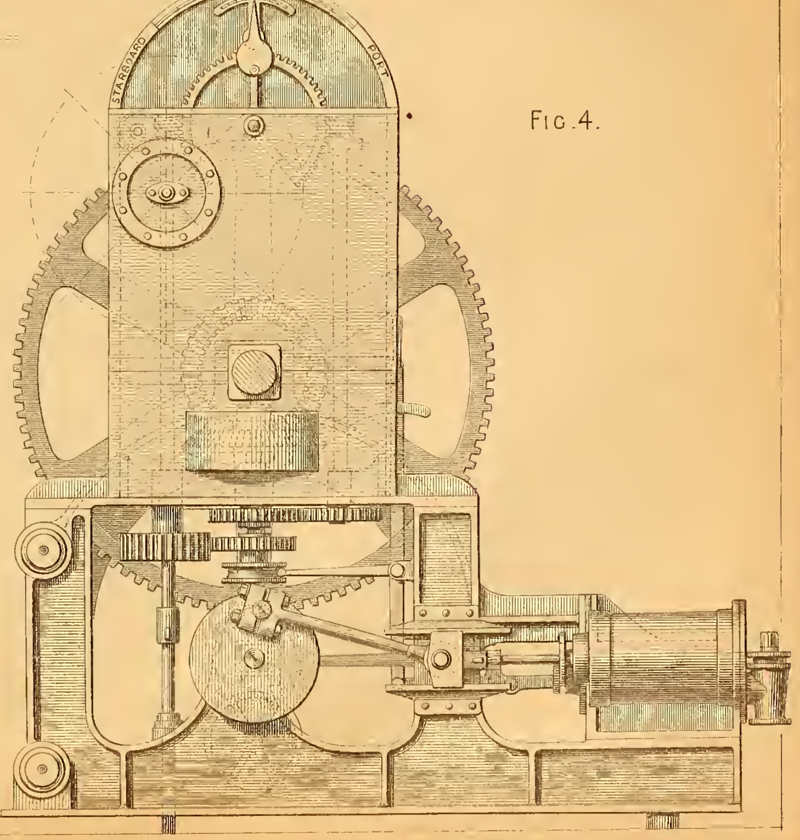


FIG. 4.

W. Smith, C.E. direx.

# THE ARTIZAN.

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1st. JUNE, 1868.

## IMPROVED SLIPWAY FOR HAULING UP VESSELS "BROADSIDE ON."

By Messrs Thompson and Noble, Liverpool.

(*Illustrated by Plate* 331.)

In The Artizan of last month a variery of methods were illustrated for obtaining access to the bottoms of vessels. These may easily be divided into two classes, viz., that in which a vessel is lifted above the water, such as slips and lifts, and that in which the water is drawn from under the vessel, such as floating or dry docks. To the latter class the chief objection is their first cost, for though floating docks have some great advantages, especially when trays are used by means of which a great many vessels may be docked at the same time, it is well known that they cost an enormous sum to build. As regards dry docks, they too are expensive to make, while in some soils it is almost impossible to construct them, and several cases might be pointed out, where large sums of money have been fruitlessly expended in the endeavour to excavate a dry dock in a treacherous soil. Even on the banks of the Thames great difficulty is experienced in their construction from this cause, and it is not an uncommon occurrence for the bottom of a dock to blow up from the pressure of the water accumulated either by land springs or the infiltration of the water from the river. Leaving out of the question the gridiron which is only available in places where there is a great difference between high and low water, there is no doubt that the slip is the simplest and cheapest method of obtaining access to the bottom of a moderate sized vessel. When required for a large vessel however the slip has to be carried such a long distance underneath the water, that the expense is enormously increased, especially where the beach is steep, while at the same time there is often a considerable difficulty in obtaining a sufficient depth of land to accommodate a long vessel "end on" on the shore.

To obviate these objections and to enable a slipway to be constructed, so as not only to accommodate a large vessel but to admit of several vessels being repaired at the same time, Messrs. Thompson and Noble have contrived a very convenient plan on the "broadside on" principle, as shown in plate 331. One of the principal advantages of the "broadside on" over the "end on" system, is that it can be much more conveniently and cheaply constructed where the beach dips rather suddenly into deep water, and it is therefore under such circumstances the the most advantageous plan to adopt. Although the expense for machinery and foundations on shore is increased in comparison with a slip constructed to haul up a vessel "end on," yet if such a plan were carried out under the above conditions, the length of the piles necessary to be used in deep water, and the stiffening required by them would be a serious obstacle to overcome. Until lately, however, the "end on" system had one great advantage over the other, as the cradle was generally made of such a form as to allow of its being readily lowered down the slip from underneath the vessel, as it encounters no obstruction in its descent, from the shores that support the vessel's sides; and thus the cradle could be made available for taking up other vessels to be repaired at one and the same time. In a slipway constructed on the "broadside on" system, the reverse was the case as the cradle could not pass these necessary impediments thus necessitating, the vessel being repaired on the cradle, and consequently precluding the possibility of more than one vessel being repaired at a time.

In the plan here illustrated, however, several vessels can be repaired simultaneously on the same slip, Messrs. Thompson and Noble having adopted a very simple and ingenious arrangement consisting of a series of short cradles, each having its own chain, but all the chains worked by the same shaft instead of the old plan of one long cradle, as will be seen on reference to the engraving. By this contrivance blocks can be inserted between the cradles, leaving the slipway clear for them to be lowered down for another vessel. Thus it is evident that by this simple modification, viz., the dividing the cradle into several parts; the number of vessels that can be repaired at the same time is only limited by the distance inland to which the slip way is carried. Upon this system it is reckoned that a vessel of 300ft. in length would require nine cradles, whilst one of 200ft. only, would take six cradles, and of course a proportionate number for any other length of vessel.

## STEERING GEAR OF THE "GREAT EASTERN."

(*Illustrated by Plate* 332.)

In the large class of steam ships as at present constructed with deck houses and various other obstacles interfering with a clear view from the stern to the stem of the vessel it is imperatively necessary that the movements of the ship should be governed from the bridge. Various well-known methods for effectively accomplishing this purpose have from time to time been adopted, but they all have for their object the attainment of one or other of two alternatives, viz., improvement in verbal communication between the bridge and the wheel, so that a person standing on the bridge may instruct those at the wheel with the greatest certainty; or improvement in actuating the rudder directly from the bridge itself. Both these systems have their objections—the former in the liability, or at least, the possibility of error in giving or receiving the instructions forwarded, and the latter in the liability to derangement of the intermediate gear and the increase of power required to work it. When we contemplate the *Great Eastern*, with its enormous length between the bridge and the stern, as also the great power required to work a rudder of such dimensions—these objections are greatly increased, and consequently a very ingenious and effective steam steering gear which was invented by Mr. J. McFarlane Gray, and manufactured by Messrs. George Forrester and Co., of Liverpool, was fitted to her previous to her last departure for America. This arrangement, which is illustrated in Plate 332, appears at first sight rather complicated, but when it is remembered that the rudder has not only to be perfectly under command, but also must be able to yield somewhat when exposed to excessive strain from the action of the waves, the problem to be solved was by no means an easy one, and the number of parts could scarcely be reduced without destroying the thorough automatic working of the apparatus.

Upon referring to the Plate (332), Fig 1 is an elevation of the steam steering gear fitted to the old arrangement of hand wheels; while Fig 2 shows the wheel on the bridge; Fig 3 is a plan of the above figures, and Fig 4 is a front elevation to a larger scale of Fig 1, shewing the method of transmitting the power of the engines to the rudder. The principle upon which this arrangement is designed entirely obviates the difficulties before alluded to of working the rudder directly from the bridge, as in this case, the power required to be transmitted is reduced to a minimum. Upon referring to Figs 1, 2, and 3, it will be seen that a small steering wheel is placed upon the bridge, having a horizontal spindle, upon the other end of which is an index dial for the guidance of the steersman. Upon this spindle is fitted a mitre wheel which gears into one fitted on the line of of shafting (shewn in dotted lines) which leads to the steam machinery at the stern of the vessel. This shafting, which is made hollow, upon arriving under the steering gear is led up vertically, as shewn in Fig. 4, and has the following work to perform :—At the upper extremity a worm is fitted to it, gearing into a worm wheel attached to which is a long index finger, which indicates on a large scale the position of the finger on the small dial on the bridge, and consequently, the position of the bridge steering wheel. About half-way up on the upright shaft is keyed a very broad spur wheel, gearing into a narrow wheel, fitted on the spindle that works the valves. The upper part of this spindle has a screw cut on it, working in a fixed nut, so that by turning the broad spur wheel to the left or to the right it will raise or lower this spindle. Towards the lower end of this spindle, and under the narrow spur wheel a grooved pulley is fitted, into which a block on the end of the valve lever is loosely fitted; the other end of the valve lever being attached to the valve rods. Thus, when the wheel on the bridge is moved, the amount of that motion is shewn on the bridge dial; at the same time, by means of the line of shafting just described, the index on the large dial plate is correspondingly moved, while by the motion of the broad spur wheel on the same shafting, the spindle actuating the valve lever is proportionately raised or lowered, and the desired motion given to the engines; and by having a stop fitted to the steering gear, the engines stop themselves when the rudder is brought into the position indicated. If at any time it is wished to steer from the stern it can be accomplished by means of a small hand wheel placed just aft of the large dial plate, and shewn in Figs 1 and 3, also, in dotted lines in Fig 4.

The valve gear of the engines is very ingenious and is illustrated by the accompanying woodcut, Figs 1 and 2. The slide valves are made circular, and therefore equilibrium, and they are each worked by one fixed eccentric on the engine shaft. The starting and reversing of the engines is accomplished by an arrangement of steam passages, worked by a stop valve, which is also an equilbrium valve, in order to enable it to be worked as easily as possible from the bridge. Upon referring to the woodcut, the action of this valve will be readily understood; as it is there shewn both the steam and exhaust is shut off. When the stop valve is opened by being moved in the direction away from the stuffing box, the steam is admitted to the cylinder in the usual manner, and the engines go ahead, but when the stop valve is moved towards the stuffing box end, the steam is admitted in the reverse direction; the central, or what is usually the exhaust port, becoming the steam port, and *vice versa*. The cylinders of the engines are made sufficiently large to work with the steam taken from the main boilers. From the above description it is shewn that the two desiderata before mentioned have been successfully attained, viz., perfect command of the ship from the bridge, and, at the same time, the inconvenience and uncertainty of transmitting a large amount of power through a long distance is entirely obviated.

FIG. 1.

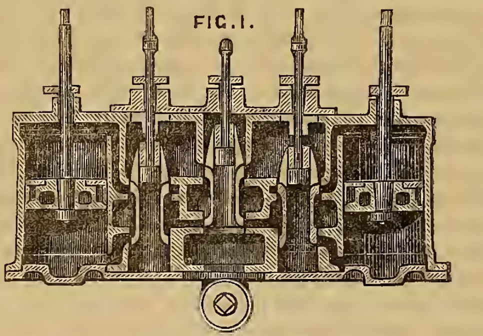
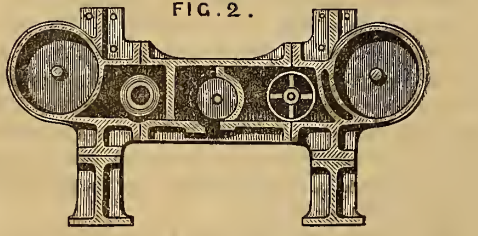


FIG. 2.



## THROUGH RAILWAY MAIL TO INDIA.

A subject which just now occupies the attention of the press in England and in India is the continuation of the railway system from London, at its termination at Basiash, on the Danube, to Bussorah on the Persian Gulf, where the mail steam-transport to Bombay begins. This question was formerly imperfectly raised by the Euphrates Valley steam and railway project, at which General Chesney laboured for so many years. Circumstances have now given a wider extension to the route, and the possibility of connecting England with India ultimately by a railway is now assured, and its execution is only a question of time—perhaps, relatively to the magnitude of the measure, of a short time. The advocacy of this subject is in the hands of Mr. Hyde Clarke, a gentleman not only known as an orientalist and from his long connection with the East, but as having taken an active part in connection with India and Turkey, and having, from several years' recent experience, a practical acquaintance with public works in Turkey. His appeal has consequently met with general attention on the part of the press; but the matter will require much and serious discussion on the part of the public before decided results can be obtained.

The measure is not only large in its compass, and most important in its political consequences, but it is one of the very few which is capable of realisation in the present stagnant state of the European money markets, and which promises to give scope for the immediate and ultimate employment of the engineering profession, now unhappily depressed. It is, therefore, with a view of awakening attention to the enterprises connected with the through route, and thereby of inducing our readers to promote the earlier realisation of the undertaking, that we are induced to offer some information on the present state of the question. Our readers will find fuller details in Mr. Hyde Clarke's papor read before the Society of Arts on the 26th May ("Journal," vol. xvi., p. 276) and in his paper, "On the Military Advantages of Communication," read before the Royal United Service Institution on the 8th May; and there are articles in most of the daily, weekly, engineering, and Oriental papers. The discussion of the measure here has created a great impression in India; and at Calcutta, Bombay, and Madras the press and public have taken the matter so seriously in hand that the Government of India has engaged in its examination.

The position of the Euphrates Valley, in a line between England and India, led General Chesney to devote his life to obtain the realisation of this route for transport; and, under the pressure of public opinion, the Government have given him from time to time some partial assistance. Its development as a steam river route failed, and, on the introduction of the railway system into Turkey, a railway was projected along the Euphrates Valley, so as to constitute a line of transport from England, Marseilles, or Trieste, to the East. This line has been surveyed by Sir John Macneill. Unfortunately, various circumstances militated against it. It was made a means of propping up the Kurrachee and the Scinde Railways; so that the other Indian interests engaged less warmly. Although its advantages were great, they were not felt to be sufficient to justify the home or Indian Government in granting a guarantee to the undertaking, and its political basis, as a purely English enterprise for English political and military purposes, ensured hostility from France, and disabled Turkey from accepting it. The consequence was an opposition from France to our own Government on political grounds, which caused our Ministry to withhold its support, and the refusal of the Ottoman Government to grant more than a concession for a short branch from Aleppo to the coast at Suedia. In fact, the Euphrates Valley Railway was by its promoters converted into a kind of Suez Canal affair at an epoch when the political complications of the Suez Canal had caused dissatisfaction in Europe and in Turkey. The Ottoman Government, too, felt no interest in the Suedia branch, as it preferred a branch from Aleppo to the port of Skanderoon. The concession and its prolongations have lapsed, after ten years of failure, and the home Government has been deprived of all possibility of giving a guarantee to the Euphrates Valley Railway Company, if it desired it, by the paramount fact that the concession for the Euphrates Valley Railway has been given to another Company, also in English hands. It is desirable this matter should be understood, as attempts are made, for personal purposes, to make the public believe that the Euphrates Valley Railway exists in some other shape, and can be carried by some other route than that of the new Company, in which it is effectually merged.

The Ottoman Government has long been most anxious to possess a network of railways, and has made great sacrifices for this purpose. After giving all kinds of concessions right and left, it finds itself in the same position as our Indian Government was after the first ten years, in possession of three hundred miles of fragmentary railways not meeting the guarantee. These railways have been most sadly mismanaged, and the fact that the greater portion was in the hands of Messrs. Peto, Betts, and Crampton is sufficient to account for their financial disasters. They will, however, emerge from this slough of despond and discredit, because they all have the elements of paying traffic; and the Smyrna and Cassaba Railway will at the next half-yearly meeting provide for that guarantee, and be in a position most likely to commence its extension. The exasperation of the Ottoman Government has been great. The gross breach of faith of the English railway directors, the imperfect state of the lines tendered as complete, the deficiency of working stock, the misappropriation of funds granted in aid of the Companies, the extravagance and imbecility of the management, the frauds in the accounts, the impositions practised on the shareholders and debenture-holders, and the enormous sums demanded of the Government for guarantee on unjust pretences, accompanied by menaces and charges of repudiation by parties who are drawing money from the Treasury, have so disconcerted the Ottoman Government they hardly know what to do. To deal mildly and generously is not to aid the shareholders, but to place money in the hands of parties to be appropriated for their own speculations: to deal strictly, as the French Government would, is to affect suffering shareholders who have given their money on the faith of the guarantees.

The visit of the Sultan to England naturally resulted in a new determination to have railways, and on his return large concessions were given to the first askers. The concession for European Turkey, including the connection between Constantinople, Adrianople, and the Austrian railways, by Belgrade or Basiash, on the Danube, has been given to a combination, headed by a Belgian firm named Vander Elst; but the chief parties are supposed to be Hungarians. During their exile the Hungarian Liberals were first and nobly received by Turkey, and, though they afterwards dispersed in the west, their connection with Turkey has been maintained, and on their recent restoration to power in their own country their attention has been redirected to their political and industrial expansion in the east. This has always been the desire of the Hungarians, and since Sadowa the dual Government, the Austrian Empire, shut out from the field of influence in Germany, has the greater tendency to direct its attentions to the east. The intermixture of its population with Slavs and Roumans likewise affects the policy of old Austrians and Hungarians. So far as the Hungarians can they will push on this portion of the through railway.

The circumstances are rather unfavourable. Turkish finance is weak, and Western Europe indisposed to furnish capital; but the new Company has begun. The Ottoman Porte, adopting a principle formerly proposed to it by Mr. Hyde Clarke, has suspended the principle of money deposit, or *cautionnement*, so embarrassing to infant undertakings, and has consented to accept as *cautionnement* a short suburban line from Constantinople to Chekmejeh, on the Sea of Marmora. This sagacious measure insures a good beginning. The land is being expropriated outside the city, from the Adrianople Gate to the western suburb of San Stefano, and this passes through some property of his Highness Mahomed Ali Pasha, who has gratuitously conceded it. His Highness is one of the wealthiest persons of the Ottoman Empire, and, if he sees his way, could furnish a large portion of the capital. At Chekmejeh is a hunting-seat of the Sultan, and the site of proposed docks. Intermediate there are large sea-side suburbs, now of inconvenient access, and the whole line will, on the establishment of railway communication, be covered with villas and factories.

Difficulties there will be with the Constantinople and Belgrade line; but it will go on. Every advance on the side of Western Europe will help it; even the rivalry of the northern lines in Wallachia and Gallicia, promoted by Messrs. Oppenheim and Brassey, and proposing to establish a connection with Constantinople over the Ruschuk and Varna Railway—even these will help forward the short and direct route, even as the Kustenjeh Railway promoted by its opening the shorter route by Ruschuk and Varna. A chord line which has local resources must carry the day.

This brings us to the other great concession and section of the through route—that from Constantinople, or Skutari, its Asiatic suburb, to Bussorah, on the Persian Gulf. The route from Skutari will be by Ismid and Eski Sheher, and then by such course as shall be selected among the mountains and table lands of Asia Minor, passing by or near the great cities to the main chain of Taurus. This is a considerable work, whether by the famous pass of the Cilician Gates, or otherwise passing in the neighbourhood of Skanderoon to Aleppo. From Aleppo there will be a branch to the port of Skanderoon, on the Mediterranean, or to one at Suedia or Seleucia, to be constructed. From Aleppo the line passes by the great Valley of the Euphrates to Bagdad, and so to Bussorah, the chief port on the Persian Gulf, and the station for the mail steamers.

The concession was made to Mr. Greig (of Vienna), Messrs. Sharpe, Capt. Stewart, and Baron Winspeare, supported by most of the Embassies at Constantinople. The guarantee is only for 5 per cent. on 300,000 francs per kilometre, or about £20,000 per mile. As Turkish stocks are low, and Turkish guarantees depreciated, the guarantee is of no immediate use for financial purposes; but there is a really valuable financial concession in the through transit duties, the Indo-European telegraph revenue, and the Indo-European postal revenues from the various Governments, and of course the conveyance of passengers, troops, goods, and stores must be productive of income.

The length of the line may be roughly taken at 1,400 miles, and the cost at £29,000,000. The whole of the Euphrates Valley, 800 miles, has been surveyed by Sir John MacNeill's staff and others, as also the branch from Aleppo to Suedia, and that from Aleppo to Skanderoon, by the Beylan Pass, was surveyed for the Ottoman Government by Colonel Messoud Bey. The country from Skutari to Eski Sheher has been surveyed for a former English concessionaire by English engineers. Thus, a considerable portion of the line has been surveyed by English engineers, and so far, were capital available, it is possible to begin the works at the main points. It is probable that, by financial combinations, some portion of the works may be begun earlier as local lines.

If the concessionaires made any application for funds to European capitalists, there is no difficulty in knowing the result in these days. Nothing is to be got from the public. The conclusion is, therefore, jumped to by many persons that it is proposed to raise capital on the Turkish guarantee, and that, as £20,000,000 is required, it is utterly visionary, and a great deal of argument has been wasted in demonstrating what everybody knows, and no one doubts. Whatever the ultimate shape of the enterprise may be as a commercial undertaking, it cannot at the present moment be placed in that category. If it were, there would be very small hope of its realisation within a reasonable period.

It is under these circumstances the plan of Mr. Hyde Clarke assumes the more importance and consistency. Taking this undertaking as a link in the chain of through railway communication between England and France, by Austria, to India and the East, he proposes that it shall be treated as an international postal undertaking; the various Governments interested giving assistance in the early steps by postal subsidies, recouping themselves for any advance by the Ottoman funds and guarantee, and ultimately obtaining an economical postal route. The share of our Government is estimated at 1½ per cent. gross liability, or £300,000 a year, but subject to reduction from various sources; so that the net liability would not exceed £50,000 a year. The subsidy is proposed to be divided by arrangement between England, India, France, and Austro-Hungary, with contributions from Holland and other countries postally interested.

Why should we or France give fifty thousand pounds or fifty thousand pence to send letters to India in ten or eleven days, instead of twenty-two days, is a very natural question? And perhaps, if it depended solely on letters, the whole matter might be left to the natural course and progress of events, and, important as is our connection with India, we might leave private enterprise to effect an improvement. The political considerations are, however, so truly important, and have been so ably developed, that they give an entirely new aspect to the question, and render its solution by the Government and public of England and France a matter almost of necessity. It is that great event of Sadowa which has most materially produced the present situation of affairs. It has altogether altered the position of Austria, by de-Germanizing it, and producing the dual system of Austria and Hungary, restoring Hungary to national integrity, and it has particularly affected France, by opposing to her a new power of North Germany, allied with Russia and Italy. Thus, too, the Eastern question, abandoned to non-intervention and the intrigues of the Greeks, has insensibly altered its aspect. So, too, the new advance of Russia, her conquest of the Caucasus, and her progress in Turkistan has greatly impressed our Indian statesmen and politicians.

It has been well stated that 3,000 miles of country in the East—in the empires of Turkey and Persia—have no more to present to the invading power of Russia than 300,000 weak troops. On the Danube she intrigues against Austria and Turkey—in the Roumanian Principalities, in Servia, in Bulgaria; and her disturbing influences extend among the Greek populations. Thus, we see before us a new Russian war, and consequently a European war. We are indisposed to take any part in such events; but the pressure of circumstances will compel us. In such a critical period simple means are afforded to England and France of strengthening the bonds of peace and of developing commerce.

Now, to develope commerce is of itself to promote peace, and a very small effort will enable us to open new fields of industry in the once-productive and now-neglected countries of Turkey and Persia. The Suez Canal has been fostered by great efforts, as a means of increasing the trade between Europe, India, and China; but by the middle Euphrates or Persian Gulf route is afforded another means of accomplishing that object, and of doing what it cannot do—promoting the internal development of Turkey and Persia.

Persia is at present so remote, and the communications with it are so troublesome, that we think very little about the country; and to those who for the first time direct their attention to this new topic it appears to be one of the shadowy absurdities of it to talk about Persia. We know rather more about China and Japan. Persia constitutes an empire twice the size of France, with a population equal to that of Spain, having a great production, largely consuming English goods by indirect importation, and supplying France with some of her best silk. Persia is now a rising star, peering above the horizon, and we shall hear more and more about it. It is being opened by the Indo-European and other telegraphs, and its first short railway is now in hand, though the great difficulty will be to get the rails and locomotives there. Teheran will shortly be within a few-hours' telegraph dispatch; and if the through railway be accomplished, it will be within little more than a week's post. Thus, all tends to the rapid development of Persia; the Government of which, stimulated by the solid progress of Turkey, is emulating its career. The inhabitants are a quick and intelligent Indo-European race, and, with improved circumstances, will turn their advantages to account. Already Persia is affording a rich mine to those shrewd pioneers the Armenian merchants and money-dealers.

It is in Persia that France has a particular interest. She has always sought influence, and we do not envy her, as it must now be employed to resist Russia. It is this interest which will induce her to support the middle route, as India moves England. Thus, a new field for distinction is opened to France, and by mutual action each country can accomplish her own purposes.

The military aspect of the question is a peculiar one. By the completion of the extension from Belgrade to Constantinople, the Austro-Hungarian forces can be mobilised on the Danube; thereby affecting, and most likely altering, the policy of Roumania, which is not Slavonian in its sympathies, but Latin. Roumania, too, would be made to welcome French allies brought by Constantinople. Servia would, under such circumstances, be brought under the influence of the Western Powers. Thus, the Danubian frontier is rendered capable of being protected, and, this accomplished, the danger of its being attacked is much lessened.

The Skutari (Constantinople), Aleppo, Bagdad, and Bussorah Railway will render like services. It divides into two sections—the northern in Asia Minor (part of the through route) and the southern or Euphrates Valley section (likewise part of the through route)—which are accessible by passengers from Marseilles, Brindisi, Trieste, or Salonika, and by troopships from England to Skanderoon, and thence by railway, through Aleppo and Bagdad, to Bussorah, and so by steamer to Bombay or Kurrachee. This effects a saving on the Alexandria route. If the through line by Europe is interrupted, then the Euphrates Valley section becomes an alternative route; so, too, if the Alexandria route is interrupted.

The possession of such a route would enable our Indian authorities in case of need to send troops—native auxiliaries and contingents—to the assistance of Turkey in Asia Minor, and thereby again materially diminishing the hazards of attack.

The great military advantage is, however, the commercial advantage—that, by the development of husbandry and trade, Turkey and Persia would become richer and stronger, and thereby better able to withstand internal antagonists and assaults from without. These, therefore, are the objects sought to be obtained: primarily, a further and better assurance for the peace of Europe in the East; secondly, the development of the vast and rich continent lying between the Danube and our Indian border; and thirdly, more rapid and assured communication for the promotion of trade and intercourse between Europe and India and the important countries lying beyond.

To effect this, we must stimulate our own Government by the effect of public opinion, and, to make this opinion operative, we must direct our attention to our true interests, in the promotion of this undertaking of the daily mail service to India by the middle route.

## SURFACE CONDENSERS

The important advantages possessed by surface condensers over those upon the common system of condensation by injection are now so generally acknowledged, that any advance towards perfecting their details will no doubt be of interest. It is well known that one of the chief sources of failure, or at least of trouble and annoyance, lies in the joints of the tubes in the tube plates, consequently it has been to this point that the attention of engineers has been principally directed. A paper was read before the Institution of Engineers in Scotland by Mr. James Howden, in which he treated upon some of the most usual and successful methods of making this joint, and from which we extract the following:—

In 1831 and 1833, the late Mr. Samuel Hall patented his arrangements of surface condensers, which in the course of the next few years he simplified and improved. To Mr. Hall the credit belongs of being the first to introduce the system of surface condensation successfully, and on a large scale in marine engines, and that, with a simplicity of arrangement and perfection of detail, that has left his successors almost nothing to do but to copy his plans, if they wish to obtain the simplest and best arrangement of condenser. His arrangement of the condenser and pumps, and circulation of the cooling water was admirably simple and effective; while his plan of fixing the tubes, which at the same time securely holds the tubes and provides for expansion, is certainly much superior in every respect to those plans which have been so much brought before our notice of late years, and for which so many advantages have been claimed.

At the present time it is a common practice to pass the cooling water through the inside of the tubes instead of the outside, as was practised by Hall. This mode, though merely a matter of arrangement and not of principle, and which, after Hall had worked out the condenser in practical shape, was an obvious modification of his plans is one which anyone may adopt if found the most convenient in any particular case. This arrangement has been much extolled, as possessing advantages over the other arrangement—that with the cooling water outside the tubes—which I have never been able to find established by actual results.

The advantages usually claimed for the arrangement of the water inside the tubes are these three:—1st. The jointing of the tubes is rendered more secure by this method of working. 2nd. That access to the tubes for examination can be obtained without breaking a vacuum joint. 3rd. That a better and more effective circulation of the cooling water is obtained when the water is passed inside of the tubes.

It will be well to try how far these claims will bear the test of examination. To save repetition, I will in this paper call the arrangement of condenser with the steam inside the tubes the "inside" condenser, and that with the steam outside the tubes the "outside" condenser. With regard to the first claim, I would merely say that some plans for fixing the tubes of inferior merit do require that the water be so applied, but the simplest and most reliable methods of jointing the tubes do not depend on the cooling water for their efficiency, and can be used equally well with either arrangement.

The second claim, that in an "outside" condenser only a water joint has to be broken to give access to the tubes, instead of a vacuum joint, as in the "inside" condenser, will, I think, when examined, be found to be rather in favour of the "inside condenser. That a vacuum joint is more difficult to make than a water joint, with planed or turned faces, will not be conceded by any practical engineer, so that I will not occupy your time in discussing the comparative difficulty. Should it be necessary, however, to take off a condenser cover at sea to examine the tubes, all that would be required in an "inside" condenser would be the shutting off of the steam from the engines and the removing the cover. In the "outside" condenser the cover could not be taken off without emptying into the engine-room the cooling water in the condenser and discharge pipe, which would be at least troublesome. In the one case the vacuum only is lost; in the other, both vacuum and water are lost, which makes the position of the "outside" condenser in this matter the more objectionable of the two.

The third claim, that of the water having a better cooling effect when passed through the inside of the tubes, appears to me also to be without any foundation in fact. It might be a sufficient reply to such a claim to observe that under similar conditions it is not found that "inside" condensers maintain a less vacuum, or require larger air-pumps, or a greater amount of water to produce that vacuum. When the cooling water is on the outside of the tubes, it is evident that a larger area of surface of each tube is in contact with the water than when the water is inside. It should follow, I think, though I have not specially made it the subject of experiment, that the heat from the steam in condensing would pass more freely from the inside of the tubes to the water outside than from the outside of the tubes to the water inside, and thus render the "outside" condenser less effective than the other.

The circulation of the cooling water also, when passing through amongst the tubes in an "inside" condenser cannot fail to be very perfect, as the water is kept in a continual state of agitation in passing through the narrow spaces where the tubes are nearest to each other. All the water in the condenser being besides in free communication in every part, it is known that in such a case, even without the current and pressure caused by the pump, the water will tend to maintain a uniform temperature throughout at the various levels, the hottest water being at the top and the coldest at the bottom. Should the water in any part of the condenser become hotter than the water in another part on the same or a higher level, this hotter water would immediately ascend, and a current set in from the colder parts to take its place, until the temperature was equalised. With an "inside" condenser, having its tubes vertical, there is therefore no need of division plates inside to circulate the water to and fro among the tubes, as it may be necessary to have in the "outside" condenser when of a large size and with the tubes horizontal.

It appears to me, therefore, on examination that in those very points in which superiority is claimed for the "outside" condenser, the "inside" condenser has the advantage. Though I would not insist very strongly on the "inside" condenser possessing great advantages over the "outside" kind, yet I consider that on the whole these decidedly lie on the side of the former arrangement, and I think that Hall showed his sagacity in preferring it to the other.

It is well known that the grease and dirt from the cylinders and boilers deposit on the steam side of the tubes, and this deposit requires to be cleaned off sooner or later, say once a year in ordinary cases This cannot be done in "outside" condensers without removing all the tubes, the grease being on the outside in that arrangement. The removal of the tubes, besides being troublesome, is often difficult, and in some cases, where the deposit is great, and it has adhered firmly to the tubes, they cannot be got out in some plans of construction without being damaged or destroyed in being drawn through the tube plate.

With the "inside" condenser, on the other hand, no removal of the tubes is required for cleaning. They are cleaned much better in their places in the condenser, where they can be washed and sponged out with facility.

It may be mentioned as a point in favour of the inside condenser, that the outer case or body is subject to an internal pressure from the cooling water only averaging 5lbs. or 6lbs. per square inch in ordinaay cases, while the outside condenser is subject to an external or collapsing pressure of, on an average, from 13lbs. to 14lbs. This would be found to be of considerabte importance in the event of any damage occurring to the condenser case, and it is an advantage which has been practically shown by the fact that a wooden box has served for the case of an inside condenser. The fact, also that the body of an inside condenser is cool, and does not, therefore, throw off so much heat in the engine room as an outside condenser, is a feature that will be appreciated in a warm climate.

Altogether, therefore, the advantages appear to me to belong to the inside condenser, and it is only under exceptional circumstances that it will not always be found a better arrangement than the other, especially if the tubes are kept vertically, as in Hall's practice. One of these exceptional circumstances may be when a steamer is running in very dirty or muddy water Mud, however, is not so difficult to remove as grease; and even when running in very dirty water, the condenser could be kept clean inside without removing the tubes, by washing out occasionally with water from the ship's hose, under a good pressure, suitable sludge doors being provided for the purpose. At the worst, in such a case, the tubes could be removed for cleaning, as must be done in every outside condenser.

I now come to notice the following different methods of fixing the tubes. 1st, That of the late Mr. Hall; 2nd, Mr. Spencer's; 3rd, Mr. Sewell's of New York; 4th, The plan of Mr. Horatio Allen, also of New York, patented in this country in the name of Mr. William Horn; 5th, A plan of my own which has, as yet, only been used by myself.

The examination of each of these plans will be rendered more complete by bringing them separately to the test of the following conditions, all more or less essential, and which I believe exhaust all the points required in any good plan for fixing the tubes. They are:—1st, The material employed must be free from injurious properties; 2nd, The plan should be simple and inexpensive both in the first cost of construction and maintenance afterwards. 3rd, While allowing amply for the necessary expansion or contraction of the tube, or condenser case, it should hold the tubes firmly in the tube plates; 4th, The plan should allow of the condenser being made either of the outside or inside kind; 5th, The material employed should be easily obtained anywhere; 6th, The plan should permit of the tubes being placed at the minimum distance apart; 7th. It should allow of the tubes being treated separately, and easily taken out and put in when required, and jointed with sufficient rapidity.

Hall's plan, which is represented by Fig. 1, consists in recessing the tube plate round each tube about one-sixteenth of an inch in width, and about

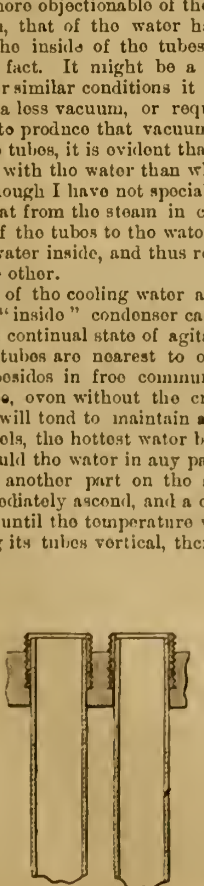


FIG. 1.

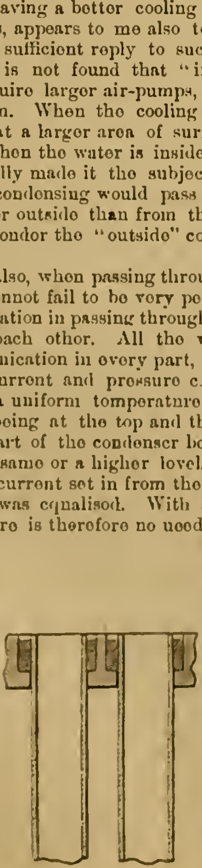


FIG. 2.

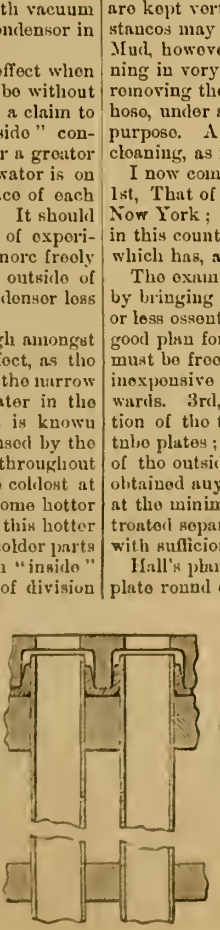


FIG. 3.

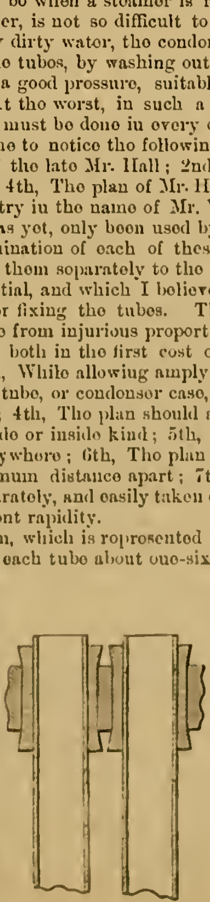


FIG. 4.

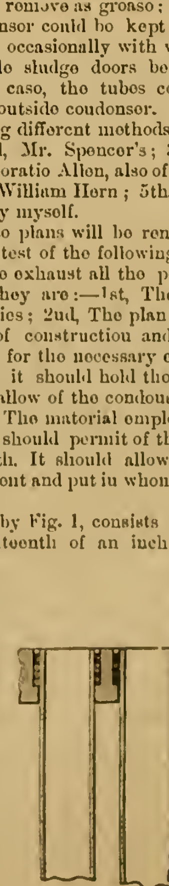


FIG. 5.

½in. or ⅝ths in depth, these recesses being screwed for the greater part of their depth. Into these recesses cotton or flax tapes or cords are put, and held sufficiently firm about the tube by a short brass gland, which is screwed in on the top of them.

These glands are simply made from a piece of longer tube having their inside diameter equal to the outside diameter of the condenser tubes. They are screwed first in long lengths, and then cut down into the short pieces required. Each of these glands has a cross slot at one end for the purpose of tightening up or unscrewing. On examination we shall find all the conditions enumerated admirably fulfilled by this plan. The first, the most important of all, and one in which most all others fail, is completely fulfilled by it. The material—cotton or flax—is perfectly innocuous, and has never been known to injure brass or copper tubes. The second condition is also well satisfied in this plan. The tube plates do not require to be more than ¾ths of an inch in thickness, and they may be cast with the holes for the tubes cored out with sufficient exactness, to very nearly their finished sizes. The screwing can be performed at the rate of from 15 to 20 per hour by an ordinary machine, and at the cost of about 6s. per 100 holes. The cost of the ferules screwed and slotted in the head ready for use is about 12s. per 100. The packing tape or cord is very inexpensive, one shilling's worth being sufficient for 130 tube ends. The first cost of construction is therefore not great, and the cost of maintenance afterwards the merest trifle, as the tubes, not being injured by the packings, will last almost indefinitely. The third condition specified is also fulfilled by this plan. With the glands properly screwed up, the tubes are held firmly and prevented from shaking and wearing themselves in the tube plates or against each other inside, so that supporting plates are not required except when the tubes are horizontal and so long or so small in diameter as not to be able to support their own weight without bending considerably. It also allows amply for any degree of expansion or contraction that may take place. This condition as regards firmness of holding the tubes I consider a very important one, and it is a point regarding which a considerable amount of misconception exists. I have heard it stated that it is necessary to have a very elastic joint to allow the tubes to expand and contract rapidly and easily, this expansion and contraction being said to take place at each exhaust from the cylinders. That some infinitesimal expansion and contraction takes place during the working of the engine will scarcely be doubted, but that this joint or almost any joint even a solid metal to metal one, will not allow for this, I would deny.

That this plan fulfils the fourth condition in being equally suitable for either the "outside" or "inside" arrangement of condenser is so obvious as to require no further comment on this point.

The fifth condition is also fully met. The material is easily obtained in its most suitable form, and anywhere at sea or abroad so long as a rope exists on board there is sufficient material always available for jointing the tubes on this plan. This is a most valuable feature, as in most other plans should the particular preparation of the material employed fail, the condenser is useless, and the engines may be left helpless.

The sixth condition is also fully sustained, no other plan I know of, with one exception, permits the tubes to approach so closely. They may be brought with ¼th of an inch or even less of each other. Though the tubes are not generally placed so close, they may be placed so without difficulty, and in many cases this would be a matter of importance.

The seventh and last of the enumerated conditions is also well fulfilled by this plan. It is at once seen that any tube can be taken out, and put in separately without disturbing any of the others. It also allows of the tubes being removed easily. In "outside" condensers especially, after the tubes have become coated with grease they are difficult to remove when the tube plates have parallel holes of some depth and not considerably larger in diameter than the tubes. In Hall's plan the holes are recessed for about ¾ths the thickness of the plates, and as it is only required that the smaller diameter be sufficient to prevent the the packing slips from passing through the holes, this part can be bored to allow the tubes to pass through easily. The jointing or packing of the tubes can also be done rapidly. If the packings are prepared beforehand they can be put into the recesses and the glands screwed up at the rate of from three to four a minute by one man or lad, and as several hands may be employed at the same time a condenser of a considerable size may be jointed in one day.

If a plan is in all other respects good it is an additional recommendation if it allows the tubes to be jointed with rapidity, but I would not place a very high value on this feature of itself. Any plan by which a condenser of say 4,000 tubes could be jointed up in four or five days would be for all practical purposes, about as good in this point as one by which they could be jointed in one day. After the first jointing for which there is or should be always sufficient time, it is not necessary to disturb the tubes. If the method of packing be efficient and material durable, it is not necessary, or even desirable, to take out more than a few rows at a time for cleaning, so that even with a plan that required a considerable time for jointing, no great inconvenience need arise from this cause.

The next plan, that of Mr. Spencer's is represented in Fig. 2. It consists in recessing the tube plates round each tube from ⅛th to $\frac{3}{16}$th of an inch in width, and about ½ an inch in depth. Into this recess india-rubber rings (generally two) are pressed sufficiently tight to prevent leakage when the pressure is on the outside of the tube plate. This plan is neat in appearance, and is also simple in construction. Testing it by the several conditions enumerated it cannot be said to satisfy the first well. The material, india-rubber, in connection with salt water acts injuriously on the brass tubes, and cases are well known to some of the members where the ends of the tubes have been destroyed by these india-rubber rings.

On the second condition this plan shows favourably as far as the first cost of construction is concerned. The tube plates may be cast with the holes cored in and the boring is easily performed. Though I believe the tube plates are in actual practice generally made of greater thickness, I see no reason why they should be more than ¾ths of an inch of brass, and in the drawing I have shown it of that thickness. As the tubes cannot be placed so closely as in Hall's plan, the weight of tube plates for same size of condenser will be somewhat more than Hall's, and the condenser also larger in consequence. The cost of the rubber rings is somewhere about seven or eight shillings for 500 tube ends. In expense of maintenance, however, this plan may not compare well, as it is obvious if the rubber rings destroy the ends of the tubes the expense of keeping them in repair or supplying new tubes will be very great. The third condition is well met on this plan, the rubber rings allowing amply for any expansion, they also hold the tubes firmly, though not quite equal to Hall's in this respect. The fourth condition is not fulfilled at all by this plan, as it cannot, when under steam, stand the pressure from the inside, and besides the heat and grease from the cylinders, which acts as a solvent on india-rubber, would soon destroy the rings with the "inside" arrangement of condenser. The fifth point is also not well satisfied by this plan. The rings must be made to order of the exact dimensions, and the want of them in a vessel abroad or where a supply could not be obtained, would practically render the condenser useless. It may be noticed, however, that in such a case some other material may be caulked into the recesses round the tubes though these are too wide to hold the material securely. The sixth requirement is tolerably well fulfilled by this plan. Three-eighths would be about the minimum distance of the tubes apart in this plan, and in practice they are generally somewhat wider. The first part of the seventh requirement is fully met, the tubes being quite independent of each other. They are not, however, so easily taken out on account of the tendency of the india-rubber to adhere to the tubes and tube plate, rendering it difficult to get the rubber rings picked out from the recesses. I believe that the tubes are sometimes damaged in being taken out from this cause. As the diameter of the holes in the tube plates at the bottom of the recessess may be left larger than the tubes, these may be drawn through tube plates without much trouble if this is attended to, and the tube plates be of the thickness I have assumed here, that is ¾ths of an inch. The practice, however, is generally to make the tube plates much thicker than this, sometimes of cast-iron 2½in. thick, where a parallel hole of at least 1¼in. in depth is left to draw the tubes through, which, should the tubes be foul, will be found a very difficult matter to accomplish. The putting in of the rings into recesses in this plan after the tubes are placed in position, though not very quickly done, I believe to be sufficiently so for all practical purposes.

The next in order is Sewell's, shown in Fig. 3, where a sheet of india-rubber held between two tube plates of about equal thickness is employed for jointing the tubes. The tubes project about ½ an inch at each end through the inner plates, or tube plates proper. The sheet of rubber, which must be of one piece, and the whole size of the tube plate is punched with holes of the same number and pitch as the tube plate but smaller in diameter than the tubes, and is passed over the projecting ends one by one, the rubber turning outwards round each like a cup leather.

The outer or covering plate about ¾ of an inch in thickness, with the same number of holes as the inner plate and exactly the same pitch, has the holes recessed to a certain width and depth, so as to pass over the ends of the tubes and embracing rubber and leave room for the expansion of the tubes when screwed up tightly against the rubber on the face of the inner plate. The diameter of the holes in the outer end of the covering plates is about the same as the inside of the tubes, so that this plate serves the double purpose of keeping the rubber sheet on the ends of the tubes, and preventing the tubes from working out of the tube plates.

On the first point this plan, like the last, has the disadvantage of using a bad material. All india rubber is more or less injurious, and sooner or later affects the ends of the tubes. Some preparations of it are, however, not so injurious as others; and I understand that great care has been taken in condensers having this plan of jointing to obtain the least hurtful kind. On the second point, this plan is far from comparing favourably with either of the two plans previously noticed, as it requires not only double the weight of brass in tube plates, but also a much greater amount of labour in construction, arising from the double tube plates, and the greater care and nicety with which the whole work must be got up. The inner and outer plates at each end must be exactly of the same pitch, so that the holes of the one when laid on the other may exactly coincide. It is evident, therefore, that the plates could not be cast with the holes cored out; they must be accurately drawn in and bored out of the solid plates. It will be apparent, therefore, that a condenser with this mode of jointing will be much more expensive in construction than those we have noticed. In maintenance after construction the expense will depend greatly on the durability of the tube ends in contact with the rubber, and whether the tubes are prevented from shaking in the condenser or not. So far as the price of the india rubber is considered the expense is not great. In the third particular this plan also comes far short. It allows sufficiently for the expansion of the tubes if they are kept quite free of the covering plates, but it does not hold the tubes of itself with sufficient firmness. I am aware that this has been claimed as one of the peculiar advantages of this plan. It is a fact, however, that if means are not taken to prevent the action of the supposed advantage, it will soon show itself to be a very serious defect. The roll of the vessel at sea and the vibration caused by each stroke of the pump would so shake the tubes in their plates that their ends would soon be destroyed. This was the actual result in one steamer where the tubes were left free to move. One voyage across the Atlantic destroyed a large number of the tubes. The vessel had to be laid up until several supporting plates were fitted inside, their function being to hold the tubes firmly, and entirely prevent this supposed advantage of elasticity in this plan of jointing. It is therefore the practice to have one or more supporting plate in every condenser with this method of jointing, however short the tubes; and I have accordingly shown in the drawings a supporting plates as an essential part of this plan. These, of course, also add considerably to the expense of this mode of jointing. The fourth condition—that of being suitable for either form of condenser—is not fulfilled at all by this plan, it being quite unfit to bear the least pressure from the inside, so much so that it will not keep a tight joint if the pressure on the inside in the least exceeds that on the outside or face of the tube plates, which is often the case when starting the engines and before the vacuum is formed, and a leak is the consequence. The fifth condition is also not well met by this plan. The material, which is specially prepared for the purpose, cannot be obtained easily anywhere; and as the whole sheet may be rendered useless by being torn or injured at one of the holes, it will be seen that in the event of a sheet being injured and none on board to replace it, the condenser would be helpless. This plan fulfils the sixth condition so far, that the tubes can be brought to within $\frac{3}{8}$ths of an inch of each other, or about $\frac{1}{8}$ more than in Hall's plan. Under the seventh head it can scarcely be said that this plan allows of the tubes being treated separately, as before one tube can be taken out the covering plates have to be taken off. With careful treatment a tube can be taken out and put in again without removing the rubber sheet, but the taking off and replacing of the covering plates before one tube can be examined or removed is an objectionable feature in this plan. When a number of tubes require to be taken out at one time this plan meets the case well, so far as the taking off the sheet rubber before the tubes are drawn and putting it on again after they are replaced is concerned. This is, however, but a part of the operation, the most difficult part being, when the tubes are dirty with grease on the outside, the drawing of them through the tube plates. In this plan, on account of the tube plates being parallel in the holes, the difficulty of drawing the tubes through is much greater than in those already described.

The next plan in our list is Allen's, which is represented in Fig. 4, where a wood ferule is driven into an annular space between the tube and tube plates tight enough to make a sufficient joint. In bringing this plan to the test of the several enumerated conditions, we find that it does not meet the first well, the wood having proved itself to have an injurious effect on the brass tubes, tending to destroy them at the ends where it is in contact with them. The second condition is so far well met by this plan, the tube plates being simple and capable of being cast with the holes cored in nearly of their finished size, though from the tube plates being necessarily thicker, and the tubes further apart than in Hall's, a greater weight of brass is required. The cost of maintenance in this plan will depend very much upon the effect of the ferules upon the tubes. The ferules do not cost much of themselves—about 4s. 6d. or 5s. per gross. This plan fulfils the third condition well, as it holds the tubes firmly in the tube plates, and allows sufficiently for expansion or contraction. It also fulfils the fourth condition, as it can be used either with the "inside" or "outside" arrangement of condenser. The fifth requirement is not, however, well met, as the material must be specially prepared, and cannot be obtained except where there is special machinery for the purpose. It will be evident also, that the condenser could not be worked should a supply of the ferules run short at sea. This plan is also somewhat deficient in fulfilling the sixth point, as the tubes could not well be brought closer together than $\frac{7}{16}$ths of an inch, which is considerably more than in Hall's plan. The seventh condition is, however, fairly fulfilled. The tubes can be treated separately. They can also be taken out easily, however foul, when the ferules are split up and removed, which is generally and most quickly done by pushing them into the condenser. The tubes can also be replaced and the ferules driven in with sufficient rapidity. Immediately before putting in the ferules it is necessary, however to squeeze them through a compressing machine; and the taking out of the broken ferules from the inside of the condenser, together with the time required to spit up the ferules and clear them from the tube plate, is also a considerable disadvantage attending this plan in connection with this point.

The next plan shewn in Fig. 5, is one that I designed and patented along with other things in 1860. It consists simply of a plaited cord run in tightly into a recess round the tube, barely $\frac{1}{16}$th of an inch in width, by a suitable tool. In 1859, when working with steam of 100lbs. pressure in a marine engine, the water was kept fresh in the boiler by using a refrigerator, in which the injection water discharged by the air-pump was cooled and again returned to the condenser. In that refrigerator and several others I made at the time, and which were in construction almost exactly like a surface condenser, I tried india rubber for jointing the holes, both in the sheets and in rings. Not finding them satisfactory, and having a very imperfect idea at the time of Hall's plan, I devised the plan of jointing with the cord. I made several models, and proved the sufficiency of the plan under a high pressure of water. From the experiments I then made, I found that a twisted cord put in the ordinary manner did not make a perfectly tight joint, as the water came through the spiral twists. The plaited cord, however, I found, when run into the recess to the depth of $\frac{1}{2}$ an inch, was quite tight under a water pressure of 50lbs. per square inch. This cord jointing I have used in every condenser I have constructed since that time, and have never found any fault whatever attending its use.

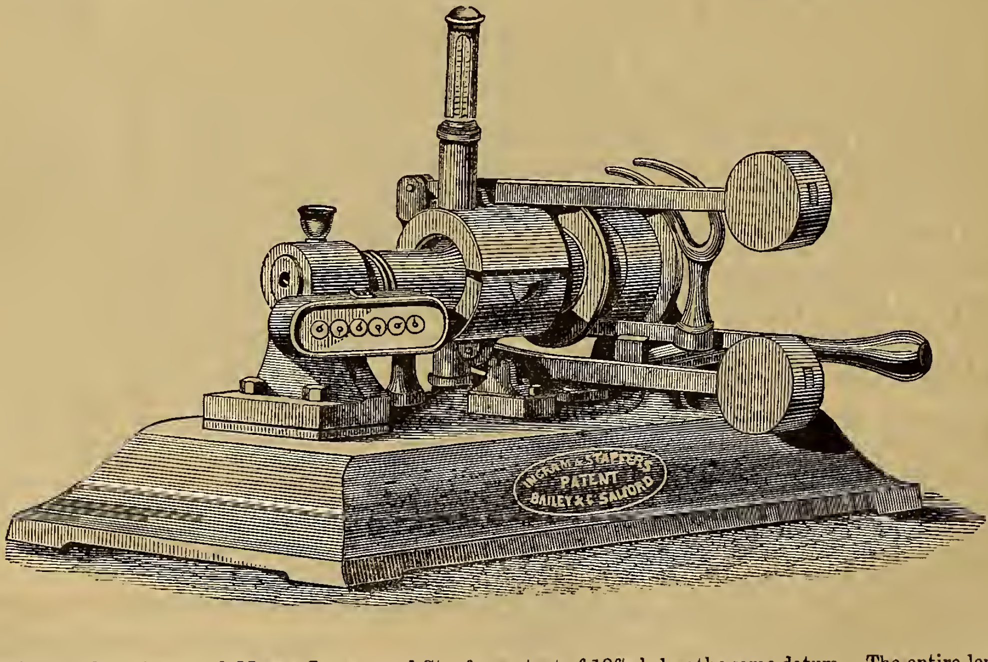
The first condition it fulfils in the highest degree; the material, a flax cord, is perfectly inocuous, and affects neither the tube or tube plates, however long it may remain in contact with them. The second requirement is also fulfilled in the highest degree. It is simpler and costs less in construction than any other plan. The cord appears to be capable of lasting for many years, and it can be taken out and used over again. One shilling's worth of new cord will joint 100 tube ends. The third condition is also fully met. It holds the tubes very firmly, as will be found by examining the models; it also provides freely for the necessary expansion. I may observe here that the holes in, the tube plates and bottom of the recesses being always larger than the tubes, and the cords being very uniform in diameter, when they are run in the tubes do not bear on the tube plates at all, but entirely on the packing cord. The fourth condition is also fulfilled, the packing being as well adapted for the "inside" condenser as for the "outside" form. The fifth condition is also well met. Though the material in the most suitable form for jointing rapidly is specially prepared, it can be made on board so long as a piece of rope can be obtained; and a condenser could be wholly packed in this manner without difficulty. The sixth condition is fulfilled by this plan in a higher degree than in any other plan I know of. The holes can be brought within $\frac{3}{16}$ths of an inch of each other, or even less, without any difficulty. The seventh condition is also fulfilled perhaps more completely than in any other plan. It is evident that the tubes can be treated separately. They are also easily taken out. The holes in the tube plates at the bottom of the recesses are only about $\frac{3}{16}$ths of an inch in depth, and as they are made easy for the tubes, there is not much difficulty in drawing out the tubes even when dirty. The packing cords themselves could be wholly taken out of a large condenser in an hour's time, and the tubes can be driven out if required without removing the packings. In jointing the tubes the cords are all cut to a uniform length, and put in by one end to the bottom of the recess by a gouge-shaped tool, about one turn being given to the cord. After several hundred are thus fixed by the ends, they are run up by a similar gouge tool in an ordinary brace and no further operation is required.

## NAVIGATION OF THE BLACK SEA.

The Porte has at length adopted useful measures for mitigating the dangers of Black Sea navigation. An international commission, consisting of delegates from each legation, was some time ago appointed at the wish of the Turkish Government in order to consider the best plan for laying down beacons. The result, up to the present time, is that nine beacons have been put down, and by the end of this month it is expected that the whole fourteen will be *in situ*, and a coloured lithographed notice to mariners has been issued in English, Turkish, French, and Italian, showing their situations. There are six on the European and eight on the Asiatic side of the entrance of the Bosphorus; the former are surmounted by a cone, and are painted in red and white horizontal bands—as it is intended also to paint the lighthouse at Kara Bournou; and the Asiatic beacons are surmounted with globes, and painted light red, like the Kilia lighthouse. They rise from 30 to 50ft. in height. In addition to these beacons, a light-ship will be placed about 15 miles N.N.E. from the entrance. This ship, which will have two white fixed lights, 28ft. and 38ft. high respectively, is in course of construction at the arsenal on a plan furnished by the Trinity, and it is to be finished by the end of August. We may hope, therefore, for an almost total cessation of the casualties which were continually occurring to shipping in the Black Sea through mistakes occasioned by the Yalam-Boghaz, or "False Entrance," which is a few miles to the east of the Bosphorous mouth. Soundings are also about to be taken in the Black Sea to a depth of 100 fathoms or about 25 miles from shore, from Chesmedjik to Kilia—the two points on each side of the entrance between which the beacons are placed—and, as a further measure, rocket batteries, which have been ordered in England, are to be established at Kira, Kara-Bournou, Magra, and Kilia on the Asiatic coast, and Osunya Bournou, Kisir-Caya, Agadjli, and Kara-Bournou on the European coast. Lastly, as cases have occurred of persons, who had escaped drowning, perishing afterwards from exposure and starvation on the mainland, where there are very few habitations, refuge houses are to be built at different points, in which a few articles will be kept for the use of shipwrecked persons. Two are already put up on the Asiatic coast, and there are six more in course of construction.

## IMPROVED OIL TESTER.

We give below an engraving of a very ingenious machine invented by Messrs. Ingram and Stapfer and manufactured by Messrs. Bailey and Co. of the Albion Works, Salford, for testing the quality of various lubricating oils, and which, from the enormous number and variety of these oils that have lately been recommended, will be found very useful in enabling engineers to discriminate between them. The principle upon which this oil tester acts is entirely different from that usually adopted. Instead of endeavouring to guage the amount of friction between two surfaces lubricated with the oil under examination, advantage is taken of the well-known law that friction produces heat, and Messrs. Ingram and Stapfer have, consequently, designed an instrument to measure the amount of heat generated under a certain amount of pressure and speed.



The method of doing this is very simple, and will be readily understood from the illustration. It consists of a spindle running in bearings at each end, fitted on a suitable bed plate, and driven by a strap working on fast and loose pulleys, and having a counter at the end to show the number of revolutions. To this spindle is fitted a pair of brasses, which are adjusted to the required pressure by weighted levers, the top brass being fitted with a thermometer.

In order to try the commercial value of any oil, a standard should first be established by which to compare the others. Taking, for instance Gallipoli oil as the standard; upon testing it with the machine it was found that with three drops the spindle made 110,000 revolutions, and the thermometer stood at 200° before the oil was exhausted. Supposing the cost of this oil to be 6s. a gallon, then, if upon trying the same quantity of an oil at 4s. a gallon up to the same degree of heat, and it was found that only 55,000 revolutions had been made, its commercial value would only be 3s.; or, supposing that another oil gave 82,500 revolutions under similar conditions, its value would be 4s. 6d. a gallon. In order to estimate the value of oils for high speeds, the oil tester is driven fast and with a light load on the brasses; and, on the contrary, the brasses are loaded heavily and the machine driven slowly, when testing oil for heavy machinery. To manufacturers of oil, quite as much as to machinists, this simple tester will be found very valuable.

## SOUTH THAMES EMBANKMENT.

On the 2nd ult. a short link in the long line of communication which these great works are hereafter intended to afford on both sides of the Thames was formally opened to foot-passenger traffic from Westminster-bridge to Lambeth-bridge.

The works upon this portion of the South Thames Embankment comprise a length of about 2,200 feet of river wall between Westminster and Lambeth Bridges, and a further stretch of 2,100ft. from Lambeth to near the gasworks. With slight exceptions the wall is of a uniform character. Unlike that on the Middlesex side, it is built on concrete faced with granite, instead of brick with a granite facing. In both cases, however, the walls are of equal strength, and have a similar inward curve. Both are finished with the greatest perfection of workmanship, and have a moulded parapet and plinth which is broken at intervals of about 60ft. with plain pedestals. To these are to be affixed the massive-looking bronze lion's heads and mooring-rings which already form such conspicuous ornaments on the Middlesex shore.

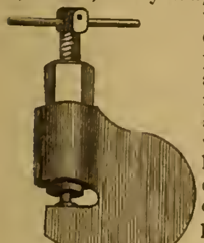
The foundations of the wall are carried down to a depth of 30ft. below Trinity high water, and it is intended to excavate the foreshore to the extent of 18ft. below the same datum. The entire length of work between Westminster and Lambeth Bridges, and for a considerable length beyond, has been executed by means of a double whole-tide timber coffer-dam of the ordinary type, but at about 800ft. above Lambeth-bridge the wall is being constructed in a trench excavated out of the ground, for at this part the wall runs inland and the ground on the river side will, after the completion of the wall, be excavated and removed, the space being thrown into the river so as to increase the stream, which is here very narrow, to a more uniform width with the upper part of the Thames, and permit the tidal water to flow more freely. The area of land thus to be converted into water is about two acres, and the area of land reclaimed from the river below this spot about six acres. When the Embankment is completed the width of the river will vary from 800ft. at Westminster-bridge to 700ft. at the Penitentiary.

The promenade now open for foot passengers, and which is 20ft. wide, will eventually be continued of a somewhat variable width along the entire length of the Embankment, and, indeed, beyond it, as far as High-street, for, to make the improvement as complete as possible, the roadway of Vauxhall-row will be widened up to its junction with the new Thames Embankment roadway. This road will extend from Gun House-alley to Westminster-bridge, and will, in connection with the extension referred to, form an approach 60ft. in width between Westminster and Vauxhall Bridges, in continuation of Stamford-street at the east and of the several roads meeting at Vauxhall-bridge at the western extremity.

The roadway will be formed along the river side for a length of about 600 yards, but will diverge from it to connect at the one end with Vauxhall-row and at the other with Palace New-road. The footway will, however, be continued along the river side for nearly the entire length of the Embankment. Upon the reclaimed land between Westminster and Vauxhall Bridges, bounded on the river side by the footway and on the land side by the intended new road, are being erected the new buildings for St. Thomas's Hospital, which will add materially to the architectural embellishment of the Embankment.

## DUDGEON'S IMPROVED PUNCHING BEAR.

This exceedingly handy little tool, of which we give an engraving below, can scarcely be termed a hydraulic bear, as oil is used instead of water, besides which, the mechanical powers of the lever and screw are also employed, thus obtaining an enormous multiplication of force. Although these several combinations are employed to work the punch, it is, in fact, a very simple tool, as may be easily shown. The head of the bear is bored out, forming a small hydraulic cylinder, and is fitted with a ram to which the punch is attached. This cylinder is filled with oil, and instead of being worked with a pump in the usual manner, a square-threaded screw fitted very accurately, and with a good length of bearing, works through the top. This screw is turned by a lever passing through its head, and as it is screwed down into the oil the ram is forced down with the combined power of the lever, the screw, and the power obtained by the difference of area of the screw and ram. In some cases two screws are used of different diameters, the smaller working through the larger screw. By this means a quick motion and small power may be obtained by using the larger screw for bringing the punch up to its work, or for punching thin plates, while the smaller screw can be employed for the heavier work. When these bears are properly fitted, the oil in the cylinders will last a long time without being replenished, but whenever that is required to be done it is only necessary to take out the screw and pour in fresh oil. The advantages of hydraulic (or oleic) power are too well known to be insisted upon here, but in this case a special feature is the absence of all pumps and cisterns.



There are obviously many other uses to which this system could be advantageously employed, but we will leave this part of the subject to the inventive faculties of our readers. Our reasons for noticing this tool after it has been invented for so long a time, is because it appears to be but little used, whereas, for repairing boilers and similar work it would be much more frequently used if better known.

## CIVIL AND MECHANICAL ENGINEERS' SOCIETY.

### THE DISPOSAL OF TOWN SEWAGE.

By Augustus Hamilton Jacob, C.E., B.A.

The undoubted importance, on sanitary conditions alone, of the subject of this paper is in itself a sufficient excuse for bringing before the Society what might not appear at first sight quite within the range of pure engineering, for the assumption might be that the various modes of dealing with town sewage, viz: precipitating, filtering, deodorising, or utilising as a manurial agent, would fall within the function or the chemist proper or his agricultural brother; but the absolute necessity for constructive works, in the execution of these different processes, demands the advice and skill of the engineer. As the urgency of sanitary reform is forcing itself on all towns throughout this kingdom, and even Europe, a wide field is gradually opening up for the display of very considerable talent in a comparatively recent branch of the profession. It should be the duty of every engineer to make himself acquainted with its principle at least, and of a considerable section of the profession to make it a speciality.

The prime cause of all the agitation for the last twenty years as to the disposal of sewage was the pollution of our rivers and watercourses, whereby what formerly had been elements of utility and pleasure were rendered receptacles for all the garbage and filth from the nearest town. Unfortunately the streams being the lowest points, there never was any physical difficulty in draining into them, their water being, in a greater or less degree, rendered unfit for drinking purposes for man and beast, and the nose and eye offended with noxious exhalations and contaminated water. These evils accumulating aggrieved persons took action at law and obtained injunctions in Chancery with satisfactory results to themselves; the consequence was that local authorities were constrained to seek some remedy to avoid legal difficulties and their concomitant expenses. The cholera epidemic fastening itself on nuclei of overflowing cesspools, untrapped drains, and poisoned water, created a revolution which culminated in the passing of the Public Health Act, 1848. This Act, which has been adopted by nearly 700 towns, was an inestimable boon to the country, as it gave local bodies the power of legislating in sanitary matters. But unfortunately in the eagerness to remove the existing abominations and establish waterclosets, drains, were constructed which conveyed town refuse to the nearest brook or river, the source of all the present river pollution difficulties.

The very first consideration with regard to the disposal of town sewage is to have it effectually removed without nuisance, without injury to health, and without offensive associations in the shape of night carts or anything which might assault even the imagination. These must be the essentials among all well-ordered and refined minds, and anything approaching to a manipulation of sewage matter in our public streets and private houses surely appears a very gross barbarism. Any such process must finally give way, even at the expense of a *presumably* more valuable manure than what now proceeds from the outfalls.

Town sewage consists of the washing of streets and roofs, human excreta, all domestic slops, and the refuse from manufactories, where such exist. The composition will vary with the amount of rainfall, the character of the soil, the water supply, the presence of manufactures, the ratio of rich to poor inhabitants, and the character of the drains, their material and inclination; the two last will require some explanation. The proportion of rich to poor, from the different amount of animal food consumed, will cause considerable variation in the composition of sewage drains passing through poor and fashionable localities. The material and inclination of the drains will influence the character of the sewage, for old nearly level brick drains with flat inverts will become coated internally with a deposit of solid matter which will materially assist in setting up premature decomposition, while on the other hand smooth earthenware pipes with quick fall will convey the sewage undecomposed to the outfall. The composition will vary also from day to day according to the habits of the people—*e.g.*, Saturday ablutions and Sunday cessations—and will alter during different hours of the day. The traffic and material composing the road surface will influence the composition. For instance, analyses gave a range for London for different localities of from 39 to 813 grains of solid matter per gallon in water collected from the streets.

The valuable elements of town sewage are ammonia, and organic matter furnishing ammonia on decomposition, phosphates, and alkaline salts. These elements are chiefly derived from the human excreta, and nearly all held in solution. The ratio of suspended matter to that in solution for normal sewage is ·26 to ·77, proving that no process of simple filtration can ensure purification.

The generally received doctrine held in this country as to the value of manure is that the value depends on the ratio of nitrogenous to non-nitrogenous constituents, or in other words, on the presence of ammonia. The amount of this substance in a manure is generally compared with that in guano as the standard manure, and thus a price can be fixed regulating its value. As human excreta furnishes sewage with the greatest part of its ammonia, it is with its composition it is necessary to deal to obtain its theoretical value. The percentage of ammonia is practically the same, weight for weight, in the solid and liquid excreta, the solid being about one-tenth of the liquid, the total weight voided per day being about 2 lb., the percentage of ammonia being 1·70. The amount voided per year will be about 730 lb., furnishing 12½ lb. of ammonia, which, at 8d. per pound, gives a value per head of 8s. 4d. It may be asked what becomes of the other valuable constituents in the excreta, and why they are not estimated? Excretæ do contain a quantity of phosphoric acid and alkaline salts, which are valuable; but as ammonia overtops these constituents in a great degree, it is found simpler—and the plan is now universally adopted in this country—to place the ammonia at a higher value than it would probably return if used alone. Knowing, then, the value of the manurial constituents in sewage per head, it is easy to determine the theoretical value per ton passing from the outfall, if it be ascertained what is the sewage flow per head per annum. Commencing at forty tons per head per annum, which is about twenty-five gallons per day, the value per ton will be 2·44d. for fifty tons, 2d. for sixty tons, 1·67d. and so on to 100 tons per head per day, when the value is one penny the last being about the value per ton of London sewage. The quantity of ammonia per gallon of sewage for these different dilutions will vary from 3·9 to 9.7 grains. Taking sixty tons as the average flow per head (being the dry-weather sewage of London) seven grains of ammonia per gallon will represent the strength. An easy rule to be remembered is that every grain of ammonia per gallon will represent a farthing per ton at the outfall.

Many persons learning the manurial value of town sewage invent different processes for its deodorisation and precipitation so as to obtain a solid substance in a more saleable form than the liquid. In these processes the fact was generally lost sight of that it is impossible to precipitate ammonia, the chief manuring constituent, except, perhaps, indirectly and expensively as the ammoniaco-magnesian phosphate. The precipitate, therefore, was nearly *effete* matter, and the most valuable fertiliser lost in the effluent water. Between fifty and sixty patents were taken out for various treatments for the manufacture of solid manure, but they all died a natural death from the impossibility of selling the material at anything like a remunerative price. The principal process was that of Mr. Kiggs, and consisted in precipitating the solid suspended matter with lime; it was tried at Tottenham, Leicester, and at one of the London outfalls. Very large works were erected which had to be subsequently abandoned from the impossibility of obtaining a sale for the material; £4 per ton was the estimated price, and it was with difficulty sold at four shillings. Treatment with lime effects a good deal of purification, but it is anything but a perfect deodoriser. The presence of lime will endanger the fish in a stream, according to the amounts of concentration. Sulphate of alumina, in addition to lime and charcoal, phosphate of magnesia, hydrochloric acid, perchloride of iron, &c., were also tried, but suffered commercially and collapsed. All these processes deodorided to some extent, but as deodorisers alone they would be too expensive to adopt. The best simple deodoriser is carbolic acid mixed with lime, as in Macdougall's powder. The only objection to carbolic acid—which, after all, is a very imperfect deodoriser at the outfalls, where it is wanted most—is its peculiar tarry smell, which, ventilating through the smallest crevices in the drains, is very offensive to some people. Simple filtration, either alone or combined with some chemical treatment, has been repeatedly tried, but without any success. At Birmingham the sewage of 300,000 persons was discharged into a filtering tank, the filtering media being gravel. The solid matter was pumped on to land where it was left to dry, when it was sold as manure if buyers could be obtained—sixpence per ton could not be got for it. At Manchester, where cesspools abound, they tried mixing the matter with the ashes of stone coal—a very imperfect deodoriser—and selling the mixture, which was done at a loss of £10,000 a year to the city. It was in this neighbourhood that the Eureka process was tried, which consists in adding sulphate of iron and evaporating to dryness. This was, of course, very expensive, and consequently failed. At Croydon an elaborate system of filtering was tried, also every possible deodorising process, to prevent the fouling of the river Wandle, but with no effect. With regard to all systems of filtration, the question of advantage depends on the state the sewage arrives at outfall; if it be long enough in its transit to set up decomposition, and evolve noxious gases, there is little use for filtering, while, on the other hand, if it arrives in a fresh and undecomposed state, there will be considerable advantage in filtering, but the tanks must be kept constantly clean.

Two processes, proposing to deal with excretal matters and abandon water closets, deserve some notice, viz., the earth system, and Captain Lieurnur's pneumatic system; the former of these two systems depends on the great power that common dry earth exerts as a deodoriser by the absorption of sulphuric and ammoniacal gases and assimilation of phosphoric acid and alkaline salts. It is only intended to deal with the excreta, and consequently a complete system of drains is required for household slops, &c. An ordinary closet is fitted with a seat and a reservoir for dry earth at back, and a chamber or vault underneath of about 50 cubic feet in area; on the pulling of a handle a sufficient quantity of dry earth is discharged into the pit covering any excretal matter. The commode or portable closet is similar in its arrangements except that an iron bucket is substituted for the pit in the fixed closet; this process requires a plentiful supply of dry earth and frequently emptyings—6 lb. of earth are required per head per day, or 2 cwt. per week, for a family of six persons. It can be conceived what difficulty would be experienced in obtaining this quantity of earth and drying it. The plan of drying is to have a drawer made to fit underneath the kitchen range, which may be filled one morning and left till the next; if required for a larger number than six persons, a portable dryer with stove will be necessary. As 224 lb. of dry earth are required per week for six persons, and as the excreta of each person weighs 2 lb., there will be a transport to each house of 224 lb., and from of 308 lb., or a transit through the house of 532 lb. per week. For a town of 20,000 inhabitants 266 cubic yards of earth will be required per week, or 13,800 per year, or about 8ft. excavated over one acre. Apart from the difficulty of getting earth and then drying it, the necessity for separate drains, the alteration of exisiting arrangements, and worst of all the periodical visits of the earthmen, it will be absolutely impossible to get the general inhabitants of a town, however small, to comply with all the necessary requirements to preserve cleanliness and avoid nuisance. Such a system may be adopted in special cases where there is such a methodical system as to insure due attention. As to re-drying the earth there is little probability that such would be generally carried out; these different manipulations must of necessity be offensive to the refined minds of a household. Captain Lieurnur's system consists in constructing iron reservoirs at the crossing of all the principal streets underneath the surface—these are connected by 5in. iron pipes with each closet of the adjoining houses; each service pipe is kept closed with an air-tight valve in the street, which can be opened at will. A steam engine and air pump are drawn through the streets, which stop at each reservoir and pump out all the collected matter into an iron tank, the house-valves are opened, and the excretal matter which has been collecting since the last visit is driven into the exhausted tank by the atmospheric pressure and eventually removed for manuring the land. This arrangement would be very costly; the large service pipes would require a great deal of exhausting, the air-tight valves would be very difficult to keep air-tight; there is no provision for household slops, and the matter which would collect in the closets between each visit of the exhauster would be very offensive. Seeing that all the above-mentioned processes are more or less objectionable, there only remains one other which is practically the most feasible and effective, that of utilising the sewage from the outfall by agricultural means. All the parliamentary reports urge in the strongest manner the necessity for avoiding river pollution by means of irrigation. The latest report published on the river Aire and Calder, says:—"Sewage interception is always practicable; when it can be applied fresh to the land there is least nuisance and least cost to the ratepayers. When the solids are extracted by mechanical deposition there is pecuniary loss on the operation and running streams, receiving the effluent water, are still polluted, the pollution being greater as the volume of the stream is relatively small. No arrangements for treating sewage are satisfactory except its direct application to land for agricultural purposes." The report then proceeds to impress on the Government the advisability of legislating on this subject.

Irrigation farms have been established at many places throughout the country—for instance, Croydon, Edinburgh, Carlisle, Cheltenham, Rugby, Worthing, &c.—and all with the most successful results. In all cases where works have been partly unsuccessful it was due to defective management, and where the farming has been conducted by private individuals. Sewage irrigation will not succeed if it does not receive some attention; it needs little, but it requires some, and it also calls for a somewhat different method of farming. If fields be irrigated by gravitation and open channels, there is a certainty of a direct money profit; if pumping be requisite, or costly means of distribution used, though there may not be an equivalent return for the money expended on works, still the addition to the rates need not be considerable, and the real difficulty, the river pollutions, may be obviated. The manner by which sewage is purified by passing over land is not, as many suppose, by simple filtration—though in some sandy soils purification may be so assisted—but is due to the power which clay has of absorbing and assimilating fertilising matter. The direct contact of the roots of the plant may assist this purification, but only assist, for we find the drainage water from an irrigation field practically pure at a time when there is no growing taking place. There is no doubt that open soils purify large quantities of sewage better than stiff clay, but the reason of this is that in very retentive soils the water cannot find its way for any depth into the ground where it would meet with fresh and more extended surfaces. But, nevertheless, very retentive soils have been found perfectly well adapted for irrigation purposes both at Worthing and South Norwood. At the latter place the soil is essentially brick earth, for there is a brickfield adjoining the farm but a few yards distant. As to the effect of irrigation in purifying sewage sufficiently to permit it to run into watercourses, we have abundant proof. As has been alluded to above, every possible process of filtration and deodorisation was tried at Croydon to prevent the pollution of the river Wandle, but to no purpose; the irrigation fields were then established, and the effluent water discharged into the river. Fish now hover about the outfall, and one of the millowners—the very persons who gave the local board so much trouble—has actually diverted some of the drainage water into his millhead. At South Norwood direct analysis shows that the effluent water contains only one grain of solid matter per gallon more than the well water supplying the town would contain after passing over the same area, allowing for the amount of concentration received by evaporation. The actual difference in impurities per gallon between the well water as it is pumped and the effluent water from the fields is four and a-half grains.

The different methods for applying sewage to land are the hose and jet, subsoil irrigation, and by surface channels. The hose and jet consists of underground pipes of iron laid throughout the farm, and connected with a high-level tank, or with steam or water pumps. To these pipes, at convenient distances, are fixed hydrants, to which are connected suitable lengths of hose with nozzle attached. This method has been tried with some success by Alderman Mechi at Tiptree, but there are many drawbacks to its use. The jet sheds the liquid over the leaves of the growing plants; the length of hose which is required, and which must be pulled over the grass, is very objectionable. There is considerable labour required in the distribution, and the expenditure in laying down all the necessary apparatus is a very serious first cost. The cost of delivery on the Tiptree Farm was 1½d. or 2d. per ton, and as the sewage, or rather liquid manure, was hardly one-third the value of London sewage its manurial value could not at all have compensated for such an expense. However, Alderman Mechi attached great importance to the use of the water alone, and said before a Parliamentary committee that it paid him to pump pure water at the rate of 2d. per ton at certain seasons; by this method the sewage cannot be purified at night time, and also a very much greater area of land would be requird to utilise a given amount of sewage.

Sewage is a very dilute manure, and consequently it will not do to encumber its value with costly means of distribution. Subsoil irrigation consists in laying down underneath the top soil perforated pipes which can be closed at will, at convenient distances apart. When necessary to irrigate the subsoil these pipes are closed, and the sewage forces its way through the holes and mixes itself with the soil. With this method there will be considerable stagnation of the sewage, the crops will hardly receive the whole benefit of the manure, as it percolates somewhat lower than the roots of the growing crop, as the pipes must be at sufficient depth to prevent injury from tillage operations. There will be danger of the holes becoming stopped, and of a deposit forming in the pipes and choking them: this method is generally condemned by engineers. Irrigation by surface channels is now almost universally adopted from its simplicity, cheapness, and effectiveness, and its power of dealing with large quantities of sewage. It is subdivided into three systems, viz., catchwork, ridge and furrow, and pane and gutter. The selection of these methods depends on the physical character of the ground. Catchwork irrigation is only applicable to very steep or sloping ground; it is perfectly essential to contour the ground very carefully, and on the contour lines thus formed gutters are cut in the ground at convenient distances from the top to the bottom of the field, the sewage being conducted along the highest point of the field discharges into the first gutter; this being laid out perfectly level is gradually filled, and overflowing equally throughout its length trickles down the pane to the next gutter, which, in its turn, becomes full and overflows to the next, and so on till the sewage reaches the bottom of the field as pure water. Arrangements can be easily made by which first doses may be given to the lower parts of the field, if it be found that the sewage water is purified before reaching them. The distance between the gutters may be 30ft. or so, depending on the slope of the ground. If the ground has too great a slope there will be a difficulty from the increased rate of motion of the sewage in purifying it, perhaps 1 in 4 or 5 would be about the limit. This is the cheapest mode of irrigating, all the gutters, &c., being constructed for about £2 per acre.

The ridge and furrow method is applicable to perfectly level ground, and consists in forming an artificial slope by excavation and filling. On the top of the ridge thus formed a gutter is cut, which receives the sewage from the main carrier. The pane on each side of this gutter is carefully levelled with a proper inclination—about 1 in 120—to the furrow, a drain cut in which leads to the nearest watercourse; the sewage being led into the gutter on the ridge, overflows on each side down the panes to the drainage gutter in the furrow. The laying out of the ground in this method costs from £4 or £5 to £15 or £20 per acre. The width of the pane on each side of the gutter may vary from 30ft. or less to 80ft., according to the crop.

The pane and gutter method is that used where the ground has naturally a slight inclination: gutters are cut radiating from the main carriers down the fields; between these gutters the ground is laid out perfectly level in one direction, with, of course, a slope in the other corresponding to that of the subsidiary carriers; at the lower part of the field a drainage gutter is cut to take away the purified water. The manner by which the sewage is distributed is as follows: The liquid flowing into the carrier runs down and is arrested by stop boards, which are simply elm boards stuck into the ground transversely to the carriers. These stops cause the sewage to dam up, and, rising over the edges of the carriers or gutters, flows evenly over the adjoining ground. This is a very effectual method of irrigating, and is largely used at Croydon.

The opponents of the irrigation of land with sewage maintain that considerable nuisance is entailed by the flowing of sewage through the open channels but this objection may be easily met by adopting a few simple precautions, viz., a careful filtration, as at South Norwood, where the sewage is made to pass through beds of burnt earth, by covering the main carriers, and by keeping the gutters cleaned out and free from the black deposit, which is the most fruitful source of nuisance. The filtrate of solid matter from the tanks may be sold at two shillings per ton, and will generally pay the expenses of filtering. As to the crops suitable for sewage farming purposes, many have been tried, and nearly all with more or less success, but the crop which has been found to give the best results and require least attention is grass, and of all the various grasses that most pre-eminently applicable is the Italian rye-grass. Sewage is a manure which must be constant in its application, and as it is its purification we have to deal with as a first consideration, it is necessary to select a crop which will not suffer from a continual application. Grass is a quick growing crop, and uses up the fertilising matter of manure very speedily, and bears a free application of water; it will also take repeated dressing with advantage, which other crops will not do. It is very advantageous to set apart a certain division of a farm for root and other crops if there be room enough, but it is always essential to preserve a certain amount of grass crop which will in itself be always ready to receive the sewage for purification when it would be inapplicable to others. Sewage has been tried with considerable success on cereal crops, but there must be great care taken that it is used sparingly, and at a particular season; too free a dressing will surely cause the crop to run to straw, but a limited dressing in time of drought will be of great advantage to the ear. At Rugby, under Mr. Lawes, sewage was applied to oats at the rate of 135 tons to 510 tons per acre; in the former case 5¼ per ton of sewage was realised, and in the latter 1½ per ton, the quantity of grain being increased in the first instance, and straw in the other. Other crops which have been successfully grown with sewage are lucerne, a plant allied to clover, rye crop or ordinary rye before it reaches an ear, flax, mangold, beet, kohl rabi, cabbage, celery, &c. Most of these have been farmed at the Lodge Farm, Barking, with metropolitan sewage, under the able superintendence of Mr. J. C. Morton, one of the lately appointed commissioners on river polution, and have returned most satisfactory and unlooked for crops. Here a crop of cabbages sown in August, and watered three or four times at fornightly intervals, produced £10 an acre, the plants being 15in. apart. A crop of mangolds sown in May, and among which were transplanted kohl rabi plants in August, after three dressings making 1,100 tons of sewage per acre, produced a return in October equivalent to £50 per acre. This result was double that obtained from other plots on the farm undressed with sewage, but which received a liberal manuring of cowhouse dung, guano, superphosphate, and salt. The only manure applied to a very poor gravelly soil to realise these very heavy crops is the ordinary London sewage. These experiments were chiefly carried out to show the Essex market gardeners the value of sewage for their vegetables more than as a means of purifying sewage in as economical a manner as possible. The greater part of the farm has been sown with Italian rye-grass, which has grown most luxuriantly.

Many interesting experiments were conducted at Rugby by Messrs. Lawes and Way on the value of sewage for green crops farming. Great accuracy was observed, and the results obtained have proved very reliable and valuable for an ordinary sample of sewage such as Rugby produces. Four distinct plots were chosen in two adjoining fields respectively, possessing a somewhat different soil. These plots were laid down in meadow grass and treated as follows:—No. 1 without sewage, No. 2 with 3,000 tons, No. 3 with 6,000 tons, and No. 4 with 9,000 tons. The soil was a lias marl of a retentive character. The fields were not drained. The amount of ammonia was seven grains per gallons, giving a theoretical value of 1¾ per ton. It was found that the result of applying sewage to mixed grasses was to choke out the finer ones and to develope individual species, and to deprive the land of weeds. The result obtained for one year were as follows:—No. 1, unsewaged, 4 tons 18 cwt. per acre per annum; No. 2, with 3,000 tons of sewage, 22¾ tons; No. 3, with 6,000, 35 tons; and No. 4, with 9,000, 37 tons. The cutting of the crop irrigated with 9,000 tons commenced towards the end of April, and gave six cuttings, the last being on the 27th of November; No. 3 was cut early in May, and gave five cuttings; No. 2 at the end of May, also five cuttings; and No. 1 in the middle of July, with only two cuttings. The value obtained per acre from the application of sewage, calculated on the amount of milk obtained from cows fed upon the sewage grass, with a slight addition of oil cake, was for plot No. 1, without sewage, £15 per annum; No. 2, £25. 7s.; No. 3, £33 6s. 10d.; No. 4, £36 1s. 4d., realising a value for the sewage of ·931d. per ton, against 1·67d., the theoretical value. The drainage water from the fields generally contained two grains of ammonia per gallon, which would give a halfpenny per ton lost.

With regard to the composition of grass and milk obtained from sewage, it was found that though a given weight of sewaged grass had not as much dry substance as a similar weight of unsewaged, still the dry substance of the sewage-grown grass contained more valuable ingredients for the production of milk. The composition of milk obtained from sewaged and unsewaged grass was almost identical; if any difference it was in favour of the former.

The quantity of sewage per acre to be applied as giving the most economic results, according to Messrs. Lawes and Way, is 5,000 tons per annum.

Though the results with meadow grass have been so successful, the crop best suited, as before stated, for irrigating is the Italian rye grass, from its very rapid growth and its power of dealing with large quantities of sewage. This crop requires to be ploughed up every third year or so, and a root crop taken off the ground, when the rye grass is re-sown. This grass can be grown, and as delicately as it is possible to grow it, by means of sewage, by taking care that it is cut immediately before it forms seed. If this precaution be observed there will be no danger of rankness or coarseness. The results at Croydon and Edinburgh where sewage irrigation has been carried on for two hundred years, have been as successful as it is possible to be. At both these places grain has been cut realising £50 per acre, but £30 to £40 may be considered the average. The amount of sewage applied per acre has varied from a few hundred tons per annum to 20,000 or 30,000 tons. At Croydon about 6,000 tons are used per annum; at Edinburgh as much as 20,000 tons. Messrs. Lawes and Way give as their opinion that any amount of sewage up to 40,000 or 50,000 tons may be applied to land with satisfactory results, but that these amounts would not at all give the greatest economic value of the constituents of the sewage. Five thousand tons per acre is that quantity which gives a result nearer to the theoretical value than any other amount. With this quantity of sewage applied to an acre of Italian rye grass properly laid down 1,000 gallons of milk may be anticipated per year, which, at 8d. per gallon, would represent a gross money return of £33 6s. 8d. As to the estimated value of sewage, it is an unfair thing to seek out every grain of ammonia and put it against its marketable value. A farmer uses his manure at certain seasons to certain soils and in certain quantities, and even then it will very seldom reproduce its marketable value. Sewage must be applied at all times and at all seasons, and whatever happens it must be purified. Under such circumstances it can hardly be supposed it will reproduce its full market value throughout the year, though there are times in the season when it may realise considerably more.

## ROYAL GEOGRAPHICAL SOCIETY.

### ON EXPLORATIONS IN THE PENINSULA OF SINAI DURING LAST WINTER.

By the Rev. F. W. Holland.

The author stated that it was his third visit to the country on the same errand, and that he adopted the independent mode in his travels, of dispensing with a dragoman and traversing a large portion of the Peninsula on foot. In commencing these explorations he had found the best maps extremely incorrect in many parts, and large districts quite unknown. He left Suez on foot, on the 10th October last, and on reaching Jebel Musa (Mount Sinai), made the monastery at the foot of the mountain his head quarters; exploring from this centre, during four months, the numerous wadies and mountains in all directions, south of Jebel Er-Rahar. He occupied a little room at the top of the convent. At sunrise every morning he was awoke by the clanging of the pieces of iron and wooden boards used as bells to call the monks to service, and after making his fire and cooking his breakfast let himself down from a little gate in the garden wall by a rope and commenced alone his daily explorations, depending on Arab ibex-hunters for his information of mountain paths, the monks and their Arab servants knowing nothing of the country beyond the convent walls. In his more distant excursions he took an Arab to carry his blanket and a bag of provisions, and slept out sometimes for three or four nights. He found, contrary to what he was led to expect, two or three springs of water on every important mountain in the neighbourhood, and considerable vegetation even at the end of a long dry season. He was thus enabled to take the heights of the mountains and measure and map out the endless and sometimes intricate narrow valleys of the country. With regard to the probable route of the Israelites and the sites of events in Sacred History, he had come to the following conclusions. After crossing the Red Sea, somewhere in the neighbourhood of Suez, he thought they took the lower road down the plain along the coast as far as Ain Szouweirn, which might possibly mark the locality of Marah. They then turned inland to Elim which he would place at Ain Howara. Their next encampment was by the sea, possibly near the mouth of Wady Ghwundel, the most fertile place in the peninsula. The Wilderness of Sin he would identify with the plain of Es Seyn, and not with the desert plains of Merkha as generally believed. From this their route would lay by Dophkah and Alusk, and afterwards up the Wady Es Sheikh to the Rephidim, the site of which after careful examination he fixed at Mokad Musa, a narrow gorge in a long unbroken wall of granite, which stretches across the centre of the peninsula and ten miles north of Jebel Musa. With regard to the true Mount Sinai, Mr. Holland thought Jebel Um Alowee possibly a corruption of Eloheem, a previously unknown mountain north-east of Jebel Muso, to be probably the true one. The plain of Senned at the foot of this mountain affords a much larger camping-ground that that at the foot of the present Mount Sinai. In conclusion, he entered a protest againt the theory that the Sinaitic inscriptions were the work of the children of Israel; he had copied some hundreds of them, and found not a single point in favour of such a theory.

The President, Sir Robert Murchison, spoke in praise of the courage and ability with which the author had carried out his arduous undertaking. Captain Felix Jones, Mr. Cyril Graham, Sir Samuel Baker, and Mr. Kennelly took part in the discussion which followed.

The following gentlemen were elected Fellows of the Society:—M. Blakiston, F. Barlow, W. Busk, F. C. Cory, M.D.; A. Ellison, C.E.; J. T. Fletcher, H. Freeman, J. L. Hart, Rev. W. Hiley, M.A.; Major T. J. Holland, S. Hoare, M.A.; S. J. Hobson, W. S. Jones, Lieut.-Col. H. Le Couteur, R. M. Miller, R. Mitchell, Lieut. C. M. MacGregor, J. H. Paul, M.D.; A. Richards, Charles W. Roberts, P. J. Rowlands, Rev. C. F. Stovin, G. E. H. Sutton, Col. R. Wardlaw.

## INSTITUTION OF CIVIL ENGINEERS.

### ON THE DURABILITY OF MATERIALS.

By Mr. Edwin Clark, M. Inst. C.E.

The author expresses the opinion, that a series of papers devoted, not so much to the special application of those philosophical principles which formed the basis of practice, as to the consideration of the principles themselves, would be of great interest: as numerous questions occurred which could be more effectually discussed in their abstract capacity, than in connection with the practical applications out of which they arose. Well-established fundamental principles had been arrived at on many subjects, which it was advisable should be definitely recorded.

The list of materials used by the engineer was small. It included stone and timber among natural productions, and bricks and cement and the metals among artificial products. It was difficult to state, even approximately, the positive life of either of these articles. The durability of any material depended, not only on its own inherent properties, but principally on the agencies to which it was exposed; as, for instance, the effects due to climate.

On examining all the facts, and seeking some common characteristic, it was found that among all the causes of decay, humidity held the first rank. The decaying influence of humidity was evidently dependent on other coincident circumstances. The mere pressure of water, or even of a saturated atmosphere, was not sufficient to induce rapid decay, which appeared to be caused by humidity only under peculiar conditions. One of these conditions was well known by the popular title of dampness. The decay caused by dampness, as in the case of dry rot, was as effectually prevented by the presence of water as by a constant currrent of air, whether perfectly dry, or saturated to any degree of humidity. Damp, therefore, was not the mere presence of moisture in the ordinary form in which it was held in solution by the atmosphere. If an hygrometer was placed in a damp situation it would simply indicate perfect saturation; no evaporation took place, but the cotton covering of the wet bulb was speedily covered by a peculiar mould, well known by its fungus-like odour, and in a short time it was converted into an impalable powder, or ash. Under similar circumstances, timber, leather, paper, and all like materials, underwent the same rapid decomposition; vegetable gums and oils, that were insoluble in water, and even dry hard paints and varnish, became soluble and liquid. Massive timbers were rapidly disintegrated to the core, entirely losing their weight, though still retaining their form; and they were often totally free from apparent moisture, although at times dotted externally by drops of brilliant water. Damp spots were, moreover, peculiarly hygrometric, indicating atmospheric changes with remarkable precision, and temporary dessication in no way disturbed this process. The peculiar odour which always accompanied this condition was one of the best tests of its existence; and the expression that a room smelt damp was strickly correct. The effects were, within certain limits, intensified by increase of temperature and absence of light, and arrested by poisons destructive to vegetable life. If this phenomon of decay were more closely examined, the process would be found to resemble, in many respects, a slow combustion. The ultimate results of combustion and decay were strikingly similar; the union with oxygen was slowly effected, and the residue was more or less diluted with foreign substances; but whether bodies were burnt, or decayed, the remains in the ashes were substantially identical. Decay might thus, to a great extent, be looked upon as a decomposition, resulting from the slow chemical combination of oxygen with the matters decomposed. Now, if slow combustion were the cause of decay, and that particular state called dampness were so important an accessory, the inquiry naturally suggested itself, what connection existed between those agencies, or in what way could damp promote the absorption of oxygen? In the case of organic substances, the presence of vegetation in the form of fungus, or mould, was an invariable characteristic of decay, and the decomposing effect of all vegetable growth was beyond question. It might be said, that the vegetable growth alluded to was the effect rather than the cause of decay. Doubtless the spores of microscopic fungi followed the law of all other seeds in vegetation only under the peculiar conditions of soil, light and moisture which were adapted to their growth; dampness and partial darkness, and absolute quietude, and even decay, might be essential to their existence; and therefore it was only under such conditions that they appeared at all. But, nevertheless, when they did appear, their presence rapidly accelerated the decay, and they furnished a vital medium, capable of accomplishing the observed effect—combustion, or slow union with oxygen, of the substances on which they throve. It was probably by some such chemical vital action, the fact could be explained, that even the hardest rocks were rapidly decomposed by the growth of lichens, or that decay should be arrested by poisons which could exert no other influence than the prevention of vegetation. It was equally remarkable, that in the putrefaction, or rapid chemical decomposition, of animal and vegetable substances, the same profusion of the lower forms of animal, as well as vegetable, organisms characterised the phenomenon.

Whatever might be the cause of decay, moisture was one indispensable element. Dry air was incapable of decomposition. Water was a carrier of oxygen in a potent form; and it was only from water, and more especially when in the form of vapour, that the oxygen necessary for decay could be obtained. The durability of tin and iron roofs in Geneva and St. Petersburg, was due to the absence of moisture; and the importance of some shelter for timber, and of thorough ventilation wherever it was employed in this moist climate, was a necessary corollary.

The durability of metals, like that of organized substances, depended, mainly, on the resistance they offered to combination with oxygen; and thus their decay might also be regarded as a slow combustion. But their durability further depended on the character of the oxides formed on their surface. Iron exposed to moisture was soon coated with rust, in the form of hydrated peroxides; and as these oxides did not adhere to the surface, additional flakes constantly formed and fell away, until the whole mass was destroyed. Wrought iron in a pure, dry atmosphere suffered, practically speaking, no deterioration in any lapse of time. It was extremely durable in distilled water free from air; but it was slowly oxidized in a moist atmosphere, and with fatal rapidity in air or water containing free acids or other corrosive agents. It was, however, efficiently protected from such agents by paint, which adhered to clean iron with great tenacity. It was also a fact, not hitherto satisfactorily accounted for, that oxidization was to a great extent arrested by vibration. The painting of wrought iron girders and roofs, more especially in the neighbourhoods of smoky towns, was a precaution of the utmost importance. Every care should be taken to expose the iron as freely as possible to the air, to leave no hollows were water could collect, to avoid the contact of damp earth, and especially of vegetation, and to throw the material into the form of heavy bars rather than thin plates. Painting was more economically performed, and was more effectual, when constantly attended to, than under the vicious practice of laying on three or four coats, and then leaving the work for years, till the paint peeled off, with a layer of rust attached to it. The Brittania Bridge furnished a striking illustration of the value of this system. The maintenance had been effected by two or three men, constantly on the work, who attended to the slightest symptom of local discolouration. As a consequence, the author did not hesitate to express his firm belief, that the total loss from rust of the 10,540 tons of which the tubes consisted, did not in twenty years amount to a single pound weight.

Cast iron when exposed to the action of sea water slowly decomposed, the iron being dissolved, leaving behind a graphite or plumbago. The action was, however, superficial and very slow. It could be preserved by painting, where accessible for that purpose, and by any protection which prevented continual renewal of the surrounding medium, as when enclosed by brickwork or masonry. In fresh water it suffered no such deterioration, and under ordinary circumstances its durability in a pure atmosphere appeared unlimited.

In the case of zinc, although the bright metal oxidized even more rapidly than iron, yet the oxide adhered with such tenacity to the metal, that it afforded an efficient protection against the continuation of the process. To this property the metal owed its great durability, more especially as its oxide was insoluble in water. In the presence of any solvent of the oxide, this metal was so speedily destroyed as to be practically useless, unless protected by paint. The destruction of zinc in smoky districts was, however, principally due to galvanic action. A similar action produced the rusting away at the base of iron railings, when fixed in stone work, as was usually the case, by being run in with lead. The contact of copper with the iron plates of a vessel was also a source of great danger; and there were numberless other instances, in which the contact of metals of different conducting powers was equally destructive. In all such cases the use of paint furnished, at any rate, a temporary remedy.

It was difficult to over-estimate the value of the introduction of the process of coating iron plates with zinc, by simply cleaning and immersing them in the molten metal. All that had been said on the subject of zinc applied equally to galvanized iron, as it was called. In a clear atmosphere its great durability, its stiffness, its freedom from expansion, and its economy, were all qualities of the highest value; while, on the other hand, without constant painting, it was wholly unfitted for the atmosphere of smoky towns, or manufactories, or, even stations where it was exposed to the fumes from locomotives. Both the corrosive and the galvanic actions, which in such cases were so destructive, did not cease with the destruction of the zinc, which was soon effected, but continued also to act, with fatal effect, upon the iron itself, as might be seen in many railway stations and sheds near manufacturing towns. The corrosive tendency in zinc and iron obliged the use of the less oxidizable metals, copper and lead. Lead slowly absorbed oxygen and carbonic acid in moist air. It was acted upon by certain waters, and was occasionally riddled with holes by the larva of an insect; and its expansion and contraction required to be carefully allowed for in its use. Its ductility rendered it a valuable material. Copper might, however, in many instances, be used with great advantage in its stead.

The action of sea water on copper was so important, that it was particularly alluded to. The object in covering a vessel with copper was solely to prevent the adhesion of barnacles and other molluscs. This property was not due to the poisonous quality of its salts, as was sometimes asserted, nor was copper used on account of its durable qualities; on the contrary, its value depended on its slow destruction. The chloride of copper formed beneath the attachment of the barnacle being a soluble salt, the creature no sooner effected a lodgement than it was at once set free by the solution of the salt; while the salts which formed on zinc or iron being insoluble, the plate was rather protected than otherwise by the tenacious parasite. Hence the difficulty of devising an efficient paint for iron ships; for while, on the one hand, it must be slowly soluble in water to prevent this adhesion, it must on the other hand, be sufficiently insoluble to be durable.

Ordinary oil paint was the most efficient material for protecting either metals or wood from the effects of moisture and air; but all oils, resins, and gums exposed to air, and especially to the light of the sun, oxidised and burnt away with more or less rapidity, leaving a powdery residue behind. As a preservative of paint against the heat of the sun and light, attention was directed to the virtue of a coating of silicious sand, dredged on the paint while wet.

The durability of matter was a subject of the highest philosophical interest. The universal law on this planet appeared to be, that no form should be permanent. Never-ceasing destruction and reconstruction were characteristic, within the range of the atmosphere, of everything that existed, whether as regarded organic life or inorganic matter; and it was probable that even the atmosphere itself was subject to the same decree.

## ON IRRIGATION IN INDIA.

### By Mr. Allan Wilson, M. Inst. C.E.

Having had fourteen years' experience in the construction and superintendence of irrigation works in the central and southern provinces of India, where wet cultivation was extensively practised, the Author proposed in this communication mainly to refer to that part of the empire. A brief account was in the first place given of the former and present system of irrigation, followed by a detailed description of the accessory works; and the cost of providing the water was then noticed.

The value of artificial means of irrigation, for increasing the fertility of the soil, was recognised in India at an early date. In the Punjaub, canals for this purpose, as well as for navigation, were constructed as far back as the middle of the fourteenth century. But it was in the southern parts of India, where the rainfall was more precarious, and the river supplies less easily available, that the most extensive works were to be found. It had been estimated that, prior to the establishment of British rule, there were, in fourteen of the principal irrigated districts of the Madras Presidency, upwards of forty-three thousand tanks and channels in repair, besides about ten thousand out of repair, having, probably, 30,000 miles of embankments, and three hundred thousand separate masonry works. Some of these tanks and reservoirs were on an immense scale, for irrigating many thousand acres, while there were smaller tanks, wells, and springs, which watered only a few acres. It was remarkable that the Government should have allowed so many fine works gradually to fall into decay, without replacing them by others; as great natural facilities exisited for storing water, and for forming canals to lead it on to the land. The irrigation works on the Godavery and Kistna rivers, in the northern Circars, and on the Coleroon, in Tanjore, had only recently been completed; but many large rivers were still allowed to flow into the ocean, almost unused for agricultural purposes.

With regard to the most general and least expensive mode of irrigation by means of artificial reservoirs, and to the methods adopted in forming such reservoirs, it was stated that in selecting a site it was essential to ascertain in the first place that the foundation was suitable; the next point to be determined was the extent of land to be irrigated, and the quantity of water necessary for such irrigation. The area of the drainage or gathering grounds could be estimated from trigonometrical survey maps of India, and the quantity of water that would pass into the tank during floods should be calculated according to the known rainfall, due allowance being made for absorption and evaporation. With these data, the dimensions of the different works could be fixed. It should, however, be borne in mind, that the depth of water was of greater importance than a large surface area, as the evaporation would be less in the former case. An examination should also be made of the valleys in the vicinity of the proposed reservoir, with a view to ascertain whether the surplus water flowing through the tank during floods could not be carried across intervening ridges, and be stored in natural basins at a small outlay, so as to fill a chain of tanks. It was explained that a tank was simply a reservoir formed by throwing an embankment, or bund as it was called in India, across a valley to dam up the drainage. The most simple description of bund was constructed entirely of earth, which was generally dug from the bed of the intended reservoir. The breadth at the top was usually about 12 feet. The inner slope was 3 to 1, and this was faced with a pitching of loose stone, while the slope of the land side varied from 2 to 1 to 1 to 1. Puddle was seldom, if ever, used; indeed it was not required, as owing to the lodgment of silt, a tank would puddle itself as soon as it had been once filled. In illustration of this fact it was mentioned, that Major-General Sir Arthur Cotton had stated that in a channel cut through loose sand, within a yard of the water's edge to a depth of 5 feet, not the least moisture was found in the excavation; the lining of silt having rendered it completely water-tight. In addition to this embankment, some of the large Hindoo works had a massive retaining wall of masonry in front, Many of these walls were built of dressed stone, close jointed, backed with rubble and a rough description of concrete; and flights of steps of cut stone were constructed down to the edge of the water.

To obviate the danger of an excessive influx of water during floods, most tanks were provided at one end, and not unfrequently at both ends, of the embankment, with a waste weir (known in India as a calingulah, was an essential feature. It was a safe rule to allow one-fourth more than the dimensions obtained by calculation, so that the water might have a free passage in the event of an excessive flood, as otherwise the earthwork might be entirely destroyed. The Author had found that many of the tanks which were now useless had been breached from no other apparent cause, than the want of sufficient outlet to carry off the surplus water during floods. In constructing these calingulahs, upright stones, varying from 2 feet to 5 feet in height, were fixed in the body of the masonry, at intervals of from 3 feet to 4 feet. When the rains were moderate, as the monsoon was declining, these spaces were filled with brushwood, straw, earth, or rubbish, to prevent the further escape of water, and to store up as much as possible. This contrivance showed how highly water was appreciated by the natives of India; but unless the process of filling up was very gradual, and its completion deferred until the rains had entirely ceased, the results were often most disastrous. Many of the ruined tanks appeared to have been breached solely from the desire on the part of the cultivator to retain the utmost quantity of water. The forms and dimensions of the calingulahs must, of course, be regulated according to the capacity of the tank, the area of the gathering ground, the rainfall, liability of drought, and other local circumstances; so that it was not possible to lay down any general rule, having regard to the great differences of rainfall, &c., in the several districts of India.

In order to draw off the water for cultivating the fields, each tank was provided with one or more sluices; their size and number depending entirely upon the area of land to be irrigated. The sluice in general use in Southern India was exceedingly simple. It was merely a tunnel through the bank, built of brick, or rubble, either arched at the top or covered with flat-jointed flags, and the side walls lined with the same. The inner end, or head of the sluice or tunnel, was closed by stones, and the water was allowed to enter through one or more orifices, generally from 3 inches to 5 inches in diameter, cut in these covering stones. The flow of water through these orifices was regulated by means of conical plugs of wood, each of which, being attached to a long handle, could be withdrawn or inserted as required. At the end of the sluice tunnel below the bank, a cistern was generally built, having its sides pierced with holes at different levels, to enable the water to be drawn off at various elevations. From this point the water was carried forward in open ducts of the requisite dimensions, in the sides of which subsidiary or distributing channels were cut, generally at the expense of the farmer, to lead the water on to the land to be irrigated. The mode of preparing land for wet cultivation was by laying it out in squares, rectangles, &c., each plot being separated from the rest by mud walls of sufficient height and thickness to prevent overflow or percolation. These squares or rectangles were kept level, and were as large as the nature of the ground would admit. When one was sufficiently flooded, the water was let off at the lower corner of the field into the next division, and so on until the whole area had been irrigated.

With a view of showing how favourable some parts of India were for forming reservoirs of large capacity, attention was directed to a design for a large artificial lake, which it was proposed to construct by damming up the gorge of a valley. This reservoir would be capable of storing sufficient water to irrigate 200,000 acres of land, and area equal to the county of Buckingham, allowing the usual average of 500 acres to the square mile as being under cultivation. Taking 170,000 acres as the extent of land to be irrigated for a single crop, this would require provision to be made for the discharge of 170,000 cubic yards of water per hour at each end of the tank; and discussion was invited as to the best description of sluice for discharging such a vast volume of water.

Another method of providing a supply of water for artificial irrigation was by damming up the rivers, by anicuts, or masonry dams (also called weirs). The sites for many of these had been so judiciously chosen by native engineers, that but little expense had been incurred in building them. They were generally formed of boulders and stones thrown promiscuously together. The side next the water had the outline of a retaining wall with a slight batter, and was laid with some care. On the down-stream side, two rows of stones composing the lower edge of the apron were carefully laid by hand, and the upper courses on both sides were similarly placed. A detailed description was given of some old anicuts across the river Toombuddra, as well as a modern one over the same stream; of an anicut across the Kistna river, near the town of Bizwarrah; and of temporary wiers of rough stones, which were not now so generally used as they were formerly. These masonry dams were, when practicable, taken advantage of for forming means of communication from one bank of the river to another, by building a bridge on the top of the weir. These dams had sluices at each end, and if requisite at other parts, to be kept open at times, so as to prevent the lodgment of silt above the weir. A head sluice should also be constructed, to enable the water in the river during a flood to be shut off, and so prevent sand, &c., from entering the irrigating channel. These sluice openings were closed by wooden shutters, consisting of teak-wood planks, a native system which had been found to answer so well that it had been adopted more or less by English engineers.

Great difference of opinion existed as to the cost of storing and distributing water for irrigation. Thus, in a report made by Colonel Dickens, in 1855, on the Shahabad district, the estimated cost of storing and supplying water from four different tanks, including the cost of the distributing channels, was 400, 352, 350, and 494, cubic yards per rupee respectively, or an average of 400 cubic yards per rupee, giving a cost of 8 rupees 12 annas per acre irrigated with 3,500 cubic yards, a quantity which was amply sufficient to raise more than an average rice crop. Colonel Rundall stated the rates per acre in the Madras Presidency at 6 rupees and 8 rupees three annas, giving an average of 7 rupees 15 annas per acre as the cost of storing water; but it did not appear whether the expense of the engineering establishment and of the distributing channels was included in these rates. The author stated, as the result of personal experience, that a few years ago, in the south of India at least, an extensive area in the immediate vicinity of the work could have been provided with irrigation works, including distributing channels, at a cost of 10 rupees (£1) for every 3,500 cubic yards. Owing to the increase that had of late years taken place in the rates of all kinds of labour, the cost would now probably amount to 15 rupees per acre irrigated.

Water was also raised from wells, banks of canals and rivers, for irrigation purposes, by means of the Persian wheel, and pumps of all kinds worked either by men or by bullock gin; the mót operated by bullocks, and the picottah by men being employed. From springs water was lifted by basket scoops worked by men. A minute account was given of these several methods, accompanied by a statement of the qualities and cost of water, as a comparative statement of the number of cubic feet raised 1 foot high per day of ten hours, raised by these different plans, in various parts of India.

As to the relative value to Government of irrigated and dry cultivation, it was stated that, in the fourteen districts of the Madras Presidency already referred to, there were about 2 million acres of irrigated and 25 million acres of dry land, and that the revenue derived from the former was 1½ million sterling against barely 2 millions from the latter, so that the irrigated land yielded three times the revenue drawn from an equal surface of dry land. As regarded the gain to the cultivator from irrigated land, independently of the certainty of reaping the crop, it might be stated that the average intrinsic or market value of crops raised on irrigated land was 20 rupees per acre, against 6 rupees for the produce from unirrigated land, or more than threefold.

The great superiority of river and tank water for irrigation purposes, as compared with well and spring water, was next adverted to, as an additional argument in favour of the formation of river and tank reservoirs. In many localities, large profits might reasonably be expected to be realised, both from the construction of new works, and from the additions and improvements to existing ones. Statistics regarding the extent of land at present irrigated were meagre, but it might be safely stated, that not more than four million acres were watered by artificial works; and there appeared to be no prospect, in spite of the large remunerative results obtained therefrom, of an outlay commensurate with the requirements of the country being incurred by Government within any definite period. Judging from personal experience and observation, the Author was of opinion that, considering the vast area requiring to be provided with these works, the comparatively small extent of the Government establishments, and the large capital that would be needed, the object could be best attained through the agency of private companies. This view would, he thought, be fully supported by a comparison of the operations of the railway companies with those of Government in regard to irrigation works. The utmost sum that had been spent by the various governments and communities of India, on these primary and highly remunerative works, was about 4 millions sterling, during a long course of years; whereas, no less than about 70 millions sterling had, within a few years, been spent by private companies on railways, which were far less remunerative, and might, moreover, be called subsidiary works, dependent for their full development and success upon the prosperity of the people. It was true that objections had been raised, and possibly not without reason, against the management of private companies; but the defects that existed were not inherent in their constitution, and might, the author believed, be obviated under suitable arrangements. Indeed, there was every inducement for a company to press on the construction of public works, in the most rapid and efficient manner, so as to obtain a better return than the moderate rate of interest guaranteed by Government; and the realization of these advantages could not fail to attract capitalists. A feeling in favour of such companies was beginning to spring up among the natives of India, and this feeling would increase as the remunerative results of irrigation works became more apparent.

## ON THE BENEFITS OF IRRIGATION IN INDIA, AND ON THE PROPER CONSTRUCTION OF IRRIGATING CANALS.

By Mr. T. Login, F.R.S.E.

The author stated that he had been engaged, during the greater part of a quarter of a century, on some of the most important irrigation works in Northern India, and an account of the prominent features of the system formed the subject of this communication.

With regard to the revenue derived from the older canals and their actual cost, diagrams were exhibited showing that, at least in Northern India, immediate direct returns must not be looked for, although such canals were certain to be financially successful eventually. If, however, in addition to the water rent, the increase of cultivation and the enhanced value of land were included, the canals even in this part of the empire must be considered highly remunerative. But the strong argument in favour of canals was, that they were calculated to prevent those awful visitations which from time to time swept off hundreds of thousands by starvation; and if canals could be constructed at an outlay of somewhat less than one pound sterling per head of the population, and return a fair per centage for the outlay, these were additional reasons for proceeding with them without delay.

The abrading and transporting power of water in motion was briefly adverted to, and the author expressed the opinion that the power of water to hold matter in suspension was directly as the velocity, and inversely as the depth; and that with given velocities and defined depths, only a certain quantity of matter could be held in suspension, whatever might be the character of the bed and banks of the river or canal. If the velocity were increased, and the depth remained constant, scour would take place; whereas if the velocity were decreased, and the depth was the same, there would be deposit.

With reference to the best slopes for canals, and how the slopes were to be regulated, it was essential, in the first place to ascertain what was the slope of the river, when not in flood, from which a supply was to be drawn, under circumstances similar to those of the canal to be constructed, that was, as to depth and soil; and then to make a small allowance for the tortuous course of the natural river. The slope—that was the velocity, or in other words, the abrading and transporting power to be given—should be such, that the deposits would be balanced by the abrasion. Experience on the Ganges canal had shown, that this required a mean velocity of about 3¾ft. a second, with a surface slope a little less than 14in. in the mile. One of the greatest problems for the canal engineer was, the best method of dealing with the excessive slope of the country through which an artificial river had to flow. In Nature this was provided for, first, by waterfalls, secondly, by barriers of rock, stretching like weirs across the channel of the river, thirdly, by rapids, formed of boulders that had been carried down the river, thus creating temporary weirs, and lastly, where only clay or sand existed, the course of the river was found to be tortuous, by which the length was increased, and the slope practically reduced; and, to a minor extent, the flow was also retarded by the sudden bends in the river, which tended to check the velocity and to increase the depth. The last plan had been almost invariably adopted in former times, and it was still to be seen in Egypt. One of the largest and best paying canals in Upper India—the Western Jumna Canal—was also constructed on this principle.

The experience gained on the Eastern Jumna Canal, where masonry falls were built after it was opened, led to the adoption of the ogee form of fall for the Ganges canal. While these works were in progress, the flooring of all the falls on the first division was lowered so as to form a cistern to receive the descending water; and the water being held up by a framework of timber, 5ft. in height, above the crown of the ogee, no injury had as yet been done to the brickwork where the water impinged. This was probably owing to the water which passed through the open spaces of the timber framework forming a cushion for the descending water. Perpendicular falls were also employed on the Barree Doab canal, and in Madras; but in the former the water was received into a cistern, while in the latter it impinged on a flooring of ashlar work The various plans adopted and proposed for overcoming excessive slopes having been succinctly noticed, it was stated that, under such circumstances, recourse must be had to barriers, or, as they were technically termed, weirs.

From a table showing, approximately, the sections and slopes best adapted for irrigation canals and water courses in Northern India, it appeared that probably the best slope for a canal discharging 5,000 cubic feet per second was about 13¾in. per mile.

A description was then given of a new system of "zig-zag" falls, which had been recommended by the author for the Rechna irrigation works; and a comparison was instituted between the cost of the falls and bridges on the Ganges canal as executed, and the estimated cost if the proposed "zig-zag" falls had been adopted, from which it was contended that there would have been a considerable saving of expense by the latter plan. As to the question whether the falls would be likely to stand the action of the water, it was proposed that the length of the slip should be so extended, that only 10 cubic feet a second should pass over each foot, which with a full supply would require a height of about 2ft.; whereas, on the Ganges canal, with two and a-half times the volume descending an equal height on brickwork, no injury had yet occurred.

In conclusion it was remarked that, six years ago, the author stood almost alone in maintaining the opinion, that the Ganges canal needed only some protective works, and did not require the radical alterations then proposed. He believed that the works might be placed out of all danger, by the judicious use of wood and iron, at a less cost than if stone were employed, without depriving the country of the benefits of irrigation beyond a very short time.

## ON IRRIGATION IN SPAIN, CHIEFLY IN REFERENCE TO THE CONSTRUCTION OF THE HENARES AND ESLA CANALS IN THAT COUNTRY.

By Mr. G. Higgin, M. Inst. C.E.

It was stated that, of all the countries in the world, there was perhaps none that so much required irrigation as Spain, nor one which so gratefully repaid the labour expended upon it, by rich and valuable results. The climate of the south and east of Spain was suitable for the production of crops of almost all kinds: productions of the torrid and temperate zones here grow together. In the gardens of Murcia and Valencia might be seen wheat, barley, corn, maize, the orange, the lemon. the date palm, the olive, the citron, the peach, the pear, the apple, rice, pepper. In Malaga and Seville, in addition to these were the sugar-cane, the cotton-plant, the prickly pear, and, in sheltered spots, the plaintain, which was seldom found out of the tropics. The soil of most of the river plains was a rich alluvial deposit, from 3 feet to 10 feet in depth. Nothing was wanting but water; and this might frequently be seen a few yards off running to the sea, useless, and unproductive. A few charts of comparative rainfall and temparature had been prepared, which showed that, with the exception of Oran, Spain was by far the driest country. Thus, while Piedmont had a fall of 37 inches, Lombardy 38 inches, Algiers 27 inches, and Bone 25 inches, Spain had only an average of 17 inches; and in two cases, that of Madrid and Alicante,the mean annual fall was only 12 inches and 13½ inches respectively. The mean rainfall of Oran was 14½ inches. A comparison of the mean rainfall and temperature during the seven irrigating months from March to September, and the mean maximum temperature during June, July, and August, of Lombardy, Piedmont, and Spain, showed that, while Piedmont had a mean temperature of 63°, and a mean maximum of 85°, with a rainfall of 29 inches, Seville, with a mean temperature of 78°, and a maximum of 111°, had only a rainfall of 5½ inches. Madrid, with a mean temperature of 65°, and a maximum of 91°, had a rainfall of only 5 inches. Alicante and Valladolid, though a little better than Seville and Madrid, were far inferior in rainfall, and superior in heat, to either Lombardy or Piedmont. The vital necessity of irrigation was thus very apparent.

The earliest, and indeed almost all the, irrigation works in Spain were constructed about the year A.D. 800 or A.D. 900, when that country was under the dominion of the Moors. Perhaps the system of irrigation and the whole administration of the waters in Valencia and Murcia were as perfect as well could be, and the results were very surprising. It was not possible, however, within the limits of the Paper, to give more than a cursory notice of these works; but such data were collected as would assist in the description of the new canals now in course of construction by the Iberian Irrigation Company. The areas of the several large irrigated districts in Spain were then detailed, amounting together to 680 square miles. According to the published Government returns, the total amount of irrigated ground in Spain was 4,439 square miles, so that it would seem that there was an area of 3,759 square miles irrigated from water wheels, small canals, tanks, &c., a quantity which was believed to be excessive. Admitting, however, that the returns were correct, even then only 4⅓ per cent. of the whole cultivated land was irrigated. While the rate of population in all Spain was only 81 to the square mile, in the irrigated garden of Murcia there were 1681 inhabitants to the square mile, and in Orihuela 767 inhabitants per square mile. The effect of irrigation was to raise the value of land ten, fifteen, or twenty times. Several illustrations of this were cited, and it was stated that, as a rule, all over Spain, good land in the valleys when unirrigated might be bought at an average price of from £5 to £10 per acre. while irrigated ground fetched from £80 to £120 per acre. In proportion to the value of the ground was the value of the water. Colonel Baird Smith gave the value of a cubic foot of water per second in Piedmont at £16 per annum, and in Lombardy at about £15 per annum. In most of the old systems of Spanish irrigation, the water was attached to the land, and was sold with it, and the value of the water could not, therefore, be ascertained. But perhaps the fair average value of a cubic foot of water per second in Spain might be taken to be that fixed by the Government for the Henares Canal, viz., £375 per annum, which was not considered a high price.

The projects for irrigating the Henares and the Esla valleys were of very old date; but it was only during 1859 that the concessions were granted, and in 1863 that a company was formed in London to carry out the works. The river Henares rose amongst the mountains of the Somosierra; its course was extremely steep, and very rapid, the total fall of the river, from the weir of the new canal to Alcalá, a distance of 36 miles, being 407ft., giving a mean fall of 11·3ft. per mile. The total length of the new canal was 28 miles. It received its waters from the river at a point 16 miles above Guadalajara, just below the junction of the Sorbe and Henares, and ended at Alcalá. The area of ground capable of irrigation in this valley, after deducting that due to roads, streams, towns, &c., was 27,170 acres. For this purpose the volume of water conceded by the Government was 175 cubic feet per second for the nine months from October to June inclusive, and 105 cubic feet per second for the remaining three months. From accurate measurements made near the new weir since the commencement of the works, it appeared that during the months of July, August, and September, the average quantity of water carried by the weir was 210 cubic feet per second, the lowest point which it had touched being 140 cubic feet per second. During the remainder of the year it carried an average of 300 or 400 cubic feet per second; but it was liable to enormous floods, and some came down during the progress of the works, which were estimated to amount to 8,000 cubic feet per second. The weir, it was calculated, would discharge 20,000 cubic feet per second.

The most difficult portion of the works was comprised in the first division—involving a rock cutting, 16ft. in depth, immediately after leaving the river; then a tunnel 3,171yds. in length through a high limestone cliff, followed by a deep cutting in gravel. At the ninth kilomètre the canal crossed the Madrid and Saragossa railway; and at the tenth kilomètre, a wide torrent bed. These were the ruling points in this section, and it was with reference to them that the actual height of the new weir was fixed. At the site chosen for the weir, the bed of the river was composed of compact clay rock, very impermeable, mixed with strata of excessively hard conglomerate. The front wall was built of rubble in hydraulic mortar, the foundation being benched into the rock. The main body of the weir was of hydraulic concrete; but in order to guard against filtration, a continuous line of cut stone was let into the rock in the centre of the concrete, all the stones being bedded in pure cement. The apron was entirely of cut stone, and from the top of the rubble wall to the crest, the weir was also of cut stone. The water for the canal was drawn off by five sluices, set in masonry arches, built of large blocks of rock-faced ashlar. At the entrance of the canal three sluices were fixed, for the purpose of scouring out any deposit which might accumulate in front of the gates. Immediately inside the head sluices, and forming a portion of the head works, there was an overflow weir, to provide for the discharge of any water which a sudden flood might admit into the canal during the absence of the guard. The weir was 130 yards long between the abutments, and its total cost, including all the head works and the waste weir, had been £17,343, or 50s. per cubic yard, as the mean price of the total cubical contents. Details were given of the prices paid for different classes of work, and the materials employed. One flood, which came down when the weir was unfinished, tried it severely. The water rose 4ft. over the crest of the finished portion, completely filling of the gap, and pouring with great force on the exposed concrete hearting of the unfinished end. This flood was estimated to have a volume of more than 9,000 cubic feet per second, yet not a single stone was displaced.

The construction of the tunnel offered no engineering difficulties. About one-half of it was in a stiff, tenacious clay, the remainder being in limestone rock. It was found necessary to line the whole with brick, as the rock, though hard when first cut, crumbled under exposure to air and water. The bricks used were made in the valley, and, after a little trouble they were obtained of a good quality, at a cost of £2 a thousand, delivered on the works. The whole of the brickwork was set in hydraulic mortar. As it was found, however, that the pure lime and sand set too quickly, the custom of the country was followed, and a per centage of white lime was mixed with the hydraulic, the proportions being 1 part of hydraulic, 1 part of white lime, and 4 parts of sand. This mortar was longer in setting than the pure mortar, and gave much better results. It could not be used where the work was liable to be immediately covered with water; but this was not the case in this tunnel.

The only works of importance on this canal were an aqueduct over the Arroyo Tejada, at the entrance of the tunnel; the bridge under the railway; and the bridge over the Arroyo Majanar. The difficulties presented by the bridge under the railway were those due simply to the work having to be carried on without disturbing the passage of the trains. This was done by shifting the line, and building one-half of the abutments at a time. The railway was carried on wrought-iron girders, sent from England. The canal was carried over the Torrent Majanar in a wrought-iron tube, 66.6 feet span. When put together, complete, this tube was immediately filled with water, to a depth of 5 feet, and had since been kept full. It was perfectly tight, both at the joints with the masonry, and in other parts. With a load of 93 tons of water, it sank ¼ inch in the centre. At the side of this tube were three sluices for discharging the canal, if necessary.

The average prices paid for the smaller works, the manner in which the excavations were performed, and the class of labourers employed and their pay, were then severally treated of.

The sections adopted for the first division of the canal had inside and outside slopes of 1½ to 1, and the banks were 6 feet wide on the top. The depth of water in the first few divisions was 5 feet, and the velocity was 2 feet 4 inches per second. This was rather high, but it was a matter of importance in Spain to avoid exposing the water in wide shallow channels, as with a less velocity weeds grew freely. Many of the old canals and watercourses of Spain had a mean velocity of 3 feet per second.

The Esla Canal, as regarded ease of construction, was perhaps one of the best in Spain. The whole estimated cost of the works, including a weir 191 yards long, was a little under £100,000; and for this amount 32,140 acres would be perfectly irrigated at a cost of £3 2s. per acre, while the cost per acre of the Henares Canal was £7 7s. The land in the Esla Valley was exceptionally rich; it was very thickly populated; and the only objection that could be made to it was its distance from any seaport.

One of the most interesting questions, in the construction of an irrigation canal, was the acreage which could be irrigated with a certain disposable quantity of water. Opinions varied very much upon this point. The amount supplied in different districts was given, and it was stated that, in Spain, the usual dotation for rice crops, was considered to be 2½ litres per second per hectare. It had been found, by M. Ribera, from a series of experiments made near Madrid, that the quantity of water consumed in the irrigation of a nursery garden was 0.36 litre per second per hectare, and for a market garden 0.47 litre per second, in both cases the water being supplied without stint. The Author had found, by experiment, based on the quantity of water actually employed by cultivators, also near Madrid, that ½ litre per second would irrigate one hectare every twelve days. This, it was thought, was quite sufficient for the cultivation of almost any crop except rice; and taking into account the fact that, in a large valley, such as the Henares, there must always be a great variety of crops, many of which would only require irrigation every twenty or thirty days, it was evident that ½ a litre per second was a good dotation for a canal. This, in English measure, amounted to 1 cubic foot per second for every 140 acres. The quantity allowed in India varied, it was believed, from 120 to 200 acres per cubic foot per second. The canon fixed by Government for the Henares canal was equivalent to 3s. 9d. per irrigation of 450 cubic metres, and for the Esla canal 2s. 9½d. for the same quantity; the lower price, in the latter case, being due to the less expensive character of the works. Some particulars of the price of water in Spain were then furnished.

Several modes of measuring the water to be supplied to the land-owners were then described, including the system adopted by the Moors, the Milanese module, the plan followed on the Marseilles canal, and a new method, by Lieutenant Carrol, of the Indian army, which had been tried on the Ganges canal. The principal objects to be sought in a module were simplicity of arrangment of the different parts, freedom from friction or any similar deranging cause, constant discharge under varying heads, and of course, an exact measure of quantity. It was of great importance that there should be no concealed machinery, and also that the measure should be capable of being easily inspected by the landholders. The module adopted on the Henares and the Esla canals could not lay claim to novelty; but it was believed it would fulfil its purpose practically. The water was measured by being discharged over a knife-edge iron weir, without any perceptible velocity, and when perfectly still. On the wall of the outer chamber was fixed a scale, whose zero point was at the level of the edge of the weir, and by means of this scale any person could satisfy himself that the proper dotation of water was flowing into the distribution channel. By arranging the sluice the guard could regulate to a nicety the height of water to be passed over the weir. Experiments were being made to ascertain the proper co-efficient for these weirs under varying heads.

As regarded the probable losses by filtration and evaporation, it was difficult to arrive at any reliable calculation, as different authorities gave such contradictory results. During the month of July, the water evaporated from the Henares Canal was equivalent to nearly ¾ per cent. of the whole volume. Another important point to the irrigation engineer was the principle followed in the distribution of the water. In the Henares Valley the ground was divided into plots of from 750 to 850 acres, each plot being served by one of the primary channels taken off direct from the main canal, one of the modules previously described being fixed at the point of departure.

## ROYAL INSTITUTION OF GREAT BRITAIN.

### ON FARADAY AS A DISCOVERER.

By JOHN TYNDALL, Esq., LL.D., F.R.S., Professor of Natural Philosophy Royal Institution.

(*Continued from page* 115.)

He thus established with numerical accuracy that the exact proportionality of the rotation acquired by the direct beam was 12°, that acquired by three passages through the glass was 36°, while that acquired by five passages was 60°. But even when this method of magnifying was applied, he failed with various solid substances to obtain any effect; and in the case of air, though he employed to the utmost the power which these repeated reflections placed in his hands, he failed to produce the slightest sensible rotation.

These failures of Faraday to obtain the effect with gases seem to indicate the true seat of the phenomenon. The luminiferous ether surrounds and is influenced by the ultimate particles of matter. The symmetry of the one involves that of the other. Thus, if the molecules of a crystal be perfectly symmetrical round any line through the crystal, we may safely conclude that a ray will pass along this line as through ordinary glass. It will not be doubly refracted. From the symmetry of the liquid figures, known to be produced in the planes of freezing, when radiant heat is sent through ice, we may safely infer symmetry of aggregation, and hence conclude that the line perpendicular to the planes of freezing is a line of no double refraction: that it is, in fact, the optic axis of the crystal. The same remark applies to the line joining the opposite blunt angles of a crystal of Iceland spar. The arrangement of the molecules round this line being symmetrical, the condition of the ether depending upon these molecules shares their symmetry; and there is, therefore, no reason why the wave-length should alter with the alteration of the azimuth round this line. Annealed glass has its molecules symmetrically arranged round every line that can be drawn through it; hence it is not doubly refractive. But let the substance be either squeezed or strained in one direction, the molecular symmetry, and with it the symmetry of the ether, is immediately destroyed and the glass becomes doubly refractive. Unequal heating produces the same effect. Thus mechanical strains reveal themselves by optical effects; and there is little doubt that in Faraday's experiment it is the magnetic strain that produces the rotation of the plane of polarisation.

Faraday's next great step in discovery was announced in a memoir on the "Magnetic Condition of all Matter," communicated to the Royal Society on the 18th December, 1845. One great source of his success was the employment of extraordinary power. As already stated, he never accepted a negative answer to an experiment until he had brought to bear upon it all the force at his command. He had over and over again tried steel magnets and ordinary electro-magnets on various substances, but without detecting anything different from the ordinary attraction exhibited by a few of them. Stronger coercion, however, developed a new action. Before the pole of an electro-magnet he suspended a fragment of his famous heavy glass; and observed that when the magnet was powerfully excited the glass fairly retreated from the pole. It was a clear case of magnetic repulsion. He then suspended a bar of the glass between two poles; the bar retreated when the poles were excited, and set its length equatorially or at right angles to the line adjoining them. When an ordinary magnetic body was similarly suspended, it always set axially, that is, from pole to pole.

Faraday called those bodies which were repelled by the poles of a magnet, diamagnetic bodies; using this term in a sense different from that in which he employed it in his memoir on the magnetisation of light. The term magnetic he reserved for bodies which exhibited the ordinary attraction. He afterwards employed the term magnetic to cover the whole phenomena of attraction and repulsion, and used the word paramagnetic to designate such magnetic action as is exhibited by iron.

He then entered a new though related field of inquiry. Having dealt with the metals and their compounds, and having classified all of them that came within the range of his observation under the two heads magnetic and diamagnetic, he began the investigation of the phenomena presented by crystals when subjected to magnetic power. The action of crystals had been in part theoretically predicted by Poisson, and actually discovered by Plücker, whose beautiful results, at the period which we have now reached, profoundly interested all scientific men. Faraday had been frequently puzzled by the deportment of bismuth, a highly crystalline metal. Sometimes elongated masses of the substance refused to set equatorially, sometimes they set persistently oblique, and sometimes even, like a magnetic body, from pole to pole. "The effect," he says, "occurs at a single pole; and it is then striking to observe a long piece of a substance so diamagnetic as bismuth repelled, and yet at the same moment set round with force, axially, or end on, as a piece of magnetic substance would do." The effect perplexed him; and in his efforts to release himself from this perplexity no feature of this new manifestation of force escaped his attention. His experiments are described in a memoir communicated to the Royal Society on the 7th of December, 1848.

After the description of the general character of this new force, Faraday states with the emphasis, here reproduced, its mode of action:—"The law of action appears to be that the line or axis of magne-crystalline force (being the resultant of the action of all the molecules) tends to place itself parallel, or as a tangent, to the magnetic curve, or line of magnetic force, passing through the place where the crystal is situated." The magne-crystallic force, moreover, appears to him "to be clearly distinguished from the magnetic or diamagnetic forces, in that it causes neither approach nor recession, consisting not in attraction or repulsion, but in giving a certain determinate position to the mass under its influence." And then he goes on "very carefully to examine and prove the conclusion that there was no connection of the force with attractive or repulsive influences." With the most refined ingenuity he shows that, under certain circumstances, the magne-crystallic force can cause the centre of gravity of a highly magnetic body to retreat from the poles, and the centre of gravity of a highly diamagnetic body to approach them. His experiments root his mind more and more firmly in the conclusion that it is "neither attraction nor repulsion causes the set, or governs the final position" of the crystal in the magnetic field. That the force which does so is therefore "distinct in its character and effects from the magnetic and diamagnetic forms of force. On the other hand," he continues, "it has a most manifest relation to the crystalline structure of bismuth and other bodies, and therefore to the power by which their molecules are able to build up the crystalline masses."

And here follows one of those expressions which characterize the conceptions of Faraday in regard to force generally:—"It appears to me impossible to conceive of the results in any other way than by a mutual reaction of the magnetic force, and the force of the particles of the crystal upon each other." He proves that the action of the force though thus molecular is an action at a distance; he shows that a bismuth crystal can cause a freely suspended magnetic needle to set parallel to its magne-crystallic axis. Few living men are aware of the difficulty of obtaining results like this, or of the delicacy necessary to their attainment. "But though it thus takes up the character of a force acting at a distance, still it is due to that power of the particles which makes them cohere in regular order and gives the mass its crystalline aggregation, which we call at other times the attraction of aggregation, and so often speak of as acting at insensible distances." Thus he broods over this new force, and looks at it from all possible points of inspection. Experiment, follows experiment, as thought follows thought. He will not relinquish the subject as long as a hope exists of throwing more light upon it. He knows full well the anomalous nature of the conclusion to which his experiments lead him. But experiment to him is final, and he will not shrink from the conclusion. "This force," he says, "appears to me to be very strange and striking in its character. It is not polar, for there is no attraction or repulsion." And then as if startled by his own utterance, he adds:—"What is the nature of the mechanical force which turns the crystal round, and makes it affect a magnet?" . . . "I do not remember," he continues, "heretofore such a case of force as the present one, where a body is brought into position only, without attraction or repulsion."

Plucker, the celebrated geometer already mentioned, who pursued experimental physics for many years of his life with singular devotion and success, visited Faraday in those days, and repeated before him his beautiful experiments on magneto-optic action. Faraday repeated and verified Plucker's observations, and concluded, what he at first seemed to doubt, that Plucker's results and magne-crystallic action have the same origin.

When an experimental result was obtained by Faraday it was instantly enlarged by his imagination. I am acquainted with no mind whose power and suddenness of expansion at the touch of new physical truth could be ranked with his. Sometimes I have compared the action of his experiments on his mind to that of highly combustible matter thrown into a furnace: every fresh entry of fact was accompanied by the immediate developement of light and heat. The light, which was intellectual, enabled him to see far beyond the boundaries of the fact itself, and the heat, which was emotional, urged him to the conquest of this newly revealed domain. But though the force of his imagination was enormous, he bridled it like a mighty rider, and never permitted his intellect to be overthrown.

In virtue of the expansive power which his vivid imagination conferred upon him, he rose from the smallest beginnings to the grandest ends. Having heard from Zantedeschi that Bancalari had established the magnetism of flame, he repeated the experiments and augmented the results. He passed from flames to gases, examining and revealing their magnetic and diamagnetic powers; and then he suddenly rose from his bubbles of oxygen and nitrogen to the atmospheric envelope of the earth itself, and its relations to the great question of terrestrial magnetism. The rapidity with which these ever-augmented thoughts assumed the form of experiments is unparalled. His power in this respect is often best illustrated by his minor investigations, and, perhaps, by none more strikingly than by his paper "On the Diamagnetic Condition of Flame and Gases," published as a letter to Mr. Richard Taylor, in "The Philosophical Magazine" for December, 1847. After verifying, varying, and expanding the results of Bancalari, he submitted to examination heated air-currents, produced by platinum spirals, placed in the magnetic field, and raised to incandescence by electricity. He then examined the magnetic deportment of gases generally. Almost all of these gases are invisible; but he must, nevertheless, track them in their unseen courses. He could not effect this by mingling smoke with his gases, for the action of his magnet upon the smoke would have troubled his conclusions. He, therefore, "caught his gases in tubes, carried them out of the magnetic field, and made them reveal themselves at a distance from the magnet.

Immersing one gas in another, he determined their differential action; results of the utmost beauty being thus arrived at. Perhaps the most important are those obtained with atmospheric air, and its two constituents. Oxygen, in various media, was strongly attracted by the magnet; in coal-gas, for example, it was powerfully magnetic, whereas nitrogen was diamagnetic. Some of the effects obtained with oxygen in coal-gas were strikingly beautiful. When the fumes of chloride of ammonia (a diamagnetic substance) were mingled with the oxygen, the cloud of chloride behaved in a most singular manner:—"The attraction of iron filings," says Faraday, "to a magnetic pole is not more striking than the appearance presented by the oxygen under these circumstances." On observing this deportment the question immediately occurs to him—Can we not separate the oxygen of the atmosphere from its nitrogen by magnetic analysis? It is the perpetual occurence of such questions that marks the experimenter. The attempt to analyze atmospheric air by magnetic force proved a failure, like the previous attempt to influence crystalisation by the magnet. The enormous comparative power of the force of crystalisation was then assigned as a reason for the incompetence of the magnet to determine molecular arrangement; in the present instance the magnetic analysis is opposed by the force of diffusion, which is also very strong comparatively. The same remark applies to, and is illustrated by, another experiment subsequently executed by Faraday. Water is diamagnetic, sulphate of iron strongly magnetic. He enclosed "a dilute solution of sulphate of iron in a tube, and placed the lower end of the tube between the poles of a powerful horse-shoe magnet for days together," but he could produce "no concentration of the solution in the part near the magnet." Here also the diffusibility of the salt was too powerful for the force brought against it.

The experiment last referred to is recorded in a paper presented to the Royal Society on the 2nd of August, 1850, in which he pursues the investigation of the magnetism of gases. Newton's observations on soap-bubbles were often referred to by Faraday. His delight in a soap-bubble was like that of a boy, and he often introduced them in his lectures, causing them, when filled with air, to float on invisible seas of carbonic acid, and otherwise employing them as means of illustration. He now finds them exceedingly useful in his experiments on the magnetic condition of gases. A bubble of air in a magnetic field occupied by air was unaffected, save through the feeble repulsion of its envelope. A bubble of nitrogen, on the contrary, was repelled from the magnetic axis with a force far surpassing that of a bubble of air. The deportment of oxygen in air "was very impressive, the bubble being pulled inward, or towards the axial line, sharply and suddenly, as if the oxygen were highly magnetic."

He next labours to establish the true magnetic zero, a problem not so easy as might at first sight be imagined. For the action of the magnet upon any gas while surrounded by air, or any other gas, can only be differential; and if the experiment were made in vacuo, the action of the envelope, in this case necessarily of a certain thickness, would trouble the result. While dealing with this subject Faraday makes some note-worthy observations regarding space. In reference to the Torricellian vacuum, he says, "Perhaps it is hardly necessary for me to state that I find both iron and bismuth in such vacua, perfectly obedient to the magnet. From such experiments, and also from general observations and knowledge, it seems manifest that the lines of magnetic force can traverse pure space, just as gravitating force does, and as statical electrical forces do, and therefore space has a magnetic relation to its own, and one that we shall probably find hereafter to be of the utmost importance in natural phenomena. But this character of space is not of the same kind as that which, in relation to matter, we endeavour to express by the terms magnetic and diamagnetic. To confuse these together would be to confound space with matter, and to trouble all the conceptions by which we endeavour to understand and work out a progressively clearer view of the mode of action, and the laws of natural forces. It would be as if in gravitation of electric forces, one were to confound the particles acting on each other with the space across which they are acting, and would, I think shut the door to advancement. Mere space cannot act as matter acts, even though the utmost latitude be allowed to the hypothesis, it would be a large additional assumption to suppose that the lines of magnetic force are vibrations carried on by it, whilst as yet we have no proof that time is required for their propagation, or in what respect they may, in general character, assimilate to or differ from the respective lines of gravitating luminiferous or electric forces."

Pure space he assumes to be the true magnetic zero, but he pushes his inquiries to ascertain whether among material substances there may not be some which resemble space. If you follow his experiments you will soon emerge into the light of his results. A torsion beam was suspended by a skein of cocoon silk; at one end of the beam was fixed a cross-piece 1½ inches long. Tubes of exceedingly thin glass, filled with various gases, and hermetically sealed, were suspended in pairs from the two ends of the cross piece. The position of the rotating torsion head was such that the two tubes were at opposite sides of, and equidistant from, the magnetic axis, that is to say from the line joining the two closely approximated polar points of an electro magnet. His object was to compare the magnetic action of the gases in the two tubes. When one tube was filled with oxygen, and the other with nitrogen, on the supervention of the magnetic force, the oxygen was pulled towards the axis, the nitrogen being pushed out. By turning the torsion head they could be restored to their primitive position of equidistance, where is evident the action of the glass envelopes was annulled. The amount of torsion necessary to re-establish equidistance, expressed the magnetic difference of the substances compared.

And then he compared oxygen with oxygen at different pressures. One of his tubes contained the gas at the pressure of 30 inches of mercury, another at a pressure of 15 inches of mercury, a third at a pressure of 10 inches, while a fourth was exhausted as far as a good air-pump renders exhaustion possible. "When the first of these was compared with the other three, the effect was most striking." It was drawn towards the axis when the magnet was excited, the tube containing the rarer gas being apparently driven away, and the greater the difference between the densities of the two gases, the greater was the energy of this action.

And now observe his mode of reaching a material magnetic zero. When a bubble of nitrogen was exposed in air in the magnetic field, on the supervention of the power, the bubble retreated from the magnet. A less acute observer would have set nitrogen down as diamagnetic; but Faraday knew that retreat in a medium composed in part of oxygen might be due to the attraction of the latter gas, instead of to the repulsion of the gas immersed in it. But if nitrogen be really diamagnetic, then a bubble or bulb filled with the dense gas will overcome one filled with the rarer gas. From the cross-piece of his torsion-balance he suspended his bulbs of nitrogen, at equal distances from the magnetic axis, and found that the rarefaction, or the condensation of the gas in either of the bulbs had not the slightest influence. When the magnetic force was developed, the bulbs remained in their first position, even when one was filled with nitrogen, and the other as far as possible exhausted. Nitrogen, in fact, acted "like space itself"; it was neither magnetic or diamagnetic.

He cannot conveniently compare the paramagnetic force of oxygen with iron, in consequence of the exceeding magnetic intensity of the latter substance; but he does compare it with the sulphate of iron, and finds that, bulk for bulk, oxygen is equally magnetic with a solution of this substance in water "containing seventeen times the weight of the oxygen in crystallised photo-sulphate of iron, or 3·4 times its weight of metallic iron in that state of combination." By its capability to deflect a fine glass fibre, he finds that the attraction of his bulb of oxygen, containing only 0·117 of the grain of the gas, at an average distance of more than an inch from the magnetic axis, is about equal to the gravitating force of the same amount of oxygen as expressed by its weight.

These facts could not rest for an instant in the mind of Faraday without receiving that expansion, to which I have already referred. "It is hardly necessary," he writes, "for me to say here that this oxygen cannot exist in the atmosphere exerting such a remarkable and high amount of magnetic force, without having a most important influence on the disposition of the magnetism of the earth, as a planet; especially, if it be remembered that this magnetic condition is greatly altered by variations of its density and by variations of its temperature. I think I see here the real cause of many of the variations of that force, which have been, and are now so carefully watched on different parts of the surface of the globe. The daily variation, and the annual variation, both seem likely to come under it; also very many of the irregular continual variations, which the photographic process of record renders so beautifully manifest. If such expectations be confirmed, and the influence of the atmosphere be found able to produce results like these, then we shall probably find a new relation between the aurora borealis and the magnetism of the earth, namely a relation established, more or less, through the air itself in connection with the space above it and even magnetic relations and variations, which are not as yet suspected, may be suggested and rendered manifest and measurable, in the further development of what I will venture to call atmospheric magnetism. I may be over-sanguine in these expectations, but as yet I am sustained in them by the apparent reality, simplicity, and sufficiency of the cause assumed, as it at present appears to my mind. As soon as I have submitted these views to a close consideration, and the test of accordance with observation, and, where applicable, with experiments also, I will do myself the honour to bring them before the Royal Society."

Two elaborate memoirs are then devoted to the subject of Atmospheric Magnetism; the first sent to the Royal Society on the 9th of October, and the second on the 19th of November, 1850. In these memoirs he discuses the effects of heat and cold upon the magnetism of the air, and the action on the magnetic needle, which must result from thermal changes. By the convergence and divergence of the lines of terrestrial magnetic force, he shows how the distribution of magnetism, in the earth's atmosphere, is affected. He applies his results to the explanation of the annual and diurnal variation; he also considers irregular variations, including the action of magnetic storms. He discusses, at length, the observations at St. Petersburg, Greenwich, Hobartown, St. Helena, Toronto, and the Cape of Good Hope; believing that the facts, revealed by his experiments, furnish the key to the variations observed at all these places.

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## ON SOME NEW EXPERIMENTS ON LIGHT.

By J. H. Gladstone, Ph. D. F.R.S.

The speaker commenced by referring to the fact we are constantly making new experiments or observations on light: in fact, all seeing is but a comparison of different degrees of light and shade, and the contrast of colours. Most of the rays, that meet our eyes from surrounding objects, are reflected rays; but some of the commonest things, such as the water-bottles and tumblers of cut-glass on our dining tables, exhibit beautifully the bending, the magnifying, the diminishing, and the production of coloured fringes, due to refraction. The purpose of this discourse was to rise from the simplest phenomena of this kind to a consideration of Refraction-equivalents, and to describe the state of our present knowledge in regard to them.

By means of the electric lamp it was shown that a piece of glass, or other transparent body, will throw a perfectly black shadow if the two surfaces through which the ray passes be not parallel; that the light is then bent on one side, and at the same time spread out into its component colours; that this bending (refraction) varies with the amount of inclination of the two surfaces to one another, but in such a way that the sine of the angle of refraction bears a constant ratio to the sine of the angle of incidence; that this constant number, termed the index of refraction, or $\mu$, belongs only to the one substance, each solid, liquid, or gas having its own index; that there is no necessary connection between the amount of refraction and the length of the spectrum (dispersion) caused by different substances, whether gaseous, liquid, or solid—for instance, a solution of an iodide always disperses more than a solution of the chloride of the same metal, even though it be diluted to the same amount of refraction.

This index of refraction is affected by change of temperature. In liquids, and probably in all gases, the bending decreases as the thermometer rises; in solids, on the contrary, as lately shown by Fizeau, the change is in the opposite direction, crown glass remaining the same, and fluor spar being the only case where he observed a diminution. This was experimentally demonstrated in regard to liquids. Thus a yellow sodium ray, which had passed through a hollow prism filled with oil of nutmeg, and thence through another filled with bisulphide of carbon, moved some inches along the screen, when the nutmeg oil was warmed a few degrees by stirring it with heated iron wire. This index of refraction is still more materially affected when a body passes from the solid to the liquid, or from the liquid to the gaseous condition; a fact that was illustrated by the visibility of the water melted in crystalline spaces in the middle of a block of ice.

The index of refraction of a mixture is moreover not always the mean of the indices of its constituents. Thus a ray passed successively through two hollow prisms filled with equal quantities of alcohol and water respectively, fell on the screen in a certain position; but when the two liquids were mixed together, and divided between the two prisms, the ray was visibly refracted to a greater distance.

These changes depend on the alterations of volume which the substances undergo; and the speaker, in conjunction with the Rev. T. Pelham Dale, had observed in liquids that the index of refraction, minus unity, divided by the density (in symbolic language $\frac{\mu-1}{d}$) is constant for all temperatures, and for all mixtures, or rather that the coincidence is very close but not quite perfect on account of some other law not yet understood. This conclusion has been abundantly verified by Landolt of Bonn, Ketteler, and Wullner, and the former experimenter has founded upon it a method of analyzing mixtures of liquids.

This unchangeable number was termed the "specific refractive energy" of the substance, and it seemed to hold good notwithstanding a change from the solid to the liquid or the gaseous condition. It was early observed that the specific refractive energy of a compound bore a close resemblance to the mean of the specific refractive energies of its components. Landolt, by multiplying this number by the chemical equivalent, facilitated the calculation greatly. He termed this new number the "refraction-equivalent," $P\frac{\mu-1}{d}$, and proofs have rapidly accumulated that the number is little affected, not only by temperature, change of aggregate condition, mixture, or solution, but even by strong chemical combination.

Thus diamond, which is crystallized carbon, has the refraction-equivalent 5·0; sulphur has 16·0. Bisulphide of carbon, $C.S_2$, which is nearly the most refractive liquid known, should therefore be represented by 5 + 2 × 16, that is 37·0. The experimental number is 37·3. But the diamond will burn in oxygen, and is thus converted into carbonic anhydride, while it is possible to reduce this gas into another containing only half the amount of oxygen, namely, carbonic oxide. The refraction-equivalents of these gases, as deduced from Dulong's observations, are respectively 10.03 and 7.53; but the difference between $C\,O_2$ and $C\,O$ is one equivalent of oxygen, and the difference between the above numbers is 2·5. This then may be taken as the refraction-equivalent of oxygen, and substracting it from $C\,O = 7{\cdot}53$ we have remaining $C = 5{\cdot}03$, practically the same number as that obtained directly from crystallized carbon. Similarly, but generally by more indirect methods, it has been determined that this element, whether pure as diamond or combined with other elements to form gases as the above-mentioned, coal-gas, or cyanogen, or liquids as chloride of carbon, benzole, oil of turpentine, alcohol, or ether. or solids as paraffin, sugar, or camphor, is still exerting the same influence on the rays of light that set its particles in motion, an influence that we can express by the number 5·0. Again to revert to sulphur, the two salts sulpho-cyanide and cyanide of potassium —K S Cy and K Cy—differ by one equivalent of this element, and their refraction-equivalents as determined from their aqueous solutions are respectively 33·4 and 17·1, numbers differing by 16·3, a number almost identical with that reckoned from molten sulpur. In this way the refraction-equivalents of a large number of the elements have been determined; and the following table comprises what seem the most probable numbers among those that have been hitherto published by Landolt, Haagen, and Schrauf, as well as the speaker:—

| | Atomic weight. | Refraction-equivalent. |
|---|---|---|
| Hydrogen | 1·0 | 1·3 |
| Chlorine | 35·5 | 9·8 |
| Bromine | 80·0 | 15·7 |
| Iodine | 127·0 | 24·4 |
| Oxygen | 16·0 | 3·0 |
| Sulphur | 32·0 | 16·0 |
| Carbon | 12·0 | 5·0 |
| Silicium | 28·0 | 6·2 |
| Nitrogen | 14·0 | 4·1 |
| Phosphorus | 31·0 | 18·5 |
| Arsenic | 75·0 | 16·0 |
| Antimony | 122·0 | 25·7 |
| Vanadium | 51.4 | 25·4 |
| Sodium | 23·0 | 4·9 |
| Tin | 118·0 | 19·2 |
| Copper | 63·4 | 11·2 |
| Mercury | 200·0 | 21·6 |

The above numbers are reckoned for the red ray. Most of them can as yet claim to be considered only as approximative; and it seems certain that some elements, as oxygen and sulphur, have more than one refraction-equivalent.

Vanadium, though included in the above table, has only just been determined, and that from the oxy-trichloride which Professor Roscoe exhibited a few weeks before. It is interesting, as it supports his theory of the close analogy of phosphorus and vanadium, for these two bodies, with sulphur, exceed all others in refraction and especially in dispersion.

The speaker stated that he was now engaged in examining the effect of salts in solution on the rays of light, and that he hoped to determine in this way the refraction-equivalent not only of a multitude of salts, but of the metallic elements themselves.

But the question may be asked, "If a substance has a refraction compounded of the refraction of its constituents, how can bodies such as Iceland spar have two refractive indices?" Now these crystalline bodies, or if uncrystallized they have become doubly refracting by being unequally heated or compressed. In either case we may suppose a different amount of tension in different directions; and the fact of the two rays being oppositely polarized, points to some such difference of molecular arrangement. It is easy to understand that the change of tension or internal structure may act in the same way as a change of density in modifying the velocity of transmitted light, and therefore the amount of its refraction. But if we take the crystal to pieces by dissolving it, there can then no longer be unequal tension or unsymmetrical arrangement of particles, and it must have one refraction-equivalent. And this is always the case. The numbers deduced from Brewster's observation of the two rays of crystallized nitre are 16·3 and 25·0, while the equivalent of nitre dissolved in water is the intermediate number 21·8.

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## MANCHESTER ASSOCIATION FOR THE PREVENTION OF STEAM BOILER EXPLOSIONS.

The last ordinary monthly meeting of the Executive Committee of this Association was held at the offices, 41, Corporation-street, Manchester, on Tuesday, April 28th, 1868, Hugh Mason, Esq., of Ashton-under-Lyne, in the chair, when Mr. L. E. Fletcher, chief engineer, presented his report, of which the following is an abstract:—

Full advantage was taken of the opportunity afforded by the Easter holidays of making entire examinations of our members' boilers. The office staff turned out to assist the inspectors, in consequence of which the high proportion of entire examinations given in the preceding table was attained. The result of these visits has been that many important defects have been discovered, but they were so similar to those so frequently described already, that little need be said upon them on this occasion.

In several externally-fired boilers the plates and seams of rivets over the fires were found, as hitherto, to be fractured.

In three externally-fired mill boilers which were unhoused and set below ground, the plates on the top were found, on being uncovered, to be dangerously corroded, in one of them so much so that three or four plates would have to be removed, while in another such extensive repairs were necessary that, having regard to the age of the boiler, it was thought better to condemn it altogether. This shews the disadvantage of placing boilers in inaccessible positions, while it is recommended that the covering of those that are unhoused should be lifted at least once in two years for examination.

In another case the furnace crowns of a Lancashire boiler were both bulged downwards immediately over the fire, through over-heating, consequent on shortness of water when in charge of the watchman during the night. Though the steam was at a pressure of 35lbs., the furnace tubes did not rend, and being strengthened by hoops of T iron at the ring seams of rivets, the collapse was confined entirely to the second plate on the crown of each furnace. The boiler had been cleaned out on the previous day, and it is stated that the water was filled up nearly to the top of the guage glass over night. It is difficult to ascertain positively at what point the water was lost, but it is highly probable that it escaped through the feed valve, and thus that the injury to the crowns would have been prevented had the feed been delivered above the level of the furnace crowns, as so frequently recommended, while, had there been a low water safety valve, the roar of the escaping steam would have given warning of the danger in time to have prevented the injury, and saved the expense of repairs.

During the past month 227 visits have been made, and 478 boilers examined, 278 externally, 6 internally, 6 in the flues, and 188 entirely, while in addition 3 have been tested by hydraulic pressure. In these boilers 95 defects have been discovered, 10 of them being dangerous.

Tabular Statement of Defects, Omissions, &c., met with in the Boilers examined from March 28th, to April 24th, 1868, inclusive

| DESCRIPTION. | Number of Cases met with. | | |
|---|---|---|---|
| | Dangerous. | Ordinary. | Total. |
| Defects in Boiler. | | | |
| Furnaces out of Shape | 1 | 1 | 2 |
| Fracture | 2 | 19 | 21 |
| Blistered Plates | 1 | 11 | 12 |
| Corrosion—Internal | 2 | 10 | 12 |
| Ditto External | 2 | 12 | 14 |
| Grooving—Internal | 1 | 8 | 9 |
| Ditto External | ... | 5 | 5 |
| Total Number of Defects in Boilers ... | 9 | 66 | 75 |
| Defective Fittings. | | | |
| Feed Apparatus out of order | ... | 1 | 1 |
| Water Gauges ditto | ... | 1 | 1 |
| Blow-out Apparatus ditto | ... | 3 | 3 |
| Fusible Plugs ditto | ... | ... | ... |
| Safety Valves ditto | ... | 1 | 1 |
| Pressure Gauges ditto | ... | 6 | 6 |
| Total Number of Defective Fittings ... | ... | 12 | 12 |
| Omissions. | | | |
| Boilers without Glass Water Gauges | ... | ... | ... |
| Ditto Safety Valves | ... | ... | ... |
| Ditto Pressure Gauges | ... | ... | ... |
| Ditto Blow-out Apparatus | ... | ... | ... |
| Ditto Feed back pressure valves | ... | 6 | 6 |
| Total Number of Omissions | | 6 | 6 |
| Cases of Over Pressure | ... | ... | ... |
| Cases of Deficiency of Water | 1 | 1 | 2 |
| Gross Total | 10 | 85 | 95 |

### Explosions.

Two explosions have occurred during the past month, by which two persons have been killed and two others injured. Neither of the boilers in question was under the inspection of this Association. The following is the tabular statement:—

Tabular Statement of Explosions, from March 28th, 1868, to April 24th, 1868, inclusive.

| Progressive Number for 1867. | Date. | General Description of Boiler. | Persons Killed. | Persons Injured. | Total. |
|---|---|---|---|---|---|
| 9 | April 4 | Plain Cylindrical, egg-ended. Externally-fired ...... | 1 | 2 | 3 |
| 10 | April 7 | Two-flue Lancashire. Internally-fired ...... | 1 | 0 | 1 |
| | | Total.................. | 2 | 2 | 4 |

No. 9 Explosion, which occurred at a colliery at four o'clock on the morning of Saturday, April 4th, and resulted in the death of one man and injury to two others, is simply an illustration of the danger of externally-fired boilers.

The boiler was one of a series of four working side by side, and connected together, all of them being of the cylindrical egg-ended externally-fired class so commonly used in collieries, while the exploded one measured 28ft. in length by 6ft. in diameter, and three-eighths of an inch in the thickness of the plates, the load on the safety-valve being 30lbs. on the square inch.

It appears that the boiler was about twenty-nine years old, and had been frequently repaired at the plates over the fire, while one of these repairs had but just been completed, and the boiler only set to work a few hours before it exploded. The repair was considered by the engineer to the collieries to have made the boiler perfectly safe, and he could not at all account for the explosion; notwithstanding which, however, just as some colliers had been lowered down the shaft and the stoker was in the act of putting some coals on to the fire, a few hours after it was set to work, the boiler burst, blowing the poor man out of the firing space and killing him on the spot, in addition to knocking down the chimney and dislodging one of the adjoining boilers, while its own shell was rent into three fragments, one of which was thrown to a distance of sixty yards, another forty-two, and the safety-valve thirty yards, a portion of a brick being shot through the roof of the cottage—though at a distance of sixty yards—in which the stoker who was killed by the explosion had lived.

The boiler failed in the first instance just at the part immediately over the fire, the old work tearing away from the new. This is frequently found to be the case, so that these boilers are often weakened by the very means adopted to strengthen them, and their explosion hastened rather than arrested by repairs. Explosions of this nature will recur as long as the use of these treacherous plain cylindrical externally-fired boilers is persisted in.

The coroner's jury returned as their verdict that "the fireman was killed by the bursting of a boiler, but that there was no positive evidence to show the cause of that explosion, though they were satisfied that it was not due to shortness of water.

No. 10 Explosion occurred at half-past four on the afternoon of Tuesday, April 7th, and resulted in the death of the fireman.

As this explosion occurred at a considerable distance from Manchester, and the report of it was received just when the whole of the Association's staff was pre-engaged for special visits to our members, to take advantage of the Easter holidays for internal and flue examinations, the scene of the catastrophe was not visited by any of the Association's officers, but it is gathered from reports received, that the boiler was of the "internally fired double flued class," and 6ft. in diameter, while it failed at the upper half of the front end plate, which was completely blown out and cleanly cut. The end plates of this class of boiler never fail in this way when suitably constructed. Nothing is easier than to make them perfectly secure.

### American Anti-Incrustator.

A patent apparatus for the prevention of incrustation in steam boilers has lately been introduced from the United States of America, where it is stated to have been productive of the most satisfactory results. The apparatus is very simple. It consists of a brass plate, about 6in. in diameter, with a number of copper points attached to its circumference and radiating from the centre, which give it the appearance somewhat of a star fish. This is fixed in the steam way, so that a rush of steam may take place over it, while a stout wire is connected to it, and attached to the plates of the boiler at several feet distant from the star, which the patentees call the battery. The patentees do not offer any theory whatever on the action of the apparatus, but bring it forward as a practical success, substantiated by numerous certificates.

So many of our members suffer inconvenience from the formation of incrustation in their boilers, that they are willing to apply the new American anti-incrustator if its action can be relied on, and consequently I have received numerous inquiries as to its efficiency. In order, therefore, to test it, the apparatus was applied by a representative of the patentees to a couple of boilers under the inspection of this Association, and its action narrowly watched.

The two boilers selected were set side by side, and of the ordinary mill class, being of the Lancashire type, internally-fired, and having two furnace tubes, while their length was 30ft., their diameter 7ft. in the shell, and 2ft. 8in. in the furnace tubes, the working pressure being 60lbs. per square inch. The incrustation in these boilers was of an adhesive character, and when the apparatus was first introduced, measured one-sixteenth of an inch on the top of the furnace tubes, and from a quarter to half-an-inch on their sides, while it was as much as three-quarters of an inch thick in places on the external shell. An apparatus was first fixed in one of the boilers on May 27th, 1867, and in the other on June 3rd, after which the boilers were closed down till No. 1 was re-opened on July 29th, and No. 2 on August 23rd. On the boilers being entered and examined, the apparatus was not found to have had any practical effect, and the patentee's representative attributed the disappointment to the oxidation of the points of the battery by the excessive impurity of the water, caused by an admixture of sewage, and therefore to meet the difficulty recommended gold points instead of copper, which were adopted, and the boilers sealed up again. On re-opening No. 1 boiler on October 7th, and No. 2 on October 19th, it was found that the result was not more satisfactory than before, and that the incrustation was not diminished, so that it was thought useless to continue the experiment longer. The patentee's representative, however, was desirous of a further trial, and proposed platinum points instead of the gold ones that had previously been substituted for copper. Another trial, therefore, was made with platinum points, but on re-opening one of the boilers, and making an examination on the 22nd of February, 1868, it was still found coated with incrustation and the result unsatisfactory, so that further trials were abandoned.

It may be added that the blow-out apparatus at the bottom of the boiler was used daily during the trial, and that before the anti-incrustator was applied, the boiler was found to shell a good deal of the scale off from time to time simply through the movement that takes place more or less in all boilers, from the expansion and contraction of the plates consequent on variations in temperature.

The results of these triaals of the anti-incrustator, therefore, were anything but successful. It is true, however, that a single series of trials may not be conclusive, but the apparatus has been adopted by several of our members, and I regret to have to report that as a rule it has proved a failure, while in the one or two cases which have appeared at all exceptional, the apparatus had not been at work long enough for a correct opinion to be formed. Under these circumstances, in reply to the numerous inquiries received from our members, I feel bound to report these facts to them, but shall be very glad if the patentees are able to overcome the present difficulties, and on further experience to establish the apparatus as a success. Should such prove to be the case, I will lose no time in reporting so happy a result, and should only be too glad of an early opportunity of doing so.

## LAUNCH OF THE ARMOUR-CLAD TURRET-SHIP "MONARCH."

The first armour-plated ship constructed on the turret principle at a Government establishment was floated out of dock, at Chatham dockyard, on the 25th ult., and named the *Monarch*. Although the *Monarch* is designated a turret-ship, yet, beyond carrying some portion of her armament in two turrets, rising an enormous height above the water, there is little to distinguish her from an ordinary ironclad ship of the broadside type, the main features of the true turret principle being altogether wanting—rendering, in fact, this last creation of the Admiralty a sort of nondescript vessel, of a cross between a broadside and a turret, without the peculiar merits of either. As a mere powerful mass of iron and wood, the *Monarch*, in her form of construction, surpasses, almost, any vessel yet built for the Admiralty; but whether her performance, either at sea or in action will justify the quarter of million sterling she will cost, has yet to be proved. In the construction of the *Monarch* the bracket frame system, first introduced by the Chief Constructor in the *Bellerophon*, and since adopted in all the large ironclads built in this country has been adopted. The ordinary features of this system of construction may be described as a double cellular bottom, water-tight bulkheads and platforms, and iron decks, which combines lightness and strength to such an extent as to greatly diminish the proportion formerly considered necessary between the weight of the hull proper and that of the defensive material carried. With the exception that the broadsides of the *Monarch* are destitute of ports, the arrangement of the armour-plating on the hull is very similar to that adopted in a broadside ironclad ship with a central gun-deck battery. The enormous height of the upper deck of the *Monarch* above the water for a vessel built on the turret principle, and the crowding of the forward upper deck with a high forecastle, entirely destroy all advantages usually claimed for a turret-ship. The upper deck of the *Monarch* rises 14 feet above the water-line, while the turret guns will be carried at a height of no less than 17 feet above the water. To protect the dead surface of the vessel's broadside, which will present so tempting a mark to the guns of an enemy, the sides of the *Monarch* amidships are protected by armour-plates 7in. in thickness, laid on a backing of teak of 12in., with an inner skin plating, in two thickness, of 1½in., the whole being further stiffened and supported by 12-inch longitudinal girders outside the skin plating, and 10-inch vertical frames inside, both sets of stiffeners being placed at intervals of two feet A belt of armour-plating of 6in. in thickness extends about 5ft. below the water-line; the fore and aft. bulkheads being also protected by plates somewhat thinner.

The turret beds of the *Monarch* are built on the main deck, the protected portion of the turrets, beginning just at the level of the upper deck. Each turret is 26 feet in diameter, and both will mount two 25-ton guns. These turret-guns are protected by means of 10-inch armour-plates, on a wooden backing of eight inches, with a skin plating in two thicknesses, each ⅝in., stiffened by 7-inch horizontal frames, with an iron lining of ⅝-inch plating on the inside. In addition to the armour-plating of the sides there are inside screens of iron plating to further protect the machinery of the turrets. At the portions of the turrets away from the guns the armour is 8in. thick, laid on 10in. of teak. The guns in the forward turret cannot be fired at a less angle than 10 deg. with the keel, while they have a limiting angle of the same amount in their training aft. In the after turret the guns can be fired at an angle of 10 deg. with the keel towards the bow, and 6 deg. towards the stern. The only direct fore and aft. fire the *Monarch* carries are two 6½ ton guns forward, which can be fired at an angle of 3° with the keel, and one 6½ ton gun right aft.

The following are some of the principal dimensions:—Length between perpendiculars, 330ft.; extreme breadth, 57ft. 6in.; depth in hold, 18ft. 8in.; load draught (forward), 22ft. 6in.; ditto (aft.), 26ft. 3in.; burden, 5,098 70-94ths tons: launching displacement, 4,450 tons. The engines, which are being built by Messrs. Humphrys, Tennant, & Co., are of 1,100 horse power (nominal), and intended to work to 6,600 horse power. The speed is estimated at 14 knots per hour.

## MONT CENIS RAILWAY.

Though this line will not be open to the public until the 8th of this month it was virtually opened on the 23rd ult., when a party of over fifty persons consisting for the most part of those officially connected with the railway, and their friends, made the journey in about 5½ hours. Everything worked exceedingly well, and the train was perfectly under control, as was shown when going 12 miles an hour down gradients of 1 in 12 the breaks being applied, the vertical wheels ceased to turn, the horizontal wheels clipped the central rail with great power, and within 30 yards the train was brought to a complete standstill without the slightest shock or concussion. When one stands upon the line and contemplates, at the Modane station, the steepness of the slope down which one has just slid easily without strain or inconvenience, he to some extent realises the prodigious force applied to restrain the momentum of the string of carriages launched upon that declivity. The control is perfect, and measurable to a nicety. In fact, on the descent of the mountain, there is nothing to warn a traveller who should not look out of window that he is on a railway of a very unusual construction. The motion is steady and easy, there is no jarring of any kind, and one soon ceases to notice the sloping position of the train.

Not less surprising than the steepness of the ascents and descents is the abruptness of many of the curves, some of them of 40 mètres radius. Some of the worst bits of the road are in the first six kilomètres after leaving Susa. Some of the curves are so sharp that one can hardly understand how the carriages, which are about 14ft. long, outside measurement, contrive to grind round them. But round they do go, with perfect ease, and, as they turn, the wheels and rails together gave out a shrill metalic sound which one at first may mistake for a whisper of a railway whistle. The places where the line runs very close to the edge of deep precipices are few in number. From the power which the engine-driver and breaksman have at their command by means of the horizontal wheels it is evident that, with common care, there exists no danger, no possibility of the train getting off the rails. This conviction is very soon arrived at by any person travelling on the line, and who takes the trouble to examine the principle and construction of the railway and carriages. Another danger, more than once suggested as scarcely to be avoided, disappears upon actual observation, viz., the risk of the crumbling of the edge of the mountain road. For the greater part of the distance, but not throughout, the railway gives the wall to the horse and pedestrian traffic, and takes the outside edge. This does not mean, however, that it is constantly on the brink of precipices; and, where it is so, every precaution has been taken. The masonry that already existed as a support to the coach road has been examined, strengthened, and extended. Large masses of fresh wall, often many feet thick, have been constructed in various places. It is so obviously the interest as well as the duty of the company to make assurance doubly sure in this respect that it is absurd to suppose every precaution has not been resorted to. Danger from avalanches has been guarded against by covered ways, some in masonry—where stones and pieces of rock are apt to fall—and others of iron roofing. The adoption of this plan has enabled the contractors of the line to make use of a considerable part of the old road over the mountain, a gradual ascent which was abandoned for a zigzag line on account of the danger to passengers from avalanches and falling stones. Exclusive of several short tunnels, the road is covered in for a distance of altogether nearly six miles, in several places on each side of the summit of the mountain. The chimneys of the experimental engines were considerably lower than are those of the French engines employed for the traffic, and the consequence has been that the covered ways are too low to allow the smoke and steam to rise, and in some places the heat is stifling. But this discomfort will have been completely avoided in a short time—as it already has been in some parts of the covered ways. Openings are being cut all along the roofs, and no more inconvenience will then be felt than if the line were uncovered—far less than is habitually experienced in the long tunnels between Turin and Genoa, and Bologna and Florence. Before winter shall return, means will have been employed to complete those covered ways in a manner that shall exclude the snow, and yet allow the smoke and vapour to rise. It is also intended to try various kinds of fuel, and if possible to adopt that which gives out the least smoke.

The time hitherto employed (in the various trial trips recently made) in getting across the mountain has been a little over four hours of actual locomotion. But stoppages are inevitable, chiefly for the purposes of watering the engine, and the journey will hardly take less time than 5½ hours, at least under present arrangements. It is a great object to economize weight, and consequently much water cannot be carried. The unnecessary weight of the French engines has to be saved in other ways. The provision of the French law by which machinery patented and used in France must proceed from French manufactories has been disadvantageous to this company. It would not be surprising if English engines were hereafter to be introduced on the Italian side of the mountain, which is the more difficult of the two. The engines must then be changed at the station before arrival at the French frontier, there marked by a large stone with "Italia" on the one side and "France" on the other. On the journey from Susa there are four stoppages for water, and two on the ascent from St. Michel on the journey to Italy. Going down the mountain no stoppages for water occur, because no steam power is used, the train proceeding by its own momentum. When under steam no more pressure is put upon the central rail than is really necessary for perfect safety, because the greater resistance opposed the larger must be the force employed to overcome it, and the greater, consequently, the consumption of fuel and the wear and tear of machinery. The stations and watering-places on the Italian side are Giaglone, St. Martin, Bard, and La Grande Croix. Half a mile below Bard is one of the worst-looking bits of the whole line, a combination of sharp curves and stiff gradients. At the Grande Croix the ascent is about terminated, the train gets to the plateau, and passes the Hospice. Then comes the frontier station and the descent begins. Lanslebourg is the main station on the line, and the locomotive depôt, and it is there that the engines are at present changed. After it came the Termignon, Bramans, Modane (the French end of the Mont Cénis tunnel), Lapraz, and St. Michel. Most of the stations are at present of a very primitive description, and the wretched hamlets near them are not likely to supply a great many travellers to the line. The terror it was supposed horses and mules would feel at sight and sound of the rapid trains and snorting engines was not very apparent in the animals that were passed upon the road. The speed of the trains on this line never exceeds 12, or at most 13 miles. For the present the managers of the line allow 5½ hours for the journey each way. The undertaking is new, and there are various little things that may be susceptible of improvement. By degrees it is hoped and expected that the time will be reduced to five hours, but there seems no probability that the speed will be augmented. The gain is sufficiently great as it is to constitute an enormous improvement over diligence travelling. To say nothing of the infinitely greater comfort and space to be found in the carriages, the gain is at least six hours. The trains will be of several kinds—first-class, express, ordinary trains, and good trains. The *maximum* number of carriages will be five or six, with one or two luggage vans. The carriages are upon the omnibus plan, and one travels sideways. The width of the carriages is 6½ft., outside measurement. By means of small platforms outside the doors, which are at each end of the carriages, one may walk through the whole train. In general there will be a luggage van between the foremost carriage and the engine, so as to protect the passengers from the heat.

## CIRCULAR VESSELS OF WAR.

A very interesting paper was read before the Royal United Service Institution on the 25th ult. by Mr. John Elder, of the well-known shipbuilding firm of Randolph, Elder, & Co., of Glasgow, in which he gave a description of his circular form of vessel. From numerous experiments he had tried with two models of equal displacement, one being circular and the other of an ordinary iron-clad, he found that the resistance when travelling through the water at the same speed was about equal, and consequently he estimated that there would be no difficulty in making a circular vessel travel as fast, or nearly so, as our present iron-clads. He proposed to drive the vessel by hydraulic power, and to cause it to revolve by forcing the water through curved pipes.

## THE SCREW GUN-BOAT "STAUNCH."

This vessel is intended to carry out a principle often advocated—one large gun on the smallest amount of tonnage that could be designed in the form of a floating steam-carriage. She is 79ft. in length only, with a beam of 25ft.; her deck 27in. above the water-line amidships, when under steam, and with bulwarks of light iron of about 3ft. in depth. She is built of iron, with water tight compartments, but is entirely unprotected by armour-plating. The one gun she carries is a 12½ ton 9-inch rifled muzzle-loader of the Elswick pattern and manufacture, with a double sided iron carriage and slide, mounted on a square platform on the vessel's forecastle, or the foremost part of the deck. This platform is fitted at each corner with a screw-box, which works on one of four columnar screws rising from the floor of the vessel's hold. The screws are driven by a donkey engine through gearing, and by this arrangement the platform with its gun, carriage, and slide can be lowered nearly below the level of the deck of the vessel whenever the latter may be steaming along the coast, or from port to port, and thus be carried with greater safety in a seaway. The bulwarks round the bows of the vessel, and in front of the gun are built up some six or seven feet inboard of the vessel's stem. They are of light iron, proof to rifle-shot fire from boats, and sufficiently high to cover the gun's crew from any such fire from the front, but, of course afford no protection against the fire from anything heavier than that of an ordinary rifle. Half-way upwards from the deck they are hinged so as throw down so far outwards when the gun is brought into action. The small donkey engine that drives the screw gearing for raising and lowering the gun also drives two small capstan heads which project above the deck on the right and left rear of the gun platform; side tackles brought to these capstan heads run the gun in and out. The training of the gun on the object to be fired at can be given by side tackles from these capstans through an arc of 40 deg., but the twin screws give a much superior means of training by making the vessel herself traverse the arc requirod, supplemented also as the screws are by the action of the rudder. The motive power of the vessel consists of a pair of engines of the collective nominal power of 25-horse, driving two three-bladed screws, each of 5ft. diameter and 7ft. pitch. Each engine has two cylinders of 14in. diameter and 14in. stroke, an air pump of 12in. diameter and 7in. stroke, worked from the crank shaft by an eccentric; one feed and one bilge pump, each 3in. in diameter, and 4in. stroke; estimated speed 7 knots per hour.

## NOTES AND NOVELTIES.

### MISCELLANEOUS.

The Institution of Mechanical Engineers—It has been arranged that the annual meeting of the institution for the present year shall be held in Leeds on Tuesday, 28th July, and following days during the time of the National Art Exhibition at Leeds. All proposal forms for the election of new members to be in time for the Leeds meeting are required to be sent in, complete with the requisite signatures, &c., not later than Monday, the 6th July.

Italian Industry.—Great efforts are now being made to develope the national industry in Italy, and to put manufactures there on a level with those of other countries. At Lodi upwards of 100 power looms for cotton and woollens are being fixed, and will soon be ready for work. A like number are being added to a factory at Mouza, near Milan. Three factories are being established at Novara, Iveria, and Belluna. At a factory at Tolmezzo several power looms are being added. An extensive factory is being established at Pirdonne. At Piazzola Signor Camorini is establishing a spinning mill for flax and wool. The well known woollen factory at Schio of Signor Rossi is also being enlarged, and several new machines fixed. In Tuscany also a large woollen factory is being enlarged. During the last two months a good deal of English and Belgian machinery has been sent to Italy. The exhibition of National Industry, now open at Turin, is a great success, and great credit is due to the committee of the Lega Pacifica (a league for the encouragement of national industry, who organised it on so short notice.) This exhibition will remain open till June.

The New Street Pavement for the City.—The Manchester mode of laying granite pavement has been tried this week in Duke-street, Smithfield, in which it will be subjected to the most severe test, as the heaviest traffic from the new goods' station of the Great Western Railway will pass over it. The plan consists of laying down granite, blocks of 6in. by 4in., on a simple bed, and filling in the interstices with a very coarse gravel, and then pouring on a very hot and liquified cement of gas asphalte. This liquified asphalte runs down between the blocks to the bottom and firmly cements the whole pavement into one mass, which is thus rendered impervious to water from above, or below, consequently the rain at once runs off. The bed always remaining dry, no pumping up of mud can occur from between the blocks of granite, so that the pavement always remains clean, and neither mud in wet weather and dust in dry weather can arise where this mode is adopted.

Insitution of Civil Engineers.—On the 26th ult., Mr. C. Hutton Gregory, President of the Institution of Civil Engineers, gave a soiree at the Rooms of the Institution, in Westminster. A large assemblage of guests responded to the invitation, taxing the powers of accomodation within the walls of the institution to the utmost. Among the numerous models and objects of interest displayed, were a fine model of the enginees of the Lord Clyde, by Messrs. Ravenhill, Hodgson, and Co.; an electrical pyrometer, by Mr. Siemens; and a new description of induction coil, by Mr. Apps. Messrs. Colomb and Bolton exhibited their flashing signals, as used at Chatham and in the Abyssinian expedition. The instrument used in Abyssinia consisted of a lamp, at the top of a thick hollow brass rod. The bearer carried the rod in one had, and by means of a pair of bellows he had the power of blowing a mixture of magnesium powder, resin, and lycopodium through the flame of the lamp, thus producing brilliant flashes at will. Mr. Richard Waygood exhibited a new donkey-pump, wherein the cylinder runs up and down a fixed piston, instead of the pision moving in a fixed cylinder. Mr. Ladd, of the Royal Institution, had on view an electrical machine for producing a powerful current by means of the mechanical force of the human arms.

New Goods Deposit at New York.—The new freight depôt of the Hudson River Railroad in New York city, is to be by far the most magnificent building ever erected in that part of the world. It extends 405ft. on Beach and Laight-streets, and 439ft. on Varrick and Hudson-streets, an area of 178,327½ square feet, or over 4 acres under a single roof. It is to have three storeys and a basement, and will be about 60ft. high from the ground on an average, and will be composed wholly of brick, iron, and stone making it absolutely fire-proof.

The Ocean Steamship Race.—The contest between the Inman steamer, *City of Paris*, and the Cunard steamer, *Cuba*, ended by the Inman steamer arriving nearly twenty-four hours before the other. The victory of the *City of Paris*, was however, a very shortlived one, for the Cunard steamer *Russia* arrived a few days after her and beat her on the passage by several hours. The *Cuba* and the *City of Paris* are both built by the same builders, Messrs. Todd and McGregor, of Glasgow, but their dimensions and model differ considerably. The *City of Paris* is a longer, sharper, and less burdensome than the *Cuba*, being 20ft. longer, and having 2ft. less beam, and less tonnage measurement, her cylinders being 7in. more in diameter, but 2ft. 6in. less stroke. The logs of both vessels prove that in bad weather the strongly built, but finally modelled ship, where the clipper model is not carried too far, makes the best sea-boat in heavy weather. During the heavy head weather of the 22nd April, the *City of Paris* beat the *Cuba* 69 miles in the twenty-four hours, and throughout the entire passage it appears by the logs that with fine weather and fair winds the *Cuba* easily beat the *City of Paris*, while in heavy seas she was no match for her.

M. Alvergniate of Paris has constructed a new apparatus for proving that electricity cannot pass through an absolute vacuum. Two platinum wires are inserted into a tube so that their free ends are within about one-eighth of an inch of each other. The air is then exhausted from the tube by means of a mercurial column after which the electric spark will not pass from one wire to the other.

P. Pellogio describes a contrivance by which the troublesome "bumping" peculiar to certain liquids when submitted to distillation, may be obviated. A glass tube, as wide as is convenient, is passed through the tuberlure into the body of the retort, nearly to the bottom. The upper end of the tube is bent at a right angle, and drawn out to nearly capillary dimensions, thus establishing a communication between the interior of the retort and the outer air. With this arrangement of apparatus such liquids as methylic alcohol, sulphuric acid, &c., distil as smoothly as water.

The United States Navy Department has opened a second lot of bids for the ironclads offered for sale, but with no better success than attended the first bids. Neither set of bids came up to the appraised value, and the department is forbidden to sell at less than this value. For iron-clads appraised at 200,000 dols., the highest of this second set of bids was but 22,000 dols., and it was evident that the bidders only estimated the iron-clads as worth the price of old iron.

The dispute between the Metropolitan Board of Works and the Metropolitan District Railway Company has at last been settled, and a solid embankment is to be made between the point where the Thames Embankment at present leaves off and Blackfriars Bridge, so that a clear 100ft. roadway will be carried the whole distance from Westminster Bridge. It is expected that the whole will be finished in the early part of next summer.

### SHIPBUILDING.

Shipbuilding at Southampton.—Messrs. Day and Co., of the Northam Ironworks, have received an order from the Peninsular and Oriental Steam Navigation Company to build an iron screw steamer of about 3,000 tons, builder's measurement, and to be fitted with direct acting engines of 600 horse power. Her dimensions will be—length between perpendiculars 345ft.; breadth, 43ft.; and depth of hold, 30ft.

### STEAM SHIPPING.

On the 6th ult. the paddle steamer *Walney*, built and engined by Messrs, Macnab and Co., Greenock, made a satisfactory trial trip on the Clyde. Shortly after eleven o'clock the vessel steamed out of the basin in the steam shipbuilding yard at Albert Dock, and after sailing up Lochgoil, she ran the Cumbræ Lights at the mean speed of 14·2 miles per hour. The *Walney* has been constructed for the Furness Railway Company, and is intended for the passenger traffic at Barrow-in-Furness, and to be used occasionally for towing purposes. The vessel is 282 tons B.M., and is fitted with a pair of 100-horse power disconnecting steeple engines.

The North-Eastern screw steamer made her trial trip from the Sunderland Docks on the 5th ult., realising on the return voyage a speed of 10 knots per hour, the engines indicating 376-horse power, with 74 revolutions, and 27½ inches of vacuum. The hull was built by Messrs. Richardson, Duck, and Co., of Stockton. The dimensions are:—190ft. long, by 29ft. beam, and 17ft. depth of hold; carrying capacity in dead weight 1,000 tons. She is fitted with water ballast, and is adapted for general carrying trade. The engines are of 90-horse power nominal, surface condensing, and have been constructed by the North-Eastern Marine Engineering Company. The cylinders are 38in. diameter and 30in. stroke, and the working pressure is 25lbs.

The trial of her Majesty's ship Bullfinch, under steam, was made, 12th ult., at the measured mile, Maplin Sands. The vessel is of 663 tons, 170ft. in length, and 29ft. beam. The engines are of the combined power of 160 horses, working two screw propellers of the Mangin description; diameter 7ft. 3in., pitch 11ft. 4½in., and immersion of the upper edge 12in. The draught of water during the trial was 8ft. 10in. forward, and 10ft. 2in. aft. The mean speed of the vessel was 11.011 knots; the revolutions 132 per minute; pressure of steam in boilers 28lb.; vacuum 24½, and approximate indicated horse power 917.

The "Victoria," ironclad, built by the Thames Ironworks Company, and engined by Messrs. John Penn and Sons, has at last taken her trial trip. It will be remembered that this vessel was launched nearly two years ago, but in consequence of the Spanish Government, for whom she was built, being then at war with Chili and Peru, she was not allowed to go out of the Victoria Docks. The trial took place at the Maplin measured mile, when the mean of four runs gave the speed as 14·1 knots; the number of revolutions per minute, 65; and the pressure of steam, 23lbs.; with an indicated power of 4,500 horse. The weather was favourable, but the tide was rather bad, being at about half ebb, at the time of trial. The dimensions of the *Victoria* are:—Length 316ft., breadth 57ft., depth of hold 38ft., displacement 4,362 tons. Comparing these dimensions and the driving power with our iron clads, the trial must be considered very favourable.

### LAUNCHES.

The Turkish Navy.—The first of a fleet of small screw steamers, building for the Imperial Ottoman Government, was launched on the 9th ult., from Mr. John White's shipbuilding-yard at Medina Dock, West Cowes. The vessel was named the Sahir, with the customary formalities, by Miss G. E. Prothero. The Sahir is 119ft. between perpendiculars, 20ft. in breadth, 11ft. 10in. in depth of hold, and measures 225 tons. O.M. Her engines will have a combined nominal power of 50-horse, and have been made for her by Messrs. A. Day and Co., of Southampton.

There was launched at Dundee on the 7th ult., by Messrs. Gourlay Brothers, a fine iron screw steamer named the *Cambria*, of the following dimensions.—Length of keel and fore rake, 216ft.; breadth moulded, 28ft.; depth moulded, 17ft. 3in.; builders' tonnage, 830; and gross register, 680. The vessel has been fitted up with surface condensing engines of 180-horse power, and has been classed A1 at Lloyd's.

Messrs. Ranpolph, Elder, and Co., launched from their shipbuilding yard at Fairfield, Glasgow, a screw steamship of 1,063 tons' builders' measurement, and 150-horse power nominal, named the *Don*, for D. R. Macgregor, Esq., of Leith, and is intended for the Baltic trade.

On Saturday afternoon there was launched from the building yard of Messrs. W. Pile and Co., North Sands, Monkwearmouth, a screw-steamer, classed 18 years in the Liverpool Lloyd's. She is 900 tons register, and was named the *Ivanhoe*. Her dimensions are:—Length, 210ft.; breadth, 30ft.; depth, 17ft. 6in. Her engines will be supplied by the North-Eastern Engine Company.

## RAILWAYS.

Railways in Italy.—The preliminary surveys of the proposed railway from Pinerola (Province of Turin) to La Torre Perlice are now completed, and have been approved of by the Minister of Public Works. This line, which is about 10 miles in length will probably be commenced shortly. The cost of construction will be borne by the various *communes* through which it passes, and will be of great importance for the Vandois Valleys, which are very prosperous, and contain a number of silk worms. At Mulanaggio, at no great distance from the line of railway, there are some very extensive quarries, which furnish stone which is highly valued for architectural uses, hugh blocks of which have been extracted for the columns of various churches and other public building at Turin.

The construction of the Pacific Railway has progressed so far that on the 18th of April the rails were laid on the highest grade of the Rocky Mountains, 8,242ft above the sea level, said to be the highest point attained by any railroad in the world. The construction parties are now working on the western slope of the mountains.

The works of the new Waterloo Station have been commenced. The station will have three platforms available for passengers desiring to proceed to Charing Cross or Cannon-street; they will be nearly 500ft. long and ample in with. The South-Western passengers will change trains at Waterloo for Charing Cross or Cannon-street, and will only have a comparatively short distance to walk.

The Mont Cenis Railway.—The experimental trains over Mont Cenis, ordered by the French and Italian Governments, have worked daily with great regularity and success. The Duke of Sutherland, Messrs. Brassey, Blount, Buddicom, Brogden, and Fell, directors; Mr. Brunlees, engineer; Count Arrivabene, a member of the Italian Parliament, and about fifty more travelled over the line on the 22nd ult. and the following day. The opening for public traffic is fixed for the 8th inst.

Metropolitan Railway.—The directors have made an inspection of the works in progress on the extension of the Metropolitan Railway between Paddington and Gloucester-road, Kensington. They were accompanied by Lord Gort and other directors of the Metropolitan District Railway, the contractors, Messrs. Kelk, Waring Brothers, and Lucas, the engineers, Messrs. Fowler and Johnson, and by other officers of the company. The works were found to be in an advanced state, and it is expected that in the course of the summer this important link of the inner circle of the Metropolitan Railways will be opened for public traffic.

Railways in Algeria.—The Paris, Lyons, and Mediterranean Railway Company is now making two lines in Algeria—viz., from Algiers to Oran and from Philippeville to Constantine. The outlay made by the company upon these lines in 1867 was £1,004,740, and to the close of 1867 £2,744,917. A geat deal of work still remains to be done upon the lines, and they will not be fully completed before 1870. The French Government has granted a subvention for these lines to the amount of £3,200,000, and a guarantee of 5 per cent. per annum on the capital expended upon them in excess of that amount.

## ACCIDENTS.

Another fearful American railway accident has occurred. At two o'clock on the afternoon of April 14th a train left Buffalo for New York, on the Erie Railway, consisting of one postal and two luggage vans, three passenger carriages, and three sleeping carriages. About three o'clock on the morning of the 15th the train was proceeding at a speed of 35 miles an hour along the banks of the Upper Delaware river, at a place called Carr's Rock, where the line is elevated one hundred feet above the stream, and runs along the side of a jagged precipice. Here a rail broke, and the three sleeping coaches and one passenger carriage, containing at least two hundred persons, were thrown down the embankment. Twenty-four persons were killed and fifty-two seriously injured.

## DOCKS, HARBOURS, BRIDGES.

Dundee Harbour Proposed Extension of Works.—Mr. Ower, the engineer to the Dundee Harbour Board, has prepared and submitted to the Board a report on the proposed extension of the Harbour Works. The trade of the port has increased so rapidly of late that it is expected that next session Parliamentary powers will have to be sought to enable the Board to borrow money to construct a new graving dock and finish the Victoria Dock.

Floating Dock at Cartagena.—The largest ship in the Spanish navy, the *Numancia*, was lately lifted on the floating dock at Cartagena, a dock made by Messrs. Rennie, at Greenwich. The *Numancia* is built entirely of iron with the exception of the teak backing for the armour plating. She is 316ft. long, 57ft. beam, draught of water 27ft. 4in., with a displacement of 7,420 tons (her displacement on leaving for the Pacific was 8,200 tons) but she was lightened before docking to 5,600 tons; she is completely encased by 5in. armour of 1,500 tons weight, and pierced for forty 68-pounders. The port sills with provisions for 600 men and 1,000 tons of coal on board, are 7ft, 6in. out of water; her full speed 13 knots; her engines are 1,000 horse-power, developing nearly 4,000. The Cartagena dock was the first introduction of iron floating docks; the length is 324ft., breadth outside, 105ft.; and inside 78ft. The actual lifting occupied 8 hours 13 minutes, but it is said it could be done in 4 hours on other occasions, now that the strength of the dock is known.

A Day Dock has been opened on the Island of Mocangue, in the harbour of Rio Janeiro. It is cut out of hard rock, and is 300ft. long by 60ft. wide.

## MINES, METALLURGY, &c.

The Union Pacific Railroad, which has struck the Rocky Mountains between five and six hundred miles west of the Missouri River, passes through a region where coal and iron are abundant. In the upper valley of the Missouri there are beds of coal 7ft. in thickness; in many parts of Dakota and Colorado the beds are from 5ft. to 11ft. in thickness, and occupy a basin of about 5,000 miles square. According to Professor Hayden, this coal is of excellent quality, and leaves scarcely any ash.

## LATEST PRICES IN THE LONDON METAL MARKET.

| | From | | | To | | |
|---|---|---|---|---|---|---|
| COPPER. | £ | s. | d. | £ | s. | d. |
| Best selected, per ton | 83 | 0 | 0 | 85 | 0 | 0 |
| Tough cake and tile do. | 81 | 0 | 0 | 83 | 0 | 0 |
| Sheathing and sheets do. | 84 | 0 | 0 | 88 | 0 | 0 |
| Bolts do. | 83 | 0 | 0 | ,, | ,, | ,, |
| Bottoms do. | 88 | 0 | 0 | 90 | 0 | 0 |
| Old (exchange) do. | 70 | 0 | 0 | ,, | ,, | ,, |
| Burra Burra do. | 84 | 10 | 0 | 85 | 0 | 0 |
| Wire, per lb. | 0 | 1 | 0 | ,, | 1 | 0½ |
| Tubes do. | 0 | 0 | 11½ | 0 | 1 | 0 |
| BRASS. | | | | | | |
| Sheets, per lb. | 0 | 0 | 9 | 0 | 0 | 10 |
| Wire do. | 0 | 0 | 8½ | 0 | 0 | 9½ |
| Tubes do. | 0 | 0 | 10½ | 0 | 0 | 11 |
| Yellow metal sheath do. | 0 | 0 | 7½ | 0 | 0 | 8 |
| Sheets do. | 0 | 0 | 7 | 0 | 0 | 7¼ |
| SPELTER. | | | | | | |
| Foreign on the spot, per ton | 20 | 10 | 0 | ,, | ,, | ,, |
| Do. to arrive | 20 | 10 | 0 | ,, | ,, | ,, |
| ZINC. | | | | | | |
| In sheets, per ton | 26 | 0 | 0 | ,, | ,, | ,, |
| TIN. | | | | | | |
| English blocks, per ton | 98 | 0 | 0 | ,, | ,, | ,, |
| Do. bars (in barrels) do. | 99 | 0 | 0 | ,, | ,, | ,, |
| Do. refined do. | 101 | 0 | 0 | ,, | ,, | ,, |
| Banca do. | 96 | 0 | 0 | ,, | ,, | ,, |
| Straits do. | 93 | 0 | 0 | ,, | ,, | ,, |
| TIN PLATES.* | | | | | | |
| IC. charcoal, 1st quality, per box | 1 | 6 | 0 | 1 | 10 | 0 |
| IX. do. 1st quality do. | 1 | 12 | 0 | 1 | 16 | 0 |
| IC. do. 2nd quality do. | 1 | 4 | 0 | 1 | 7 | 0 |
| IX. do. 2nd quality do. | 1 | 10 | 0 | 1 | 13 | 0 |
| IC. Coke do. | 1 | 2 | 0 | 1 | 3 | 0 |
| IX. do. do | 1 | 8 | 0 | 1 | 9 | 0 |
| Canada plates, per ton | 13 | 10 | 0 | ,, | ,, | ,, |
| Do. at works do. | 12 | 10 | 0 | ,, | ,, | ,, |
| IRON. | | | | | | |
| Bars, Welsh, in London, per ton | 6 | 5 | 0 | ,, | ,, | ,, |
| Do. to arrive do. | 6 | 2 | 6 | 6 | 5 | 0 |
| Nail rods do. | 6 | 15 | 0 | 7 | 0 | 0 |
| Stafford in London do. | 7 | 7 | 6 | 8 | 10 | 0 |
| Bars do. do. | 7 | 5 | 6 | 9 | 10 | 0 |
| Hoops do. do. | 8 | 2 | 6 | 9 | 15 | 0 |
| Sheets, single, do. | 8 | 15 | 0 | 11 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. mrch. Tyne or Tees do. | 6 | 10 | 0 | ,, | ,, | ,, |
| Do. railway, in Wales, do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. Swedish in London do. | 10 | 0 | 0 | 10 | 2 | 6 |
| To arrive do. | 10 | 0 | 0 | 10 | 2 | 6 |
| Pig No. 1 in Clyde do. | 2 | 12 | 6 | 2 | 16 | 6 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | ,, | ,, | ,, |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 7 | 0 | 0 | 7 | 10 | 0 |
| STEEL. | | | | | | |
| Swedish in kegs (rolled), per ton | 14 | 5 | 0 | ,, | ,, | ,, |
| Do. (hammered) do. | 14 | 15 | 0 | 15 | 0 | 0 |
| Do. in faggots do. | 16 | 0 | 0 | ,, | ,, | ,, |
| English spring do. | 17 | 0 | 0 | 23 | 0 | 0 |
| QUICKSILVER, per bottle | 6 | 17 | 0 | ,, | ,, | ,, |
| LEAD. | | | | | | |
| English pig, common, per ton | 19 | 7 | 6 | ,, | ,, | ,, |
| Ditto. L.B. do. | 19 | 2 | 6 | ,, | ,, | ,, |
| Do. W.B. do. | 21 | 5 | 0 | ,, | ,, | ,, |
| Do. sheet, do. | 20 | 5 | 0 | ,, | ,, | ,, |
| Do. red lead do. | 20 | 15 | 0 | ,, | ,, | ,, |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 10 | 0 | 22 | 15 | 0 |
| Spanish do. | 18 | 15 | 0 | 19 | 0 | 0 |

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* At the works 1s. to 1s. 6d. per box less.

## LIST OF APPLICATIONS FOR LETTERS PATENT.

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

### Dated April 20th, 1868

1276 T. A. Warrington—Economic candlestick
1277 C. D. Abel—Press copying letters, &c.
1278 C. D. Abel—Treatment of textile fabrics
1279 J. Cooke—Rotary engines and pumps
1280 L. Maria Ruiz—Speaking telegraph
1281 J. Fawcett and J. A. Fawcett—Steam boilers
1282 J. B. Farrar—Spinning machinery
1283 W. Malam—Manufacture of gas, &c.
1284 J. McGbie—Spinning or twisting
1285 S. W. Worssam, jun.—Planing wood
1286 W. W. Symington—Machinery for sizing, &c.
1287 J. J. R. Humes and J. G. Sullivan—Bricks
1288 A. V. Newton—Construction of rings
1289 G. Coles, J. A. Jaques, and J. A. Fanshawe—Elastic bands

### Dated April 21st, 1868.

1290 J. Woolfield—Corrugating sheets of metal
1291 A. Cole and J. Carter—Lamps
1292 S. Jackson—Motive power
1293 W. Gorse—Cut nails
1294 E. Kemp and H. Gourlay—Steam engines
1295 A. Paget—Hauling, &c., ropes
1296 G. Coles, J. A. Jaques, and J. A. Fanshawe—Producing thin strips from various substances
1297 L. Bing—Ascertaining the actinic power of light
1298 S. Dreyfous—Removing cotton from cotton pods
1299 A. D. Renshaw—Shearing wool
1300 J. H. Johnson—Correcting the deviations of the mariner's compass in iron ships
1301 J. Fugl and H. T. Fugl—Curtain poles

### Dated April 22nd, 1868.

1302 M. S. Maynard and R. Grime—Governing the speed of motive power engines
1303 J. Johnson—Metallic packings
1304 J. Edwards—Railway point indicators
1305 W. Clarke—Ornamental fabrics
1306 J. H. Bolton—Sizing warps, &c.
1307 C. B. Ingham—Stamping designs
1308 T. Whittaker—Waterproof fabrics
1309 H. Howse—Safety matches
1310 R. Side—Motive power machines
1311 A. Fiddes and C. J. Curtis—Safes
1312 T. L. Scowen—Hook-button for boots, &c.
1313 T. L. Scowen—Hook-button boot
1314 W. R. Lake—Lubricating packing
1315 W. R. Lake—Manufacturing small articles from sheet metal
1316 W. R. Lake—Carpet linings
1317 H. Hill—Waterclosets, &c.
1318 W. E. Newton—Paddle wheels
1319 H. D. Chard—Construction of buildings
1320 H. H. Murdoch—Thrashing machines
1321 R. F. Fairlie—Railway carriages, &c.
1322 D. Skeoch—Spindles
1323 E. Sampson—Utilising the hoop, &c., of an ordinary loo or other table

### Dated April 23rd, 1868.

1324 W. Hamilton—Generating steam
1325 T. Hardcastle—Bowls for mangles, &c.
1326 E. Rostron and W. W. Whittaker—Felt
1327 J. Whitehouse—Tailors' irons
1328 J. Bush and H. Welchman—Fastening for brooches
1329 J. M. Stanton—Furniture castors
1330 G. F. Stidolph, J. Stidolph, and T. Simpson——Brushing and sweeping machines
1331 A. M. Clark—Motive power
1332 J. Armstrong—Permanent way
1333 W. R. Lake—Steam cultivator
1334 C. B. Hardick and J. Hardick—Direct acting engines
1335 J. Reid—Casks, &c.
1336 J. Rogers—Preparation, &c., of certain vegetable products
1337 J. Casson—Sawing wood
1338 A. Carter—Making nails, spikes, &c.
1339 W. R. Lake—Cartridge boxes

### Dated April 24th, 1868.

1340 M. Z. A'Aschan—Medicinal compound, &c.
1341 I. Baggs—White lead, &c.
1342 T. T. Macneill—Apparatus for indicating the distance travelled by cabs, &c.
1343 C. Brown—Apparatus for baking, &c.
1344 J. R. Johnson—Firearms
1345 R. Nuttall, T. Nuttall, and B. Barber—Woven fabrics
1346 D. C. Lowber—Wire tie
1347 C. W. Harrison—Preventing incrustation in boilers
1348 J. Liddard and G. Buxton—Railways
1349 J. Wetherbilt—Scoring at billiards, &c.
1350 W. H. Ryland—Fastenings for articles of dress, &c.
1351 J. Dewar—Making and preserving manure
1352 W. Bartram—Cartridges
1353 W. Bartram—Filling cartridges
1354 G. A. Welch—Preservation of life at sea
1355 J. Bernard—Preparing ores

### Dated April 25th, 1868.

1356 T. F. Casbin—Actuating railway signals, &c.
1357 W. N. Hutchinson—Receiving the recoil of ordnance
1358 G. Marston—Retaining the outer ends of tapes
1359 J. Craven—Fringe on shawls
1360 J. Holding and R. Holding—Looms
1361 P. Spence—Purification of gas
1362 A. W. Pocock—Working valves
1363 R. Cocker—Purifying wood, &c.
1364 C. Drake—Concrete buildings
1365 A. Clark—Steam generators
1366 A. Parkes—Varnishes
1367 J. Atkins—Ornamenting sheets of metal
1368 T. Pemberton—Supports for fire-irons
1369 F. C. Hills—Manufacture of gas, &c.

### Dated April 27th, 1868.

1370 E. P. H. Vaughan—Telegraphy
1371 J. Hepworth—Boilers and furnaces
1372 S. Tidmarsh—Locks
1373 D. Geraci—Armour material
1374 V. De perdange—Connecting pipes, &c.
1375 P. Nisser—Explosive compound
1376 K. V. Barnekov—Breech-loading firearms
1377 H. Chaytor—Rolling stock of railways
1378 R. Holt—Papering woven fabrics
1379 L. Perkins—Wrought metal wheels
1380 J. Scoffern—Sheathing ships' bottoms
1381 L. Perkins—Tubular steam boilers

### Dated April 28th, 1868.

1382 E. McDonnell—Impervious concrete
1383 J. Pearson and M. Pearson—Jacquard engines
1384 G. T. Bousfield—Hair seating, &c.
1385 G. A. Cox—Carpets, &c.
1386 A. Jack—Reaping machines
1387 A. Baal and C. Gann—Reefing sails
1388 A. Dietz—Preparing glue
1389 Henry Waugh—Screening grain
1390 W. Whitworth—Sewing machines
1391 E. A. Rippingille—Motive power
1392 J. Bottomley—Umbrellas

### Dated April 29th, 1868.

1393 G. B. Bibacci—Gas engines
1394 S. Rohotham—Bird cages
1395 J. Gray—Coating for preventing the fouling to which ships are liable
1396 T. and G. Cope—Moulding tobacco
1397 W. Wright—Manufacture of iron
1398 A. Geary—Protecting the moustache when eating soup
1399 C. D. Fox—Nicking screw blanks
1400 J. Booth—Manufacture of fabrics
1401 J. J. Long—Matches, &c.
1402 J. McKean and J. Stenhouse—Sizing yarns
1403 H. Deacon—Chlorine
1404 R. Scott—Dressing millstones
1405 J. H. Johnson—Preserving meat
1407 A. Homfray—Iron or steel shackles, &c.

### Dated April 30th, 1868

1408 F. Wise and E. Field—Separation of foreign matters from water
1409 J. Gough—Actuating the knife in paper cutting machines
1410 W. Ferrie—Blast furnaces
1411 J. Denby and J. R. Beard—Woven fabrics
1412 J. Betteley—Shipbuilding fastenings
1413 R. Ward—Spinning tobacco
1414 J. H. Cassell—Sheathing iron ships
1415 S. Chatwood—Safes
1416 S. Parr and A. Strong—Construction of walls
1417 J. W. Goundry—Carrying railway tickets
1418 B. F. Weatherdon—Soldering tin boxes
1419 M. A. F. Mennons—Planing tools, &c.
1420 W. R. Lake—Spinning
1421 T. Beeley—Boilers
1422 J. H. Johnson—Gelatine

### Dated May 1st, 1868.

1423 J. Lillie—Regulating the flow of liquids
1424 C. D. Abel—Production of colouring from aniline
1425 E. Leheup—Manufacture of wooden boxes
1426 A. Munro—Machinery for cutting stones
1427 A. B. Childs—Separating mixed substances
1428 J. Warne—Junction or fastening for pipes
1429 W. E. Everitt—Copper, brass, and metal tubes
1430 P. Marlin and A. Tack—Producing gases from liquid hydrocarbons, &c.
1431 J. H. Johnson—Boiling and shearing textile fabrics

### Dated May 2nd, 1868.

1432 J. Heaton—Reverberatory and other furnaces
1433 F. Barnett—Unspillable pail or vase
1434 H. A. Bonneville—Measuring flow of liquids
1435 H. A. Bonneville—Propelling vessels
1436 T. Hawkes, F. W. Spencer, G. Spencer, and J. Stenner—Seed and manure drill
1437 E. G. Camp—Mallets for playing croquet
1438 L. Binns—Looms for weaving
1439 H. Y. D. Scott—Kilns for burning lime
1440 J. Maistre—Process for dyeing wool
1441 A. Smith—Furnaces for burning creosote
1442 J. E. Boyce—Umbrellas and parasols
1443 J. H. Johnson—Exhibiting minute photographs
1444 W. R. Lake—Generating gas
1445 J. L. Budden—Drying wool
1446 W. R. Lake—Buckets and vessels of wood
1447 W. R. Lake—Dynamometers

### Dated May 4th, 1868.

1448 H. Glover—Retaining corks in bottles
1449 W. E. Gedge—Applying a coating of silver upon any animal, vegetable, or mineral substance
1450 A. Vickers—Locking nuts of screw bolts
1451 I. Mathhi—Warehousing petroleum
1452 C. P. Aston—Chimney pots
1453 J. Wertheim and L. Hirschhorn—Lockets
1454 T. Pemberton and G. A. Pemberton—Bells
1455 E. Morgan and G. H. Morgan—Carriages
1456 W. Marshall—Clipping lace
1457 W. Ester and M. Terrero—Preserving animal and vegetable substances

### Dated May 5th, 1868.

1458 D. P. Wright—Drawing off liquids
1459 D. P. Wright—Taps
1460 W. Taylor—Iron and steel ships
1461 W. Sketchley—Wood cutting
1462 C. W. Siemens—Cast steel
1463 C. D. Abel—Axle-boxes
1464 F. W. Gerhard—Engines
1465 J. Dawber—Steam-engines
1466 J. Clough—Screw gill-boxes
1467 J. Hickmott—Preserving metallic articles
1468 J. Court—Sewage traps
1469 G. Kent—Refrigerators
1470 D. R. Macgregor and P. Taysen—Paint
1471 W. Beale—Ladders
1472 W. Walker and H. F. Smith—Expressing oils
1473 F. J. King—Preserving potatoes
1474 J. Lamb—Bobbin frames for carpet looms
1475 W. E. Newton—Pick axes
1476 J. Wilkinson—Printing carpets

### Dated May 6th, 1868.

1477 A. Scott—Attaching clothes
1478 J. M. Stanley—Heating apparatus
1479 R. Lublinski—Tips of umbrellas
1480 T. Warren—Glass furnaces
1481 J. Young—Coke-ovens
1482 C. J. Chubb—Getting coal
1483 J. Palmer and J. B. Palmer—Matches
1484 H. J. Davies—Cleaning gold, &c.
1485 A. C. Henderson—Albumen
1486 S. Drummond—Preventing fraud in collection of fares in omnibuses
1487 F. T. Hall—Railway tickets
1488 W. E. Newton—Combs
1489 M. Henry—Steel and iron
1490 S. Holt—Preventing accidents on railways
1491 J. G. Walker and C. Stein—Separating tares
1492 J. G. Walker—Pressing millstones
1493 W. Harvie—Lamps
1494 J. H. Johnson—Draught in steam-boiler

### Dated May 7th, 1868.

1495 M. A. Muir and J. McIlwhan—Looms
1496 H. A. Bonneville—Spring mattresses
1497 B. Pickering—Expressing oils
1498 R. A. Green—Bearings, shafts, or pivots
1499 A. C. Henderson—Plates for heliography
1500 A. C. Henderson—Renovating files
1501 K. H. Cornish—Entrenching tools
1502 R. Harlow—Withdrawing water from baths
1503 A. Strauss—Pipes for smoking
1504 J. H. Johnson—Sewing machines
1505 W. E. Gedge—For administering resinous sudations
1506 W. E. Gedge—Spinning flax, &c.
1507 R. Evans—Dressing millstones
1508 J. Bruce—Bolters for dressing flour

### Dated May 8th, 1868.

1509 R. K. Miller and A. B. Herbert—Knotters for straining paper pulp
1510 G. Bowden and J. R. Dickinson—Fluted brush, and pencil-point protector
1511 H. N. Penrice—Machinery for tunneling
1512 W. Husband and B. Dœring—Rock-boring
1513 C. E. Brooman—Preparing zirconia
1514 A. James—Polishing needles
1515 W. Seck—Hulling grain
1516 J. A. Jones—Manufacture of iron

### Dated May 9th, 1868.

1517 G. F. Griffin—Corking bottles
1518 J. C. Bowler—Castors
1519 J. Norman—Calcining ores, &c.
1520 W. E. Everitt—Casting copper tubes
1521 H. H. Hazard and W. Grimwood—Shutters
1522 S. Moulton—Vulcanized india-rubber
1523 R. Weygood—Stoves
1524 A. M. Clark—Breech-loading fire-arms
1525 W. H. Wilkinson—Types and cases
1526 J. H. Crane—Breech loading fire-arms
1527 G. T. Seydel—Heating and ventilating
1528 S. Hall—Artificial fuel
1529 J. H. W. Biggs—Selecting warp threads and drawing them through the eyes of harness

### Dated May 11th, 1868.

1530 R. Moore—Crushed sugar
1531 J. Crossley—Looms
1532 W. Webster and R. W. Barnes—Head rests for use of photographers
1533 A. D. E. Boucher—Hollow metallic pieces
1534 A. D. E. Boucher—Enamelled cast iron
1535 A. M. Dix—Supplying finings to casks
1536 C. E. Brooman—Furnaces
1537 W. R. Lake—Holding scrubbing brushes
1538 J. B. Kingham—Nail machines
1539 A. Holbrook, jun.—Sewing books
1540 R. Leake and J. Beevers—Prevention of smoke

### Dated May 12th, 1868.

1541 S. Buxton—Pens
1542 T. Briggs—Securing bales
1543 G. A. H. Dean—Envelopes
1544 W. R. Lake—Fans
1545 T. Pope—Curry-comb
1546 S. F. Armstead—Blow-pipe apparatus
1547 C. Vero—Hats
1548 T. Sainton—Ends and joints of pipes
1549 W. D. Brown—Reaping and mowing machines
1550 J. H. Nutt—Straining surface for oil

### Dated May 13th, 1868.

1551 J. Slater—Breaking-up macadamized roads
1552 S. B. Boulton—Landing, &c., timber
1553 F. W. Crossley and W. J. Crossley—Breaking the boon of flax
1554 H. B. Barlow—Preventing incrustation in boilers
1555 G. Dixon—Upholsterers' fringes
1556 A. Prince and A. C. M. Prince—Telegrap
1557 S. B. Allen—Rasps
1558 C. Farrow—Cleansing bottles, &c.
1559 J. W. Chamberlain—Steam-engines
1560 M. Sefi—Boilers
1561 W. Taylor—Iron and steel ships
1562 W. Baldwin—Looms
1563 H. B. Mullord and A. Mullord—Bonnets
1564 C. Iles—Thimbles
1565 R. M. Clunes and F. W. Davis—Harrows
1566 W. E. Newton—Braces or suspenders
1567 F. Dixon—Cases for holding bottles
1568 W. E. Newton—Axles and axle-boxes
1569—W. Tasker—Steam-engines

### Dated May 14th, 1868.

1670 J. W. Wilson—Spring stuffing
1571 H. Marsden and T. H. Blamires—Wadding
1572 W. Gadd and J. Moore—Looms
1573 J. Ashford and W. H. Collins—Dress ornaments
1574 G. de Sainte Marie—Colouring capsules, &c.
1575 T. B. Kay—Carding engines
1576 G. Konig—Album for photographs
1577 J. Driver—Consumption of smoke
1578 J. Dewar—Preserving vegetables
1579 J. E. Piper—Oil for lubricating
1580 W. E. Newton—Felt hats
1581 W. E. Newton—Steam-engines
1582 V. G. Bell—Locomotive engines and tenders
1583 W. A. Brown—Hand signal-lamp
1584 N. Basevi—Projectiles
1585 E. Ashworth—Rollers for drying fabrics
1586 W. Walker—Cutting and dressing millstones
1587 J. G. Walker—Dressing stone
1588 W. R. Lake—Directing boxes and parcels

### Dated May 15th, 1868.

1589 T. J. Gathercole and T. R. Comyn—Umbrella
1590 H. C. Crofts—Bricks
1591 J. H. Johnson—Hollow bricks
1592 J. H. Johnson—Holders for photographs, &c.
1593 J. Hicks—Bellows of musical instruments
1594 F. Hyde—Bevel gearing
1595 T. Singleton—Looms
1596 S. Chambers and C. Broadhead—Preventing the radiation of heat from steam pipes, &c.
1597 A. Pelard—Portable hydrotherapic apparatus
1598 A. V. Newton—Liquid meters
1599 J. Robey—Consuming smoke
1600 W. Smith and G. B. Smith—Gas meters
1601 A. M. Clark—Permanent way of railways
1602 W. R. Lake—Embalming dead bodies
1603 J. Price—Testing strength of rails

### Dated May 16th, 1868.

1604 J. G. Tongue—Stitching books
1605 W. Rule—Dressing metallic ores
1606 H. J. H. King, J. Auchinvole, and A. Patrick—Gauges for ascertaining pressure
1607 T. Briggs—Signalling on railway trains
1608 A. J. Murray—Reaping machines
1609 R. Rayner—Apparatus for cooking, &c.
1610 A. M. Clark—Lamps
1611 J. A. Adams—Cooking ranges
1612 C. Golden—Breech-loading guns
1613 W. Alldsy—Forge-bellows
1614 A. Parkes—Parkesine for billiard-balls
1615 G. Price—Pianos
1616 G. Smith—Dies for bricks
1617 W. E. Gedge—Extracting wool from hides
1618 W. R. Lake—Iron and steel
1619 M. A. Hamilton—Churn

### Dated May 18th, 1868.

1620 J. W. Anderson—Temples for looms
1621 E. Billington and W. Jolley—Conveying and regulating the pressure of steam
1622 W. Manwaring—Lawn mowing machines
1623 G. Watson—Raising and lowering weights
1624 W. Needham and J. Kite—Depuration of fluids
1625 L. Goldstein—Umbrella and parasol cloths
1626 J. F. Spencer—Valves of engines
1627 A. M. Clark—Ironing and finishing linen
1628 J. Mitchell—Carriage-springs
1629 J. Grantham—Iron and steel ships

### Dated May 19th, 1868.

1630 E. P. H. Vaughan—Preparation of anhydrous chlorides
1631 E. P. H. Vaughan—Pipes for smoking
1632 R. Pearce—Separation of copper from silver
1633 J. Flachfield—Cases for pipes for smoking
1634 D. Riddell—Bread and biscuits
1635 J. Steel—Cask-washing
1636 J. Elce—Looms
1637—D. A. Cooper—Solitaires for gloves, &c.
1638 J. Pollock—Drawing corks
1639 T. Griffen—Bleaching

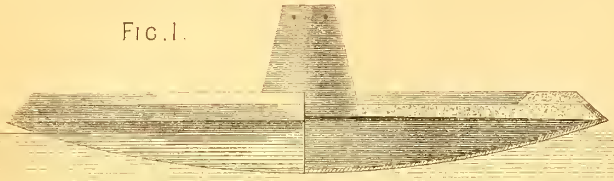
### Dated May 20th 1868.

1640 W. Jones and J. Hetherington—Stretching woven fabrics
1641 H. H. Johnson—Advertising in railway tunnels
1642 J. Kennett—Ventilating sewers
1643 J. Fry—Folding perambulators
1644 R. Froehlich—Opening sardine and metal cases
1645 C. L. Taverdon and J. Moret—Pump
1646 A. G. Hutchinson—Burglar detectors
1647 F. D. Nuttall—Reverberatory furnaces
1648 J. B. Whiteley—Stretching, &c., woven fabrics
1649 A. Ball—Steam engines
1650 W. F. Batho—Planing or shaping metals, &c.
1651 H. D. Hoskold and G. P. Wheeler—Artificial fuel
1652 Z. Poirier—Stopper for bottles
1653 A. Leslie—Steam cultivation
1654 D. Jones and J. Jackson—Imparting heat to feet and body while travelling
1655 W. Tijou—Steam-pumps
1656 C. R. Havell—Water-heating apparatus
1657 W. England—Measuring liquids
1658 A. V. Newton—Sewing machines
1659 W. Inglis—Steam engines and boilers
1660 W. Sim—Watering and cleansing streets
1661 G. T. Bousfield—Looms
1662 O. Barnard—Chairs and furniture
1663 J. Couvers—Crank and crank shafts
1664 W. R. Lake—Marking and creasing tucks on a sewing machine

# CIRCULAR VESSELS OF WAR.

BY Mr JOHN ELDER, GLASGOW.

FIG. 1.



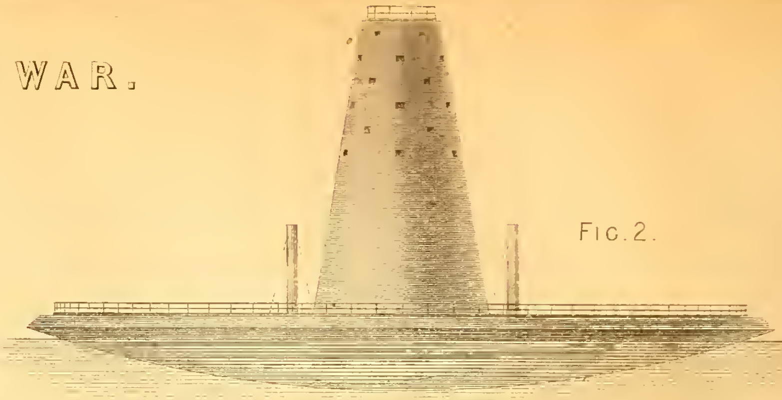


FIG. 2.

FIG. 3.

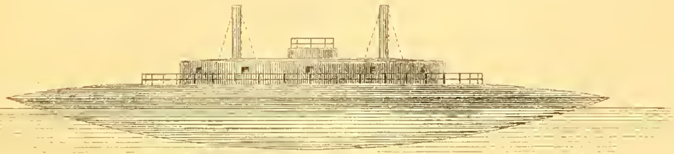


FIG. 4.

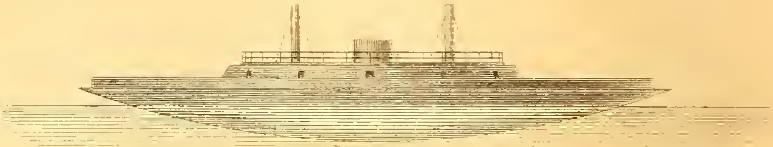


FIG. 5.

FIG. 6.

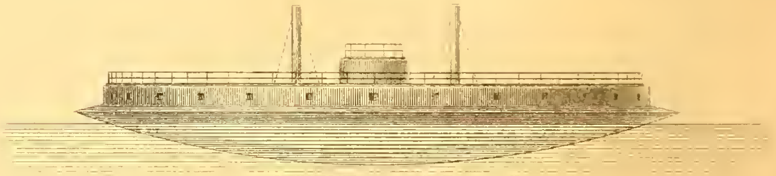


FIG. 7.

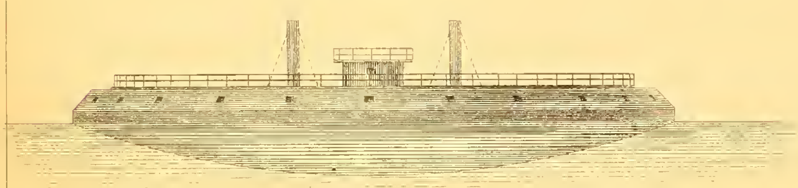


FIG. 8.

FIG. 9.

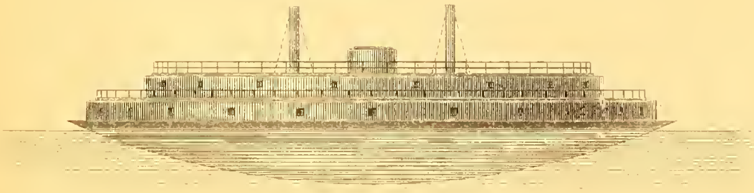
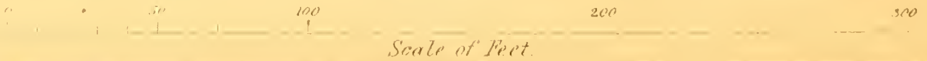


FIG. 10.

FIG. 11.

FIG. 12.



Scale of Feet.

# IRON ROOF FOR THE INDEPENDENT GAS WORKS.

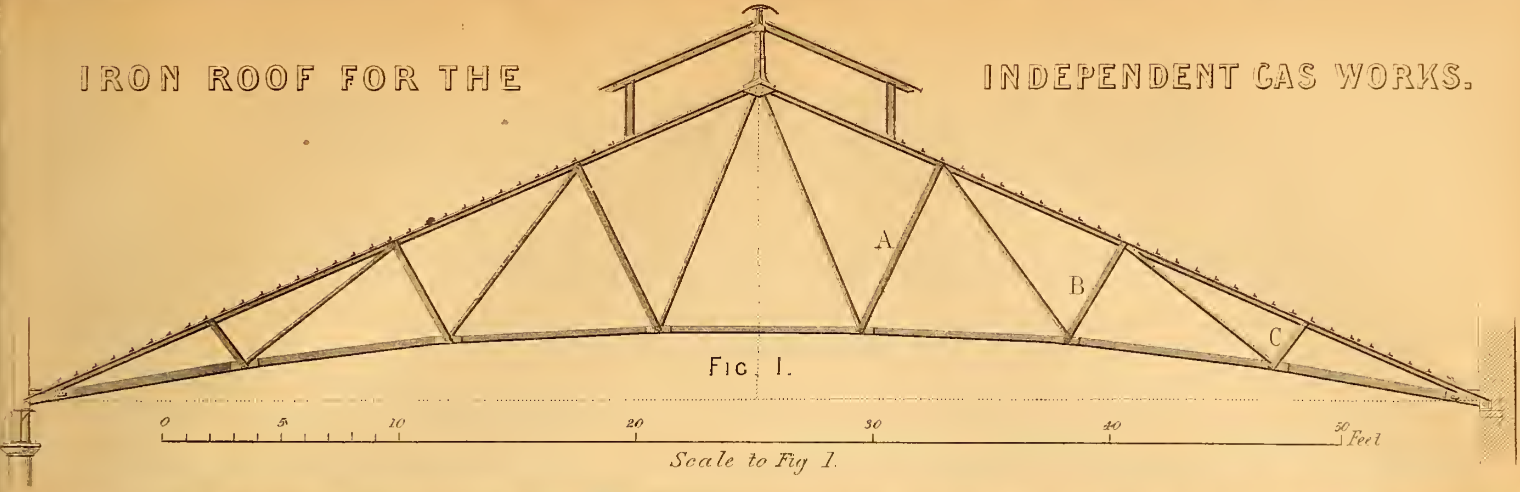
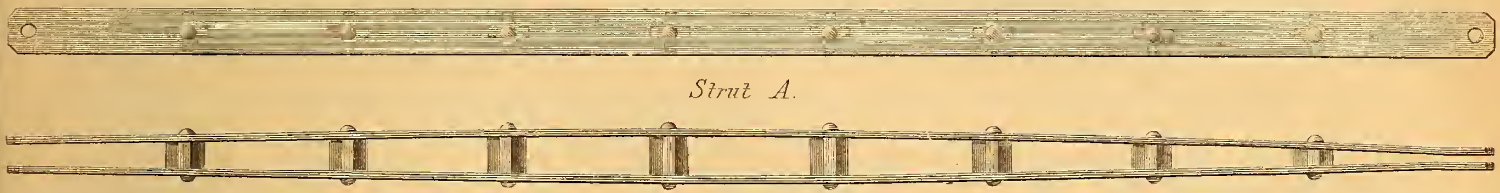
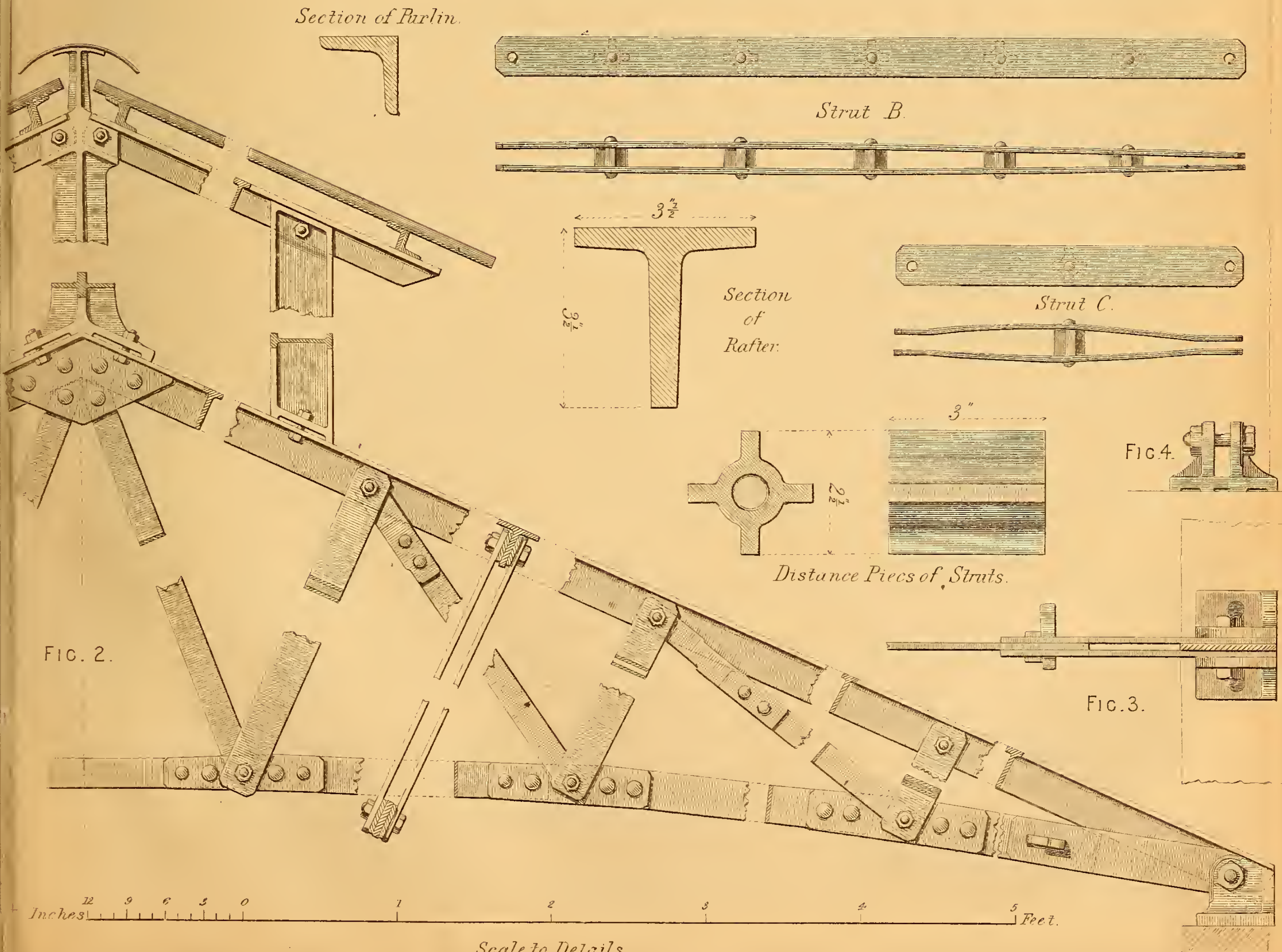


FIG. 1.

Scale to Fig 1.



Strut A.



W. Smith C.E. direx.

# THE ARTIZAN.

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## CIRCULAR VESSELS OF WAR.

(*Illustrated by Plate* 333.)

In Plate 333 we give a series of illustrations of various forms of circular vessels, as designed by Mr. John Elder, of the well-known firm of Randolph, Elder, and Co., Glasgow. The idea of employing a circular ship for war purposes is not altogether new, as the First Emperor Napoleon, when scheming at his celebrated project for invading England, amongst other designs created by his fertile genius, produced an enormous circular vessel. This ship, or rather, floating fort, was to carry an army, and was to be propelled by numerous sails and windmills; but, as might be imagined, its construction was never attempted. Of late years also, vessels of almost every conceivable shape, including circular, have been proposed, but it does not seem that in any instance it was intended that these vessels should serve as anything more than floating forts, acting entirely on the defensive; in fact, from the shape of the immersed portion of the vessel, locomotion, except to a very limited extent, was evidently out of the question.

The chief peculiarity of Mr. Elder's designs appears to be in the form of the hull, which, upon referring to Plate 333, will be seen to be not only circular in horizontal section or upon the deck, but also in vertical section; so that, notwithstanding the fullness of the water-lines, a clean entrance, and equally clean run, may be obtained, through having very fine buttock or vertical lines. In illustration of this fact, Mr. Elder stated, a short time ago, in a paper read by him at the Royal United Service Institution, that he had tried a series of experiments upon the relative resistance in passing through the water of a vessel upon his construction and a vessel of the ordinary form of equal displacement. His method of comparing the resistance of the two different shapes was as follows: he made two models of exactly equal displacement—one similar to a modern ironclad, and one circular—and towed them through the water by means of ropes attached respectively to each end of a scale beam, when he found that the beam indicated an equality of resistance between the two models by standing almost always at right angles to the strain. These experiments were repeated frequently, and in all sorts of weather, the result, as far as could be judged, being that the circular vessel was scarcely so good at high speeds in smooth water, but was much better in every respect in rough water. Of course, as it is well known, experiments upon models are by no means conclusive as to the performance of a large vessel; still they are the most reliable data that can be obtained, especially as the models were of a fair size, the circular one being, we understand, about 5ft. in diameter, and the other in proportion. If a vessel of this shape offers no more resistance in travelling through the water than vessels of the present form, it only requires an equal propelling power to make them travel at the same speed; and this, Mr. Elder considers, may be obtained by means of the hydraulic jet, which, however, we must leave for consideration in a future number of The Artizan.

The advantages of this shape for a ship of war, supposing it can be made to travel at anything nearly equal in speed to existing vessels, are enormous. From the peculiar shape of the hull, the sides (if they may be so called) forming a very acute angle with the horizon, but little heavy armour plate would be required, while, by running a circular bulkhead a short distance from the periphery, its safety would be still further insured. The extreme stability of this form is another great recommendation, enabling it to be employed for a great variety of purposes. The draught of water is only about one-half that of the ordinary shape of vessel, consequently it could be employed in many places where our iron-clads would be useless; this lightness of draught probably accounts for the smallness of its resistance when travelling through the water. The facility with which it may be turned is obvious; in fact, when required, it may be made to act as a floating revolving turret, being caused to rotate as fast as the guns can be fired. This power of rotation might also be employed when the vessel is required to act as a ram, somewhat in the fashion of a gigantic circular saw.

Various modifications of the shape above water may be made as will be seen upon referring to the plate. Thus Fig 4 shews a vessel with a battery of about 100ft. in diameter protected by 10in. armour plate, having also a powerful cutting edge round the periphery. Fig 3 is a somewhat similar vessel but with a rounded back to strengthen the edge for ramming purposes. Fig 1 is intended more particularly for defence, having earthworks instead of iron plating. Fig. 2 illustrates another purpose for which this vessel might be used, viz., to carry a high tower for the purpose of firing down into a fort or over an embankment; in this case the vessel being made 300ft. in diameter for the purpose of greater stability. Fig 5 shows its adaptation for the purpose of carrying large mortars which are so difficult to carry in vessels of the present shape. Fig. 6 shows the battery extended nearly to the outside of the vessel with a raised pilot house in the centre; while Fig. 7 shews the battery extended entirely to the periphery. Fig. 8 shows a vessel carrying four revolving turrets, so that a fire could be kept up upon several spots at the same time. Fig. 9 shows a double tier of guns by which means an enormous weight of metal could be hurled against an enemy. Fig. 10 shews the cutting edge of the vessel beneath the water, a much more formidable position for it, provided the vessel could be driven at a sufficiently high rate of speed. Fig. 11 is somewhat similar to Fig. 6, but with a higher free-board, and Fig. 12 shews a large vessel carrying in addition to a battery near the periphery four revolving turrets above, thus combining an enormously heavy battering power, with facilities for firing at several objects at the same time.

From what has been said we think that it will be evident that Mr. Elder's designs are worthy of attentive consideration, and though at first sight the idea appeared somewhat chimerical to us, the more they are looked into, the more feasible they appear.

## IRON ROOF AT THE INDEPENDENT GAS WORKS, KINGSLAND.

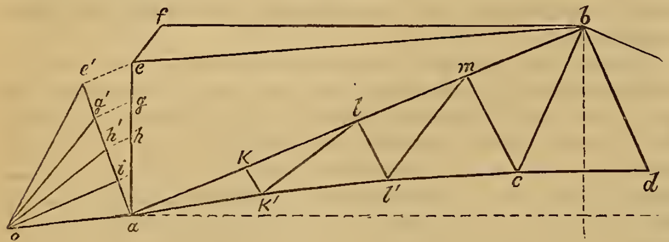
(*Illustrated by Plate* 334.)

Some years ago we published a series of papers on roof construction by Mr. J. J. Birckel in which the theoretical portion of that subject was very carefully investigated; the strains on the several component parts of principals of various systems of trussing generally in use being represented graphically by means of very simple diagrams, and in which the rise of the roof, or rather the rise of the truss, was made the term of comparison for the strains on all the parts of the principals (see The Artizan volume for 1862).

Since then, we have become acquainted with another system of trussing frequently adopted by Mr. Grissell, of the Regent's Canal Iron Works, if not originated by him, which, upon investigation, we find, is lighter and more economical than any other triangular truss that we have illustrated, and consequently we feel quite justified in laying before our readers a practical example of these roofs, by way of supplement to the series referred to.

In these roofs the several struts which support the rafters are parallel to each other and at right angles with the rafters. The main tie as usual is slightly raised out of the horizontal, and the braces or ties of the secondary trusses slope from the bottom of each strut to the top of the succeeding one, except those in the centre of the principal which carry the strain transmitted by the last strut back to the rafters at the crown of the roof.

Having referred the reader to the original series of these papers, we shall not now take the subject up from the beginning, but at once pass on to the explanation of the accompanying diagram, constructed by means of the method of parallel projections, so fully explained by Dr. Rankine in his work on applied mechanics.



The line, $b\,e$, being drawn parallel to the tie rod, $a\,c$, let the vertical line, $a\,e$, represent one-fourth the vertical load on the principal, then the thrust upon the rafter, due to the primary truss is represented by the length of the rafter, and the pull upon the tie rod is represented by the line, $b\,e$.

In order to define the strains arising from the secondary trussing, let $a\,e$ be divided into four equal parts; then $a\,h$ (which contains two of those parts) represents the vertical load upon the joint, $k$; $a\,g$, that on the joint, $l$; and $a\,e$ being one-fourth the vertical load on the principal, that on the joint, $m$. If now the line, $a\,e'$, be drawn perpendicular to the rafter, and the lines $e\,e'$, $g\,g'$, and $h\,h'$, parallel to the rafters, then the lines, $a\,h'$, $a\,g'$, $a\,e'$, will respectively represent the thrust upon those struts. By now producing $a\,o$ in prolongation of the main tie, and drawing $e'\,o$ parallel to the brace, $b\,c$; $g'\,o$, parallel to the brace, $m\,l'$; and $h'\,o$ parallel to the brace, $l\,k'$, these lines will represent the pull upon the braces in the order in which they have been enumerated, and a very interesting circumstance is revealed in the fact of their converging all at the point $o$; $a\,o$ represents the additional pull upon the main tie due to each secondary truss, so that the pull on the main tie is as follows :—

Between $c\,l' = b\,e + a\,o$.
Between $l'\,k' = b\,e + 2\,a\,o$.
Between $k'\,a = b\,e + 3\,a\,o$.

In like manner, $o\,i$ being drawn parallel to the rafter it will represent the additional thrust upon the rafter due to each secondary truss, and the thrust upon them is as under :—

Between $b\,m = a\,b + o\,i$.
Between $m\,l = a\,b + 2\,o\,i$.
Between $l\,a = a\,b + 3\,o\,i$.

If $b\,f$ be horizontal and $e\,f$ parallel to the brace, $c\,b$, then $b\,f$ represents the pull upon the portion, $c\,d$ of the main tie, and $e\,f$ the additional pull upon the brace, $c\,b$, due to the primary truss.

Our plate illustration represents a roof 60ft. 9in. span, erected at one of the London gas works, in which the rafters are made of ⊤ iron, $3\frac{1}{2}$in. × $3\frac{1}{2}$in. × $\frac{1}{2}$in. × $\frac{9}{16}$tbs; the main tie rod of flat iron from $2\frac{1}{4}$in. × $\frac{1}{2}$in. to $3\frac{3}{4}$in × $\frac{1}{2}$in.; the braces also are made of flat iron, $2\frac{1}{4}$in. × $\frac{1}{2}$in.; and the struts, of two bars of flat iron, each stayed together by cast iron washers riveted in between them.

Fig. 1 is a general elevation of one of the principals with purlins (or slate laths) and ventilator complete, where it will be seen that the slate rests directly upon the angle purlins, which are placed at distances of eleven inches, and the slates held in place by means of nails clenched round the bottom face of the laths. The ventilator roof, however is covered with corrugated iron. Fig. 2 is an enlarged part elevation of the principal showing the mode of connection of the main ties, rafters, struts and braces. Figs. 3, 4, and following, show details of the shoes, struts, rafters, and purlins or slate laths.

A number of roofs of this description have been made by Mr. Grissell for some of the London gas works, for Chatham Dockyard, for Messrs. Maudslay's new works at Greenwich, and other places.

The following is a statement of the weight of a principal, 70ft. span, of three different modes of trussing :—

| | | Tons. | cwts. | qrs. | lbs. |
|---|---|---|---|---|---|
| Trussing, No. 1, illustrated in 1862, | = | 1 | 6 | 1 | 13 |
| King post trussing | = | 1 | 6 | 0 | 23 |
| Trussing, as per present illustration | = | 1 | 3 | 3 | 19 |

## THE SUPPORTING POWER OF PILES BOTH OF WOOD AND IRON.

A paper upon the supporting power of piles was read last January at the Franklin Institute (U.S.,) by the Hon. W. J. McAlpine, C.E., and as our knowledge upon this important subject is but very limited we now give it in a condensed form :—

The formula which is generally used to determine the supporting power of wooden piles, is either that of Weisbach or Saunders. In the common range of practice, the results of these two formulæ do not widely differ, but the latter says that his result gives the "safe load" while the former says "that for duration and security such piles are only loaded with from one-tenth of one-hundredth of their strength."

The formula which I have to submit to your consideration is as follows :

$$P=80\ (W+.228\sqrt{F}-1.)$$

Where P represents the extreme supporting power of the pile in tons; W, the weight of the ram in tons, and F the fall of the ram in feet.

This formula was derived from a number of experiments, made upon piles driven for the foundation and coffer-dams of the U.S. Dry-Dock at Brooklyn.

The structure weighed fifty thousand tons, which had to be supported on an area of forty thousand square feet; but the weight could not be equally distributed, and some portions of the foundation had to sustain a weight of three or four tons per square foot. The material as developed by the excavation, preliminary borings, and subsequent examinations to a depth of sixty feet below the foundation, was a silicious sand mixed with comminuted particles of mica and a little vegetable loam, sand was generally encountered in the form of quicksand. The material into which the foundation piles were driven was nearly uniform in character, which furnished an excellent opportunity of comparing the experiments made at different times, with hammers of different weights and falls. It may be interesting to state, that the whole number of bearing piles driven for the foundation was 6,539 and 1,744 sheeting piles, acting in part as supporting piles, which gives nearly 1·7 piles per square yard, or excluding the sheet piles, 1·4 per square yard. These piles were chiefly of spruce timber, from twenty-five to forty feet long, and averaged thirty-two feet driven length. They were from twelve to eighteen inches diameter at the head, and never less than seven inches at the foot. They were banded with iron, and occasionally shod, but shoeing produced no increase of penetration. The average number of blows given to each pile was seventy-three. The average distance moved by the first five blows was eight inches at each blow, by the middle five blows, three inches at each blow and by the last five blows from two inches to no movement at each blow. When from any cause the piles went more than an inch at each of the last five blows, another was driven in the centre of the quadrangle, and it was found that this so compacted the material, that the adjacent piles were immovable under the effect of almost any number of blows, of a ton, ram, falling thirty feet. In other words, all of the piles were driven "home," or equivalent to such home driving. The Nasmyth hammer, it is true, produced a deeper penetration of perhaps ten per cent., but under its persuasive powers, the strongest and toughest timbers yielded. A record was kept of the distance moved by each blow, on every pile used in the structure, and the weight and fall of the hammer. The piling machines were unusually well made, so as to reduce the friction of the hammer in its fall, and facilitate the operations. The leaders were generally thirty-five feet long, though there was one of fifty-seven feet. The hammers were generally of a ton weight (2,240 pounds), but there were some used ranging from a thousand to forty-five hundred pounds. The experimental piles were selected so as to show the effect of the size of the pile, the weight and fall of the ram, and the rapidity of the blows, as determined by the record before alluded to. The analysis of these experiments showed the following general laws :—

1. That when the height of the fall of the ram was increased, the sustaining power of the pile (driven home) was increased in the ratio of the square root of the fall.

2. That when the weight of the ram was increased, its effect was to increase the sustaining power of the pile by 0·7 to 0·9 times the amount of the ratio due to such increased weight.

3. That when piles of the same size were driven by the same hammer and from the same height of fall to different depths, their sustaining power was in the ratio of the squares of their frictional surfaces of penetration.

4. That a pile driven home by a hammer of a ton weight, falling thirty feet at the last blows, in such material, would sustain as many tons as there were superficial feet of exterior surface of the pile in contact with the earth, which, however, may be considered as excluding the support due to its sectional area.

The formula above stated is based upon these laws (excluding the third) and the co-efficient is reliable for such material as was found at that place. It is very desirable that similar experiments should be made in soils of different kinds, which would make this formula applicable to all the usual cases met with in construction. I have made experiments elsewhere, but unfortunately they were in soil too nearly similar to the above, to enable me to give any new co-efficients. They served to show the general accuracy of the formula given. I may here remark, that the circumstances of each particular case must determine how much of the absolute sustaining power should be deducted to show the load which can be safely imposed upon the piles. When there is no danger from the vibration of the structure being communicated to the piles, nor from the scouring action of the water, they may be safely loaded with one-third of the weight determined by the formula. The sustaining power of a pile driven home, the resistance which it meets with, and the force of the blow are, of course, equal. The subsequent subsidence of the material around the piles, however, increases its supporting power, and this varies in different kinds of soil. This increased support cannot, however, be relied upon, if there is any subsequent vibration in the piles or scour around them.

In foundations under water, there will be a degree of fluidity given to the material by the operation of driving, which lessens the frictional resistance to the penetration of the pile; but the superior gravity of the sand to that of the water, allows it to settle in close contact with the pile, and gives a great co-efficient of support, than if it was driven through the same kind of material in a dry state. In comparatively slender elastic wooden piles, the vibrations caused by the blows enlarges the passage and loosens the material in contact with the sides, and although these vibrations absorb a portion of the force of the blow, they probably increase the penetration. Wooden piles are used under the following conditions, each of which should be separately considered :—

1. To compact a soil which is not quite firm enough alone to support the superstructure.

2. As columns of support, where the material immediately below the structure is very loose, and is underlaid by a firm material; and,

3. Where the support is mainly expected from the adhesion of the adjacent material to the pile.

The first of these conditions need not be here discussed; and in regard to the second, it is only necessary to caution the young engineer that it is one of the most unsafe and dangerous kinds of foundations that he can use. In concluding this branch of the subject, it may be added, that, with a given power, a considerable advantage is given by increasing the weight of the ram, and, with a corresponding force of blow, less injury is done to the timber and to the iron rings. Also, that there is no increased force of blow obtained by a fall of more than forty feet, as the friction on the ways is increased so rapidly that no increased velocity is attained by falling from a greater height. In machines less well made than those at Brooklyn, the limit of useful fall is probably thirty feet or less.

On comparing the results of the Nasmyth machine with those of the ordinary ones, it was observed, that although the force of its blows was much less, the effect was much greater. With the former, a pile of thirty five feet length was driven home in seven minutes, while with the other machines, an hour or more was required to drive a similar pile. The first part of the operation did not exhibit so marked a difference between the two machines as was afterwards shown, while the piles were meeting with greater resistances. In the first case, the force of the blow in each machine was in part absorbed by the vibrations of that part of the pile above ground; while in the latter, these vibrations, for the instant, removed the partially fluid earth from contact with the pile. The blows of the Nasmyth ram were given at intervals of less than a second of time, and before the material displaced by the vibrations of the preceding blow had had time to subside, and therefore nearly the whole force of its blow was employed in the displacement beneath the pile. In the other machines, the blows were given at intervals of a minute, by which time the vibrations had ceased, and the material had partially subsided around the pile, so that a considerable portion of the force of the blow was consumed in overcoming the friction along the sides, and in the removal by new vibrations, leaving only a comparatively small portion of the force to displace the earth at the bottom. This effect would probably be produced in nearly all descriptions of earth, although it would be greater in loose and partially fluid material, than in clay or compact soil. The use of the Nasmyth machine demonstrates the value of quick blows, not only in the economy of driving, but also in obtainig a deeper penetration, which is often very desirable. The comparative cost of driving by the use of different kinds of power is nearly as follows:—

| | |
|---|---|
| By steam with the Nasmyth ram | 5 |
| “ “ ordinary machines | 9 |
| “ horse-power with “ | 12 |
| “ man-power—tread-wheel | 15 |
| “ “ cranks | 20 |

And these sums represent cents. per lineal foot of pile driven in 1846. In February, 1861, I made some experiments to determine the supporting power of a large iron columns considered as piles—that is, of the external frictional resistance. I regret that the circumstances of the case did not warrant the extraordinary expenditure necessary to determine the absolute sustaining power of iron piles, but it is interesting to know, that the piles sustained a load of 716 pounds per square foot without any movement, at a time when the material around it had been for weeks disturbed and loosened by the constant escape of air from the pneumatic process, which was being carried on at another column but six feet distant. I am of the opinion that this column would have sustained double this load before it would have moved; but for safety I have assumed half a ton per superficial foot of the exterior frictional surface of iron piles, which is one-half as much as I ascertained that wooden piles would bear. The frictional resistance depends upon the extent of the surface in actual contact, which in the minute particles of sand at the Navy Yard, must give the largest co-efficient. At Harlem the silting of the same kind of fine sand between the interstices of the gravel and stone, would also give a large co-efficient, but probably not as great as the former. The angular particles of the sharp sand would probably be indented into wooden, but not iron piles and, together with the less regular surface of the former, would increase its frictional resistance. A careful consideration of these circumstances, as well as of the experiments, confirm the opinion above expressed. I will now state how these experiments were conducted; the main beam of the lever was a stick of Georgia pine, 60 feet long, averaging 18 by 16½ inches. The short arm was 4 feet long; the bearing points were turned steel rollers, 1½ inches diameter and 12 inches long, set in and bearing upon cast iron plates, also bored out. The lever was strongly trussed by a king-post of oak 9 feet high and 13 inches square, resting on a cast iron block, and arranged with folding wedges at the bottom, to strain the truss to its bearings. A heavy cast iron saddle was fitted to the top of the post, through which passed a large turned iron pin. The long truss rods were two bars of iron 2½ by ¾ inches, and the shorter rods of three pieces of 1¼ inch iron. connected to a joggle by two links of iron, and by lugs of iron on a heavy plate on the main beam, and another heavy plate of iron was placed near the outer end of the main beam, to which the long truss rods were attached or hooked on lugs. The truss was calculated to allow a strain of 150 tons to be placed upon the column, but was strong enough to have allowed twice that strain. The leverage being 14 to 1, would have brought an uplift of 2,000 tons on the fulcrum. The works were carried on in the middle of the river, from a temporary platform of piles which would not have borne this load, and therefore we had to depend upon the combination of such load as the platform would bear, the resistance of its piles to an uplift, and a series of trusses, by means of all which the tenacity of nearly forty of the platform piles was obtained, and, in a later experiment, by using the weight and resistance of a large iron column already driven a short distance into the earth. But the constant escape of the condensed air into the earth of the river-bed, had so loosened the hold of these platform piles, that they yielded when the uplift pressure reached seven hundred tons, and, to our regret, the experiment had to be discontinued, almost at the point when it would have fully demonstrated the problem so earnestly desired.

I am now desirous of calling attention to the value of iron piles for foundations in deep water, and where the use of wooden piles is objectionable.

To illustrate my views, I propose to take for an example the case of our western rivers, where many bridges are now being proposed for railroad crossings, and where the like difficulties occur, as in crossing many of our Atlantic coast estuaries.

The engineer, before commencing the construction of such a bridge, will study the stream well and ascertain the greatest depth of water which its freshest currents produce, not only at the site of the proposed bridge, but far up and down stream. He knows that no obstruction can be placed in a stream like that of a series of bridge-piers, for producing the greatest scour, and especially if an ice or driftwood gorge should occur at his bridge, to which it is peculiarly liable, from the frequency of the obstructions, extending entirely across the channel. Will wooden piles afford a safe foundation for such a structure? The sand of the river-bed, although so easily removed by the water, strongly resists the penetration of piles when driven in the ordinary manner. The timber is not strong enough to resist the force of a blow, or rather, the resistance of a penetration of more than twenty-five feet, though perhaps the Nasmyth machine would obtain one of thirty feet. One-half of the piers would probably, and some of them would certainly, have to be founded on one of the bars in shallow water. If the water was in this case five feet deep at low water, and a scour of twenty-five feet only should take place, the piles would be washed out. If a pit should be dredged say to twenty feet below low water, and the pile be forced to penetrate thirty feet, and a scour of thirty feet should occur, the piles would have lost $\frac{5}{9}$ths of their supporting power, and their number must be accordingly increased. It would then appear that the limit of the use of wooden piles for the foundations of piers under the assumed circumstances, is when the scour of the river will not reach to a depth of thirty feet below low water. But I turn from this subject to the substitution plans, viz., the use of iron piles for foundations, or of large iron columns, which will not only form the piers themselves, but also their own foundations.

If the sand is free from logs and stone, then small piles may be used say of one foot diameter, with expanded iron bases. Assuming that the weight of the pier, superstructure and load, is fifteen hundred tons, and that such piles are driven to a depth of sixty feet below low water, with the a scour of thirty feet, the external frictional surface of the remainder of pile and the area of the base, will afford a sustaining power which will require about thirty piles to carry the load with safety. If logs or stone are encountered, the iron columns must be enlarged sufficiently to allow the workmen to descend them, and remove or cut away the obstruction. The least diameter which will permit of this descent is thirty inches, and in this case there must also be provided a working chamber at the bottom, of probably five feet diameter. This chamber can be made by a conical instead of cylindrical pipe at the bottom, which must be made thicker than the other parts of the column, as a greater part of the load will be carried by it, with a strain partly across the shell. It may, at first, be supposed that the column with this shaped bottom, will be more difficult to drive, but it will be seen that with any process of interior excavation, the column in this shape will descend with even more facility than if cylindrical. In addition to the increased bottom support which this expanded base of iron will give, the concrete filling may be extended below the bottom of the column from four to six feet, and also beyond its external lines from two to three feet, thus giving a further expansion of the base, equal to eight feet or more in diameter. Nine such columns will bear the assumed load with safety.

It will be observed that the iron piles and columns derive the largest portion of their support far below any possible action of the river currents, and therefore, that they may be relied upon for safely carrying the structure under the most unfavourable circumstances. The first use of this system was a process patented by Dr. Potts, to found a lighthouse on Goodwin Sands. It consisted in exhausting the air from the hollow iron pile, and then the pressure of the atmosphere, the weight of the pile, and sometimes that of an added load, caused it to penetrate into the sand. The bridges at Rochester and Peterboro' and some others in England, as well as those in this country, were all commenced upon that plan: but, while it answered very well for small piles in a sandy bottom, it was found, inefficient with large piles, and of no value when they encountered, in their descent, logs, stone, or even a compact material. Messrs. Cubitt and Hughes, the Engineers of the Rochester Bridge, 1849, and Messrs. Gwynne and Fleming, the Engineers of the Pedee Bridge, a year later, changed the process from the vacuum to a plenum: and the latter will now be more particularly described as I employed it at Harlem. The pile consists of a number of hollow cast iron cylinders, 6 feet in diameter, $1\frac{1}{4}$in. in thickness and nine feet in length, provided with flanges on the inside, by which they are bolted together, one on the top of the other, until the desired length is obtained. The lower cylinder is chamfered at the lower edge down to about a quarter inch thickness. From a platform on temporary wooden piles or large scow boats, a derrick is placed, which suspends the column and lands it with the sharp end on the bottom of the river in the place where it is to be driven. Another cylinder, called the air-lock, is placed on top of the column, usually made of boiler iron sides, of the same diameter as the columns, with a top and bottom plate of cast iron, in which are man-holes, that can be closed at pleasure by plates, with hinges opening on the lower sides, and lined with rubber at the joints. In the top and in the diaphragm or lower-plate, are cocks, usually two inches in diameter. Leading from the outside of the air-lock near its bottom, are two curved tubes, four inches in diameter, which also pass through the diaphragm and are closed by cocks. The air-lock is bolted to the top of the column. Small air-pumps, usually worked by a small steam-engine, are connected with one of the curved pipes in the air-lock, by means of a flexible four-inch tube. The lower man-hole plate is then closed, and air is forced into the column. With the first stroke of the air-pumps the operation of compressing the air commences, and as this pressure increases, it forces the water out through the open bottom. This continues until the pressure of air equals that due to the head of water outside the column, and the water has all been forced outside. The workmen then enter the air-lock, and, closing the upper man-hole, a cock is opened in the lower diaphragm, and the compressed air from below is admitted. When the pressure has become equalized, the lower man-hole plate falls, and the workmen can pass down on ladders to the bed of the river to excavate the material, which is raised in canvas bags to the air-lock, by means of a drum, the shaft of which passes through stuffing boxes to the outside, where it is worked by hand, on signal. When the column has been entirely cleared down to the bottom, care is taken to see that no obstructions, such as boulders, logs, etc., remain under the rim of the column, and the workmen ascend into the air-lock, and, closing the lower valve, the compressed air in the air-lock is allowed to escape through a cock in the upper plate. When the air in the air-lock has become equalized with the atmosphere, the upper valve falls, the men pass out and the bags of material are removed. Men are then stationed at the guy ropes and the four-inch cock in the curved pipe is opened, and the compressed air in the column allowed to escape quickly. The upward pressure of the air in the column, on a surface six feet in diameter, neutralizes the weight to an extent which is governed by the depth of the bottom of the column below the surface of water. By allowing the air to escape quickly, in the manner mentioned, this weight is suddenly restored, with an effect similar to a blow, while, at the same time, the rapid inrush of water at the bottom, causes a complete scouring of the material at and under the sharp rim of the column, and the resistance to driving the column is simultaneously removed. The friction of the outside of the column against the material through which it penetrates, is greatly diminished by the current of water passing along its surface from the river, on its way downward to the inside. If no rocks, trees, or similar obstructions are encountered, the column will continue to settle quite rapidly during the time the air is escaping, and afterwards, until the material has stopped scouring under the edges, and has compacted itself under the pressure of water sufficiently hard to sustain its weight. The amount of settling in one operation will frequently amount to ten or twelve feet, or even more. When boulders or logs are met with, the column stops, and it is then recharged with air. The workmen descend and remove the obstruction, and the process already described, is repeated. In this manner columns of the largest dimensions may be sunk to depths of a hundred feet, or perhaps still deeper.

The question has been raised, whether life can be be supported at such great depths, and many engineers speak of the ill effect upon the health of their workmen: but this is contrary to my own experience and that of my brother C. C. McAlpine, who entered the columns daily and remained there for several hours at a time, while conducting some of the more important and delicate operations required. The greatest depth at which we have been under water was over fifty feet. The pressure due to this depth was about 22 pounds to the square inch over the atmospheric pressure; or, with the latter, added, 37 pounds; but this again was frequently increased by the extra pressure required to drive out the water through the compacted material around the outside of the column, so that the pressure was often increased by as much as an additional atmosphere, or about 52 pounds per square inch in all, equal to a depth of about eighty-five feet below the surface of the water. After entering the air-lock it was closed against the atmosphere, and the pressure equalized with that in the column, in the manner that has been already described: and this operation, and the other one of equalizing with the atmosphere when passing out of the column, were the only times when difficulty on the part of the workmen was experienced. Men of certain kinds of constitution sometimes suffered greatly; the blood starting from the nose, ears, and mouth, and the pain of changing pressure being almost insupportable upon the eye-balls and drum of the ear. These men were usually of a very nervous temperament, and excitement would induce them to keep their nerves under great strain, which added to their difficulties. No trouble was experienced in procuring men, however, who could bear the pressure perfectly well without injury. A little practice and familiarty soon accustomed them to the circumstances. The muscular action of swallowing would always relieve the ear drum, temporarily, from pain and pressure; but, after a little practice, even this was found to be seldom necessary. With new men the pressure would be let on gradually; but those more accustomed to it did not hesitate to equalize as fast as their means of doing so allowed, or in a space of less than a minute. The pressure once fully on, it would be difficult, from bodily sensations, to determine a difference of pressure amounting to at least one atmosphere. The effect, while under pressure, is to cause a feeling of exhilaration, so sensibly felt by the workmen that a lazy man becomes industrious, and there is seldom occasion to urge any of them in their work. The ventilation is of course, excellent, and the operation of breathing becomes so easy, that the inhalations are slower and shorter than in the usual atmosphere. Upon leaving the column and again entering the ordinary atmosphere, the absence of the stimulus of so much oxygen produces a certain degree of lassitude for a time, unaccompanied, however, with any other difficulty. It could not be observed, either in our case or that of the workmen, that in an experience extending over a year, any effect prejudicial to the health or constitution was produced. I have already alluded to the extension of the concrete filling below the bottom of the column, and to its lateral expansion beyond its vertical lines. I believe that this has not been used in any similar work, and as it so much increases the supporting power of the column at its greatest depth, and at so small an expense, I have thought that a more particular description of the method adopted by me would be interesting, particularly as it has been questioned by those who have not tried it, whether this extension and expansion was practicable in all situations. I will first call your attention to the increased support which this expanded base furnishes. In a column of three feet diameter, with an expanded iron base of six feet, and a further expansion of the concrete filling to ten feet diameter, and driven forty feet into the earth, the external frictional support would be about 180 tons, and the support from the bottom areas from four to eight hundred tons. This increased support of three to seven hundred tons, would be obtained by an expenditure of less than a hundred dollars. The extension of the concrete filling downwards, must, of course, be proportioned to its lateral expansion; that is, the thickness of the concrete beneath the outer periphery of the column must be increased, to bear the increased load which its expansion laterally will enable to be placed on the column.

Treated as a column, a tube of three feet diameter, three-fourths of an inch thick, and fifty feet long, between the bridge seat and where it is secured against lateral momvement by the surrounding earth, would sustain say seven hundred tons with safety; and, if desired, ribs may be introduced, which, with its flanges, will double or treble this strength. The method adopted at Harlem at first, was when the column had been driven to the required depth, to drive under its exterior periphery, wooden sheet piles, five feet long, three inches wide and one and a quarter inches thick, on an angle of thirty degrees; but only in sections of a few feet in width at a time. These sheet piles acted merely as a roof or support to the sand above, and if the air presure had been kept up for a day and night beforehand at an extra pressure, it drove out the water from the sand and permitted the excavation to be made in nearly dry earth. This excavation, however, must be performed rapidly, that is, within two or three minutes, or otherwise the pressure of the water and the weight of the superincumbent sand, which then becomes rapidly suffused with water, forces its way through the roof. If the excavation and concrete filling is quickly done, the operation will always be successful. A little experience on the part of our workmen enabled them to judge whether the earth was in proper condition to give success. This operation was confined to a small section at a time, and these sections were never undertaken contiguous to each other, but always on opposite sides of the circumference of the column. When a ring of concrete had been put in by the means above stated, it formed an actual prolongation of the depth of the column, and that part of the concrete under it could be extended several feet deep without encountering the water. The material which was encountered at Harlem in several places, was very fine sand, which is the worst that could have been met with, and therefore I feel assured that this method may be practised under almost any circumstances that would be likely to occur. Towards the end of our operation our men became so expert that they would extend the concrete three feet beyond and four feet below the iron column, in fine sand without the use of roofing. It has been stated that our hydraulic cement will not set in the concrete in these columns. While this is true of concrete, put in large masses at a time, when properly put in, the concrete will set even better than in open air. The cause of this failure is, that the surface sets with extraordinary rapidity in the highly condensed air, and when the concrete is put in, in large masses, the moisture from the interior has no opportunity to escape, and consequently, it remains in a pasty condition. To remedy this I used small tubes of iron, passing down through the concrete, vertically, to beneath the bottom, and perforated on their sides, by means of which a film of air was interposed between the exterior water and the concrete, and the condensed air was circulated through the mass of the latter and absorbed its excess of water, and caused the whole mass to set quickly and very strong. Difficulties have heretofore been met with in the placing of the column and keeping it accurately in position. There is no occasion for this. If practicable, they should be driven from a platform and not from a float. The bottom of the column should be placed in its precise position, and if care is exercised to keep it plumb while being driven, there is no danger of its divergence at the bottom. In several cases we encountered the edges of sloping rocks, which did not change the exact perpendicular descent of the column. The columns at Harlem were driven with almost perfect accuracy: none of them varied one inch from the position designed. The delay and difficulty of driving them through logs and boulder-rocks is much less than might be anticipated. In one of the columns a succession of boulders was encountered, over thirty in number, nearly all of which were so large or so situated, that they had to be cut through. These very unusual obstructions did not delay the sinking of this column more than a fortnight. In another case a column was driven through the hull of a sunken vessel, when the timber was extraordinarily tough and strongly bolted. This delayed us but two days. We also cut off some very large oak logs. The cost of removing the excavation from one of the columns was seventy-five cents per cubic yard, though generally it cost double that sum. The indraft of sand was about three times the displacement of the column; though as we acquired experience, we were enabled to materially lessen the indraft. The force employed upon the various parts of the work was as follows:—

1 Foreman and 3 men within the column.
1 Superintendent, 2 riggers and 4 labourers outside.
1 Engine-man and 1 fireman.

The time occupied in the driving of the columns an average depth of twenty-five feet below the bed of the river, in sand, gravel, boulders and timber, expanding and sealing the bottom with concrete, was from seven to twenty days for each column. The lowest of these figures representing the time required for those presenting but few difficulties or obstructions, and the highest number of days the excess of time required to overcome the most serious difficulties.

Generally the water was expelled from the column through its open bottom, but sometimes the earth became so compacted by subsidence, or a stratum of clay was encountered, which presented a barrier to the passage of the water in that direction.

In this case it was forced up through a syphon-pipe within the column, and discharged through a curved pipe into the atmosphere near the bottom of the air-lock. This syphon-pipe was also used as a sand-pump to discharge the material from the column. Although successful and economical, it was attended with too much hazard to the lives of the men within the column to warrant its use. The rapid consumption of the oxygen of the air whithin the column by the use of lamps, led us to devise plans for sending down through the bull's eye glasses, reflected light. For this purpose we used common mirrors, which reflected the sun's rays; and the success of that plan demonstrated that sufficient light could be furnished artifically and reflected into the column, to answer all requirements. During the winter, when the thermometer fell below zero, the workmen complained of cold, and the air forced into the column was first heated by the exhaust steam, discharged into a register. In midsummer they suffered from the intense heat, which rose to above 100°, and this was moderated by allowing the spray from a stream of water to fall upon and be evaporated from the sides of the cast iron column above the water. A reduction of from 10 to 15 degrees was thus effected. I have understood that elsewhere work on such columns had to be abandoned during the day, from the excessive heat within the column. The condensation of the air converts the latent heat in the atmosphere into a specific heat, and raises its temperature ten or fifteen degrees, and when the air was again allowed to escape, it brought the thermometer, placed in the line of its exit, nearly down to the freezing point. The capacity of the atmosphere for the retention of moisture was beautifully illustrated within the column, when from any cause the pressure of the air was suddenly relieved, which produced a dense fog and deposition of moisture.

The power used for condensing the air was an imperfect six-horse engine, and sometimes the operation in hand required more power than this engine could furnish. We therefore sealed the top and bottom of one of the empty columns, and kept it charged with air at a high pressure, and by means of a flexible pipe to the column which was being sunk, we availed of this additional power. This reservoir of power was of great advantage in some of the operations, as we could charge the column a second time instantly with air, after it had ceased sinking by the ordinary process, and repeat the sinking process, while the earth adjacent to it was still loose; and it also gave us complete command of the descent of the column, so that we could at any instant check it at the desired point. The mass of metal which we were handling weighed nearly fifty tons, and with this adjunct we could almost instantly destroy its gravity or restore it at will. It was grand to witness this huge iron tube commencing its descent into the river, at first slowly, but increasing in velocity by its momentum, until it became almost dangerous, when at the turn of one's wrist it was slowed; again it was started and again arrested, and so, by repeated plunges, until it was finally brought up within an inch of the desired depth. The Harlem work developed two most important points, not hitherto applied to this system of foundations, viz: the large increase of the supporting power by the expanded concrete base, obtained at an insignificant expense, and the increased effect in driving by the use of the air reservoir, as well as the complete control which it gives on the descent of the column. The duration of the metal under water has been a subject of inquiry. It has been alleged that certain kinds of cast iron, immersed in acidulated water, undergo an entire change and lose their strength, and it is inferred that foul and salt water will produce the same change to some extent. This change is confined to graphitic iron; but when the metal is combined with carbon, as in the white iron, no such change occurs; and as this combination is more and more complete so does the iron become less liable to this change. The white and the mottled irons are subject to a slight oxidation when placed under water, but this corrosion is limited to a trifling depth, and it has been asserted that such slight oxidation prevents any further action on the metal. The result of numerous experiments show that with moderately hard iron, the corrosion in salt water will not exceed one-tenth of an inch in a century, and in fresh water will be inappreciable.

## LIQUID FUEL.

The substitution of liquid fuel for coals is attended with so many advantages that it is not a matter of surprise that it is constantly the subject for new inventions, all of course having for their object the perfect, and consequently the most economical, combustion of such fuel. Perhaps the most successful method, if the results as recorded can be considered accurate, is the Aydon system as designed by Mr. Aydon, of the firm of Wise, Field, and Aydon, an engraving of which is given below. The apparatus is very simple and can be easily fitted to any boiler without making any alterations in the furnace. In the engraving fig. 1, is a sectional elevation, and fig. 2 a sectional plan of the apparatus as used in compound furnaces, or those in which either oil or coal can be burnt, and is fixed above the furnace door. The oil is allowed to flow through the pipe B, and as it runs out at the end of this pipe it is blown into fine spray by a jet of steam (by preference superheated) which is conveyed from the steam chest by the pipe A. The steam is regulated by a tongue piece C, which can be nicely adjusted by means of a screw at the back end as shown in the engraving. A short piece of pipe D is fitted on the front end of the apparatus to conduct the spray in the required direction. The following data of some of the performances of this invention has been supplied by Messrs. Wise, Field, and Aydon:—Trial at Messrs. Barnes, Hackney.—Galloway Boiler—2 furnaces, time 248 hours; water 50°. Total amount of water evaporated, 51,456 gallons; ditto per hour, 208 gallons. No. of pounds per hour at a pressure of 35lbs. 2,080lbs. Oil burnt per hour = 95·8lbs. Water evaporated per pound of fuel = 21·71lbs. Reduced evaporation as per Mr. Rankine's formula, 25·3lbs. of water per 1lb. of oil burnt. Cornish Boiler, Hackney.—This boiler previously burnt 3 tons Welsh coal per 24 hours. Time of trial for oil from March 7th to March 14th, 1868. The oil used in 168 hours was 768 gallons, or 109 gallons per 24 hours, or 4·5 gallons per hour. Water evaporated or expended 32,928 gallons, or 1,960lbs. of water per hour by 46lbs. of oil — ∴ 1,960 ÷ 46 = 42·5lbs. of water evaporated per 1lb. of oil, at 32lbs. pressure, which amount reduced by Mr. Rankine's formula gives 46lbs. of water evaporated per 1lb. of liquid fuel.

FIG. 1.

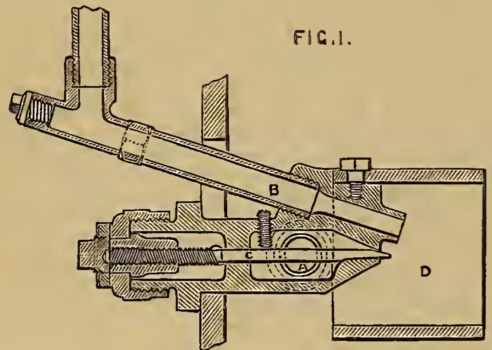
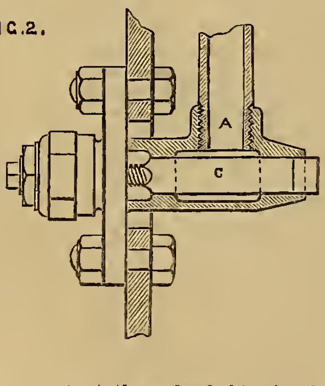


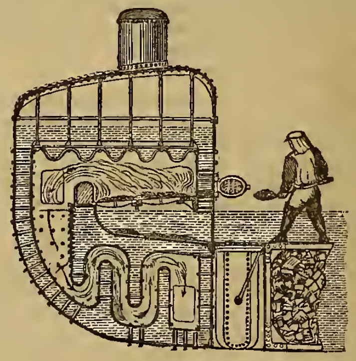
FIG. 2.



It will be observed that the evaporative power of the liquid fuel given above is very great, in fact so much larger than anything previously heard of that it would be very desirable to have some trials made with greater nicety than could be done with a boiler in regular work.

## IMPROVED MARINE BOILER, BY THOMAS DUNN, MANCHESTER.

Amongst the many and various inventions of Mr. Dunn, steam boilers are conspicuously represented, and one of the latest of his inventions in that direction is now illustrated. It will be seen on reference to the engraving that the furnace instead of being in the usual position, near the bottom of the boiler, it is here placed as high as possible. Mr. Dunn's idea being that when a large body of water is above the furnace, a considerable quantity of steam is condensed in struggling to the surface. The down draught adopted here is also considered beneficial, and admits an easy method of supplying air behind the bridge for consuming the smoke.



Another advantage which he claims for this boiler is the height of the stokehole by which arrangement the boiler may be fired when the vessel is half filled with water; this no doubt is an enormous advantage in some cases of leakage, &c., where possibly a ship might be saved by being enabled to steam the few additional hours. We notice also that the crown of the fire box is corrugated, which gives greater heating surface and increased strength, this, however, can scarcely be considered a novelty.

## PURIFICATION OF SEWAGE.

An interesting and important experiment in the purification of sewage was lately made, at the sewage works of the Tottenham board of health. Some time ago an injunction was granted, for the purpose of restraining the further discharge of the sewage of Tottenham into the River Lea. The consequence was that the board came to an arrangement, in accordance with which they undertook to discover by experiment, and as soon as possible to adopt, the best mode of deodorising and purifying the liquid matter. Two plans have been already tried, but the purifying fluid which was then brought into requisition was the patent of Mr. C. G. Lenk, of Dresden, and was a peculiar preparation of alum. The immediate effect of adding this preparation to the water to be purified is to precipitate the solid and organic contents, the water gradually becomes clear, and any offensive smell disappears. The experiment was made in the presence of Dr. Hall (chairman), Dr. Brickwell, Mr. Clarke, members of the board of health; Mr. Marshall their engineer; Mr. Lenk, the inventor, &c. The system hitherto adopted by the Tottenham authorities consists in the discharge of the sewage into a large tank about 50 feet long by 20 in width. Lime is thrown in, and the stuff is gradually allowed to settle until the solid parts sink to the bottom. The surplus fluid is then discharged into the river, and the residuum is utilised as manure. This mode has proved altogether inefficient. Not only does it render the manure comparatively valueless, but it does not destroy or mitigate the poisonous properties of the water discharged into the Lea. The consequence is that the board of health is deprived of a large income which might be employed for local improvements, and that the river is polluted so as occasionally to be a nuisance and a source of danger. Mr. Lenk's "Patent Essence," as it is termed, operates very differently from the defective system just described. 26,000 gallons of sewage were discharged into the tank, and into this were gradually poured about sixty gallons of the "Patent Essence." At first the smell was most offensive, and nearly intolerable, but as the chemical preparation mixed with the liquid the odour perceptibly decreased. After some time a remarkable change was visible in the contents of the tank. The solid substances were precipitated to the bottom, the water on the surface became gradually clear, and at the end of an hour it was found to be, not only transparent, but almost clear, by contrast with its condition when discharged from the sewer. Mr. Leunig, the agent, is so confident of the purifying power of the fluid that he is ready to enter upon experiments on a far larger scale with a view to the possible solution of a problem which has long puzzled sanitarians.

## THE ALEXANDRA DOCKS, NEWPORT.

On 28th of May the ceremony of cutting the first sod of this important undertaking was performed by Lady Tredegar.

The undertaking, as originally proposed, involved a capital outlay of 600,000*l*, but at present it is only intended to proceed with one of the still-water docks, leaving the second one until financial matters assume a more favourable aspect. The outer dock will be of the following dimensions:—Length between gates, 350ft.; breadth, 65ft.; and divided by a pair of intermediate gates, so as to form two locks or one great lock. Vessels of 1,800 tons, or steamers of 2,500 tons drawing 23 feet water, will be enabled to enter or leave over an average period of three hours on every tide throughout the year. The dock is to be 1,500 feet in length, and 500 feet in width, having an area of 17¼ acres. The depth of water over the cills will be 35ft. average spring tides, and 25ft. neap tides. A graving dock, 350ft. long and 65ft. wide, communicating with the outer dock, is also to be constructed. On the west side of the dock, cranes for discharging ballast, and a double staith for stiffening vessels with coal, will be erected, and the north end will be used for the purposes of the import timber trade, and for erecting warehouses for bonding. The west side and the north end of the inner dock will be occupied with coal staiths, and there will be adequate siding room on the low level to accommodate a large trade. A portion of the east side will be devoted to the iron trade. Power has been taken to abstract water from the River Ebbw, by which the use of tidal water will be to a great extent dispensed with, thereby avoiding much inconvenience and expense. The docks will be connected with the entire railway system of the district in the most convenient manner by means of six intended branch lines of railway; 161½ acres of land, exclusive of water area, have been secured for the purposes of wharfage, sidings, warehouses, &c., also 93 acres adjoining the River Ebbw, for deposit of ballast. The company will also be enabled to take, at any future time, 213 acres to the south of the present site for further dock extension. These docks have been designed by Mr. Abernethy.

## ROYAL GEOGRAPHICAL SOCIETY.

### LAST MEMOIR ON ABYSSINIA; ANTALO TO BESHILO; AND TOPOGRAPHY OF MAGDALA.

By Mr. C. R. Markham.

On the 6th ult. a paper was read by Mr. C. R. Markham, who has just returned from Abyssinia, having accompanied the expedition as the geographer of the society. The paper, which was entitled "Last Memoir on Abyssinia; Antalo to Beshilo; and Topography of Magdala," was a most elaborate document, containing valuable information with regard not only to the geography, but also the geology, agriculture, metrorology, &c., of the country. We make the following extracts:—

The paper commences with a general account of the features and formation of the country between Antalo and Magdala, which it describes as being a mountain region entirely composed of volcanic rock, but divided into two very distinct parts by the River Tacaze. That of the north is an elevated ridge crossed by several lofty ranges of mountains, and that of the south is a plateau of still greater height, cut by ravines of enormous depth. The former contains the source of the Tellare, a chief affluent of the Tacaze and those of the Tacaze itself; the latter is drained by the principal affluents of the Blue Nile. From Senafe to Antalo the rocks are almost all aqueous or metamorphic, with a few trachyte and basaltic boulders on the surface, but to the southward of Antalo there is a considerable change, which is not confined to the geological features of the country; the scenery becomes grander, vegetation more vivid and more abundant, and the supply of water more plentiful,

After giving some interesting information with reference to the magnetic courses and distances (chained) of the stations between Antalo and Magdala, the plain of Antalo is described as bounded on the south by the deep valley of the Musgi, beyond which lies the mountainous range of Wodgerat towering up into the peaks such as Alaji, which attains a height of 10,000 feet above the level of the sea. A peculiar feature of the whole region is, that while the backbone of the mountain system runs north and south, with the drainage to the east and west, it is crossed by ranges of great elevation running across it in the direction of the drainage, and divided into sections. Thus the Wodgerat Mountains rise up as a great southern barrier, separating the dreary plains around Antalo from the rich valleys of the volcanic formation. On the other side of Wodgerat Mountains is the valley of the Atala. There are two ravines running up through the northern faces of this transverse range and leading south of Atala—one well to the south coast, and called Garah-dekdeh, and the other straight or nearly due south, and which was the one selected for the march of the English troops. It is called Beat-Mayra, and forms a very beautiful gorge. A noisy stream flows down this gorge to join the Musji, and irrigates a succession of barley crops grown carefully on levelled terraces, which rise one above the other up to the ravine. Above them the gorge is full of fine trees—tall acacias, myrsine, figs of various specios, and a very pretty crotalaria. The road often crosses the stream, and at some points passes along a ridge above it, with the tops of the trees rising from the bottom to just on a level with the traveller's eye. At one place the mountain sides recede, where there is a stretch of velvety turf,and the break is overshaded by white spring willow trees. This is the halting place of Meshek, and here the steep ascent of the saddle of Alaji commences with the lofty peak called Amba Alaji to the right, and the cone-shaped mountain-top of Yumasa to the left. The saddle was found by a comparison of aneroid barometer observations to be 9,700 feet above the level of the sea. The Amba rises up on the right some 600 feet high, ending in a steep grassy peak with scarped precipices just below. Here on a rocky shelf are five or six houses, with thatched roofs, almost overhanging the pass, and constituting the abode of the chief of Wodgerat. Beyond the Ahyna Valley, which is separated from the Valley of Atala by a range of mountains on the south of the latter, which derive their name from a high peak called the Bota, there is another transverse range, viz., that of Ferrah, also named after a mountain mass rising up to the right of the road. This Amba Ferrah is an enormously grand precipice, a glorious mass of rock, not terminating in a peak like Alaji, but in angular walls of rock with bright green steppes and ledges intersecting them.

From Ferrah Amba there is a range of mountains running north and south, and forming a distinctly-marked water-shed, viz., the Doba and Makham Valleys through which the road passes—being on their eastern sides, and the drainage of these valleys being to the east as far as Ashangi. There are five conspicuous peaks on this longitudinal range, commencing from Ferrah—viz., the Ferrah Amba itself, Assaji Fahefti, Bokero, and Sarenga. There are deep cracks round the base of Assaji, which are stated by the natives to have been caused by the earthquake in 1854, and they also assert that these earthquakes caused great change in the water system of the Doba Valley, some springs drying up and others appearing. The mountain sides which slope down from Belago are covered with trees and flower bushes, and the scenery becomes very beautiful. The lower country to the eastward of this Alpine region, from Antalo to the Tacaze, is occupied by lawless tribes of Mahommedans, called Azebo Gallas. From the summit of all the passes, looking to the eastward, could be seen the same broad valley, apparently extending north and south for upwards of 200 miles, and receiving all the eastern drainage from the Abyssinian Alps. Beyond it in the far eastern distance were ranges of mountains rising one above the other, and the valley itself appeared to be covered with jungle and to have a river running through it. In this country, still entirely unknown to Europeans, dwell those incorrigible robbers and murderers the Azebo Gallas, who profess Mahommedanism, and make incessant raids on the Christian inhabitants of the highlands; hence the thick kol-quall fences around all the villages, which are usually perched on isolated hills. The mountainous country between Makham and the basin of Lake Ashangi is about 14 miles across, is well wooded, the drainage being still to the eastward. Lofty peaks shut out the view to the west. The view from the southern edge of this highland is magnificent. Far below lies the bright blue lake of Ashangi, bordered by a richly-cultivated plain and surrounded by mountains on either side. To the westward this mountain barrier is very high, but to the east the hills are comparatively low, and appear to slope away ripidly on their eastern side to the Valley of Gallas, which is at a much lower elevation. Thus the landscape presents the curious effect of an Alpine lake surrounded by mountains and without an outlet, lying on the edge of a vast extent of country at a much lower elevation. Around the north end of Lake Ashangi there are deep fissures fall of soft mud and quicksands, which are excessively dangerous. These fissures are said by the natives to have been formed by earthquakes in 1854. The Lake of Ashangi is four miles long by about three broad, and is situated 8,200 feet above the level of the sea. It furnishes one of the very rare examples of a freshwater lake, without any apparent outlet, the water probably escaping at some point on the eastern side by percolation. Myriads of ducks, geese, cootes, and curlews, frequent the lake, or wade amongst the reeds of the treacherous mud on its shores. The surrounding mountains are all volcanic. About the south end of the lake there is a break in the mountains, and a gradual ascent leads to the plain of Wofela. To the south the mountains forming the high table land of Womberat rise rapidly from the Wofela plain, and the jagged volcanic peaks to the westward are a continuation of the range which bounds the Ashangi basin. From Womberat there are distant views of the Galla country to the eastward, while far away to the S.S.E. is the mysterious plain of Zobul, concerning which there are many traditions. It is said that in ages long gone by there was a Christian kingdom in Zobul; that old churches are still standing there; that the bells are heard ringing from afar, but that no man dares to approach them because the spirits guard those holy places. The narrow valley of Lat, the Dassat mountains and pass, the latter of which is 9,820 feet above the level of the sea, and the ascent of the Abuyaweder mountains to the summit of the Wondaj Pass, which is seven miles in length, Deldi being 7,400 feet and the Wondaj Pass 10,500 feet above the level of the sea, the highest point on the road between Senafe and Magdala, are next passed in review. The Abuyaweder Mountains separate the valleys of the Tellare and the Tacaze, the source of the former being on the north, and that of the latter on the southern face. The streams flowing down the deep ravines to the south unite and form the Tacaze. The Ayu-Tucaze, the fountain of traditions, is close at hand at the foot of a peak called Ayu-Kirkum, and this stream has the honour of being considered the source of the great fertilising tributaries of the Nile, because Menilek, son of the Queen of Sheba, is said to have struck the rock there and caused the water to well forth. Old Tellez correctly described the Ayu Tucaze ravine as the place where three several springs gushed out violently within a stone's throw of one another. They are shaded by a grove of kosso and juniper trees, surrounding a Christian church. The ravines of the Marora, the Briganut-wuns, the Sohora-wuns, the Rigach-wuns, and the Mal-wuns, are next described. The streams flowing down them unite and form the River Tacaze, which runs from east to west in a deep valley. All the ravines are bright green, with irrigated wheat and barley crops, whilst here and there a village is perched upon overhanging rocks, with a clump of trees concealing a church close by. South of the Tacaze the nature of the country entirely changes. From the Wondaj Pass, looking across the Tacaze Valley, a view of the Wadela plateau presents itself—a mighty wall, 2,600 feet high, rising abruptly from the valley, and ending in a level summit at an elevation nearly equal to that of the Wondaj Pass itself.

The bed of the Tacaze was found to be 7,795 feet above the level of the sea; that of the summit of the pass of the Wadela plateau, at the north-eastern part, was 11,400 feet, but towards the Zeta River not more than 9,100 feet above the level of the sea by observations of the boiling point and aneroid. The English troops, after crossing the Tacaze, and reaching the plateau of Wadela, instead of marching direct to Magdala by Kosso Amba, turned off in a south-west direction, in order to reach the great road made by Theodore across the Zeta Ravine, from the Wadela to the Talanta plateau. The heights of these table lands along a line where the Zeta divides them is the same—viz.: 9,200 feet above the level of the sea; and it is evident that they were once a single mass of columnar basalt, and, in the course of ages, the Zeta has cut its way down for a depth of 3,500 feet, carrying millions on millions of tons of earth and rock away to fertilise the delta of the Nile, and forming a ravine of extraordinary size, which, had it not been for Theodore's marvellous road, would have been the most formidable obstacle on the line of march from the coast to Magdala. The bed of the Zeta is 5,720 feet above the level of the sea. The depth of the ravine is 3,480 feet. The descent performed by Theodore's road is four miles six furlongs in length; the width of the river bed is 200 yards, and the ascent to the Talanta plateau is three miles and two furlongs; the latter plateau is a mass of columnar basalt between the rivers Zeta and Beshilo. The southern part of the plateau is about five miles across, but it becomes broader to the north-east; the distance between the rivers increasing as their sources are approached. The plain is quite treeless, except a few clumps round a few churches, and with a rich black soil several feet thick. The ravine of the Beshilo is even deeper than that of the Zeta, the bed of the river being only 5,638 feet above the level of the sea, and the river itself up to the horses' girths. The length of the descent is four miles four furlongs, and the width of the river bed 113 yards. The north-west side of the Beshilo ravine, with the exception of a break, where a little stream called the Berheri-waka (pepper water) runs down into the Beshilo, is a mighty basalt wall 3,500 feet high, broken by one or two irregular terraces, but on the south-east the original basaltic wall is now cut deeply about by ravines and gorges, which leave isolated peaks and plateaus between them. The Magdala system or knot of mountains rise up between the Menchura and the Kulkula ravines, the sides of the east and west being steep and precipitous, and nearly 3,000 feet high. Magdala itself is a mass of columnar basalt with scarped perpendicular sides, and with a plateau on the top about two miles long by half a mile broad. The Magdala system consists of the plateau of Magdala itself, the peak of Selassie, and the plateau of Fala, the three heights being connected by saddles at lower elevations. The Magdala district, with reference to the Talanta plateau, is not, properly speaking, a mountainous region, but simply a portion of the grand basaltic mass which has been cut up and furrowed by the action of water during many ages. After describing the climate during the month of April, and stating that the real rainy season does not commence until the middle of June, Mr. Markham proceeded to narrate a curious phenomenon, which occurred on the 13th of April, the day of the capture of Magdala, as follows:—"Early in the forenoon of that day a dark brown circle was seen round the sun, having the appearance of a blister, and being about 15 degrees in radius; light clouds passed and repassed over it, but it did not vanish until the usual rainstorm came up from the eastward late in the afternoon." Walda Gaba, the king's valet, informed Mr. Markham that Theodore saw it when he emerged from his tent in the morning, and remarked that it was an omen of bloodshed. The geographical results of the expedition are summarised as having been most important. The remarkable passes from the coast to the high lands of Abyssinia have been thoroughly explored, the mountain chains forming the watershed of a vast region have been examined, and the numerous sources of the great fertilising tributaries of the Nile have been accurately surveyed.

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## SOCIETY OF ENGINEERS.

### REDHILL SEWERAGE WORKS.

By Sydney A. Reade, M.A., C.E.

These works were designed and carried out by M. Baldwin Latham, C.E., President of the Society of Engineers, for the Town Council of the Borough of Reigate, the author being appointed by Mr. Latham as resident engineer of the works. The first contract for the works has just been completed by Mr. Joseph Brown, of Croydon, under the author's supervision; and it is now proposed to bring before the notice of the Society of Engineers the general character of these works, as regards both their design and execution, in the hope that, as the subject of sanitary engineering has been this year presented for their consideration by the President of the Society in his inaugural address, a brief and plain account of what may be called a particular case of this branch of the profession may not prove uninteresting to some of the members; he will also venture to make such general remarks on the subject as seem to him to arise out of this particular case.

The Town of Redhill in the county of Surrey, is about twenty miles south of London, and must be well known to all travellers on the Brighton and South Eastern Railways, it being the junction of these two main lines together with the branch of the South Eastern, which runs westward to Reading; it forms part of the borough of Reigate, and is governed by the Mayor and Corporation of that borough, who having adopted the Local Government Act a few years ago, soon turned their attention to the sanitary improvement of this rapidly increasing village, and took measures to provide for its complete main drainage, and a profitable disposal of its sewage. The town is situated at the junction of two valley lines at right angles to each other, one running (approximately) north and south, the other east and west. A stream runs through the former, falling southward at the rate of about 8 to 10 ft. per mile, and as the latter rises considerably westward, the surface drainage of that part of the town has a rapid fall towards the stream, which sometimes occasions the flooding of a large area on each side during the winter months.

The geological strata of the whole of the drainage area included in the present scheme belongs to the lower green-sand formation, underlying, however, in the river valley a deposit of peat of variable thickness, reaching in some places to a depth of 15ft. and upwards; this, as may be imagined, forms a perfect quagmire in wet seasons, and even at the driest time of the year is in a state of complete saturation at a small depth from the surface. About seventeen or eighteen years ago the road from London to Brighton was carried through this bog, the foundation being formed of faggots and brushwood, and the portion of this road nearest to the railway station was chosen as the "high street" of the future town, without regard being paid to the propable difficulties of drainage, health of the inhabitants, or even stability of the houses, which are all built on the surface, in most cases, without any kind of foundation, the Town Hall excepted, which is built on piles. Such being the position of the town the course that must necessarily be taken by the outfall sewer, which is to effect its drainage, is obviously determined by the direction of this lower valley line, the red line on the plan shows its actual position as at present constructed; keeping nearly parallel to the stream and emptying itself into it at the temporary outfall which will hereafter be abolished and the main sewer carried on to the proposed irrigation fields. This land forms part of Earlswood Common, and is situated about 1¾ miles south of the town, and at a level sufficiently low to allow a fall of about 1 in 600 to be given to the outfall sewer. The area over which it is proposed to send the sewage contains 63 acres, and the area of supply contains about 500 acres, on which there are now but 750 houses and a population of 4500. As this would only be 71 individuals for each acre of irrigation land it is probable the whole of the 63 acres will not be laid down at first, but the area gradually extended as the population increases.

The Lord of the Manor (Earl Somers) has agreed, with the consent of the copyholders, to give up this part of the common to the Board of Health gratis, on the condition of their purchasing 16 acres of land on a higher level, to be kept as a recreation ground for the inhabitants of Redhill; the Corporation have arranged to purchase this land for the sum of 4000*l.* They will thus obtain 79 acres for that sum, or at the rate of 50*l.* per acre, which is less than one-sixth of the value of average land in the neighbourhood. The common at the surface is stiff clay, not more than from 4 to 8 ft. deep, overlying the sand before alluded to, but not containing any admixture of sand; part of this clay is used for brickmaking, and the author found the bricks produced from it of very superior quality. The north side of this ground slopes gently towards the south, the north side is nearly flat; it will probably be laid down for irrigation on both plane and gutter and bed systems; from its favourable position, open towards the south, and sheltered by the hills on the north, the author would anticipate heavier and more frequent crops of rye grass than are now obtained at South Norwood, where the soil is very similar. The first great requisite for the successful prosecution of sanitary improvements having thus been fortunately obtained, the next thing to be considered was the size of the outfall sewer; this of course, is determined by 1st., the maximum quantity of fluid matter it is designed to take; 2nd., by the maximum inclination it is possible to give it. As regards the former it is not the author's intention to go into any minute calculations respecting the probable amount of rain falling on this drainage area per annum; what amount of it will find its way to the sewers; how long it takes to do so; what proportion will fall in streets, roofs, and back premises, and thence to arrive at the dimensions of the outfall sewer. It would, no doubt, be an easy matter to take some of the published tables, and run the finger down the columns for the figures answering to Redhill, its area, population, &c., but conclusions based on this sort of arithmetic are as likely to be wrong as right. To use Mr. Rawlinson's words "you may as well say that all sorts of diseases may be cured with one set or sort of pills, as that tables of strength of materials and dimensions of sewers can be relied upon without the experience of practice." In answer to questions of this kind, he gives a list of towns drained by him, with their population, area, &c., and the dimensions of the outfall sewers in each case, and the author would add Redhill to the list of practical examples, which, after all, are the best guides in assisting the judgment of young engineers. It will, however, be generally admitted, that in towns where the existing sewers are sufficient to take off the greater part of the rainfall, they need not be interfered with; but the new sewerage designed to take all foul matter and a certain proportion of the rainfall. With this end in view the outfall sewer at Redhill is designed. It is eggshaped, 3ft. 9in. × 2ft. 8in., sectional area 7·64 square feet, perimeter 10·12 ft., a hydraulic mean depth, therefore, when running full of 0·755 ft.; its capacity of discharge under these conditions would be about 1400 cubic feet per minute.

It should be mentioned that the outfall sewer at present receives a small supply of water from the deep-seated springs in the sand. This amount the author has carefully measured, and finds to be 30 cubic feet per minute, and not perceptibly affected by the amount of rainfall at different times. Adding to this the average flow of a small brook which has been diverted from the roadside into the sewer, and which may be taken at 50 cubic feet per minute, and the probable maximum flow of sewage from the present population at 31·25 cubic feet per minute, we have a total of 111·25; to which may be added 1,000 cubic feet for the proportion of the maximum rainfall that will reach the sewer; leaving a margin for the extension of the population, which there is good reason for supposing will double its numbers in the next ten years. It is probable, also, that many of the shallow drains, which at present needed not to be interfered with, will, as houses multiply, necessarily be abolished, and the refuse water they now convey away be brought into the sewer.

Before leaving the subject of the dimensions of egg-shaped sewers, the author asks permission to submit to the notice of the members three general formulæ applicable to the construction of egg-shaped sewers, which he deducted for his own convenience in calculating the area and perimeters of the Redhill sewers and in constructing the templates for the bricklayers; which are as follows: B = equal diameter of circle forming invert; C = diameter of arch; R = radius of curve forming sides; D = depth; then B = ⅓D; C = ⅔D; and R = D. These are the proportions taken from Molesworth, and are those for which tables of areas, hydraulic mean depth, &c., have been constructed. They certainly offer great facilities to the draughtsman; but it will readily be admitted that circumstances may arise where a sewer having a greater proportional width to its depth than is given by this construction, may be desirable; for instance, the engineer, from the proximity of the surface of a road to the crown of his arch, or from other causes, may wish to reduce the depth of his sewer while still preserving the same sectional area, and retaining the advantages of the egg-shape: and there is no reason why he should be compelled to use this particular form, and no other, merely because it has been the custom to do so. In our case the main sewer was partially above ground for a considerable portion of its length, and it was desirable to reduce the mound in the field through which it passed as much as possible. Now, it is easily seen that if the proportion of B and C to D are altered, and also the proportion they bear to each other (as given above), R is no longer equal to D, and the two circles do not touch, the distance between their centres being no longer equal to the sum of their radii. It thus becomes necessary to furnish the draughtsman with a new value for R which shall be perfectly general in its application. This expression and the other two for the area and perimeter will be as follows:

R being the radius of the side, $r$ of the arch, and $r_1$ of the invert, and $d$ the distance between the centres of the circles, obviously equal to D − $(r + r_1)$, we shall have

$$(1.)\ R = \tfrac{1}{2}\left(\frac{d^2}{r-r_1} + r + r_1\right)$$

$$(2.)\ A = \frac{\pi}{180}\left(\theta^\circ\,(R^2 - r_1^2) + 90\,(r^2 + r_1^2)\right) - d\,(R - r)$$

$$(3.)\ C = \frac{\pi}{90}\left(\theta\,(R - r_1) + 90\,(r + r_1)\right)$$

The above are easily deduced, and might prove useful to others, as I have found them. The angle $\theta^\circ$, which is that subtended by the arc forming the the sides, may be found from its sine, or tan., for

$$\text{Sin.}\,\theta = \frac{d}{R-r},\quad \tan.\,\theta = \frac{d}{R-r_1}.$$

Up to the present only 220yds. of the outfall sewer have been constructed, and a temporary outfall formed into the brook. As there was some delay in obtaining the necessary borrowing powers from Government for the purchase of the land, the Corporation thought it undesirable to postpone the construction of the sewers till that was obtained. Now, however, that the land question has been satisfactorily settled, and the greater part of the drainage system completed, there is no further hindrance to the continuation of the outfall sewer to the proposed irrigation fields. The bricks for the sewer were specified to be radiating, and at first the author had them made of two different forms—one to suit the exact mean radius of the arch, and another for the invert. This, however, was found to cause a delay at the brick-yards, and caused the author to substitute a mean brick, which answered all curves of the different sewers, without making the outer joints objectionably wide. The inverts were cast in blocks in the usual way, and were allowed a week to set before being inserted in the work. The curve forming the sides of the sewers was built with ordinary-shaped bricks, the radius being large enough to allow this to be done. The thickness was 9in., and the compost composed of two parts sand to one of Portland cement, which was specified to be of such quality as to bear a tensile strain of 180lbs. on the square inch. After seven days immersion in water specimens were tested, from time to time, and answered the required test; but the author hopes to elicit opinions from some of the members as to the value of this test, which he believes is adopted by the Metropolitan Board of Works; in cases where rapidity of setting is important, it is, no doubt, of value, but to prove the actual strength of the cement when thoroughly set—*i.e.*, when at its best—it seems to fail. The author has found cement taken from some casks which were supplied by Messrs. Hall and Co. for these works set hard in a few hours, when other specimens would take as many days. One instance, out of many, he selects: in casting the blocks for the 2ft. culvert in the London-road, where the ground was very bad indeed, the foreman complained that one or two casks of cement were so bad that they were obliged to reject them, as the cement would not go off at all. A specimen was mixed on a board and examined; after a few days it was found to be so soft that the impression of the finger could be made on it. A portion of the same cement was inserted in the testing-frame, and allowed to remain for three weeks, and was then tested by the author and Mr. Hornibrook (borough surveyor of Reigate), and found to bear a tensile strain of 367lb. per square inch, or more than twice the required strain; and its hardness was found to be about 3½ to 4 on Moh's scale of hardness, as it easily scratched a specimen of heavy spar; although, had it been subjected to the seven-day test of 180lb., it must have failed entirely to bear it.

The foundation at starting was very good, being a sandy clay, dry and firm. This continued, however, only for a length of about 50yds., at the end of which a small brook was crossed, and the treacherous morass entered upon; although, at a dry season of the year, the ground was wet and sloppy, and in some places so soft as to be dangerous to walk on. A few days previous the author had surface drains cut as deep as the level of the brook would admit, and connected with it at a point as far down stream as was practicable. The surface water was thus drained off to a depth of 1ft. or 18in., and the ground through which the excavation was to run rendered fitter for moving about materials; it was never, however, hard enough to admit of cartage, which necessited planking to be laid for wheelbarrows to convey all the required materials. The depth of the sewer, from the commencement of the morass to the Brighton-road, averaged under 5ft.; so that the crown of the arch was above the surface of the field. The subsoil may be described as soft peat, black, mixed occasionally with clay and sand, not fibrous, like the Irish bogs, and very wet. Of course an artificial foundation was necessary on such ground, and from the three which were described in the specifications, and of which drawings were furnished, the author decided on (No. 2), which was formed of hurdles interlaced with brush-wood, laid on three longitudinal sleepers, not less than 16ft. long, and covered with concrete which reached to within 18in. of the springing of the arch. The concrete was composed of four parts of broken stone, two of sand, and one of Porland cement, or about one cask of cement to a yard of gravel and sand. In getting in this foundation, the method adopted was to excavate a 16ft. length and sink a sump hole; the sleepers were then inserted so as to break joint, the hurdles, which were 6ft. × 3ft., laid over them, and a layer of concrete 6in. thick tipped in from barrows. The hand-pumps were kept at work to keep the water down until this layer had sufficiently set. A wooden template, of the exact form of the outside of the sewer, and 10ft, or 12ft. long, was then suspended from cross-timbers, so that its lower extremity just touched the layer of concrete, and the spaces between this template and the sides of the excavation were filled in with concrete to the required height; when this had set sufficiently the template was moved on, and another length completed in the same way. Before commencing to put in the invert in the first instance, the foundation was tested to ascertain if any subsidence would occur; for this purpose the pumps were stopped, the templates allowed to rest on the concrete bottom, and then loaded with bricks equal to $2\frac{1}{2}$ times the weight of the sewer for that length, levels were taken from a bench mark on an adjacent bridge, and after a fortnight taken again: no perceptible subsidence had taken place, and the brickwork was then proceeded with. In excavating, it was found necessary to remove the material some distance from the side of the trench as it was taken out, for though the sides were close timbered the additional weight forced up the bottom. This moving away of material, and moving it back when the sewer was completed, caused this part of the work to proceed but slowly; some difficulty was also experienced in drawing the runners after the brickwork was got in, owing to the tenacious nature of the soil. The author should mention that the foundation was slightly modified: 1st., the concrete was brought up perpendicular at the sides flush with the sides of the excavation; 2nd, square sleepers of foreign fir, $5\frac{1}{2} \times 5\frac{1}{2}$in., were substituted for fir poles 6in. diameter; and, 3rd, one foot of concrete was laid over the hurdles instead of 6in. The total length of the 2ft. 8in. × 3ft. 9in. sewer was 223 yards. The details of the cost will be given at the close of this paper in connection with that of the other sewers. At the manhole the main sewer turns at right angles along the Brighton-road, diminishing in size to 3ft. 6in. × 2ft. 6in., and at the same point is joined by a 15in. pipe sewer diminishing to 12in., which will take drainage from the high ground in the extreme south of the district. The ground traversed by the 3ft. 6in. × 2ft. 6in. sewer from this point to where it turned off the road was, with one exception, the worst the author had to deal with. The peat continued at the surface for a distance of about 350ft. along the road, it averaged here about 6ft. deep, and gradually passed into a sandy clay abounding in green grain, and very watery, Lower down the clay disappeared, and a quicksand was met with for the first hundred feet; and so it was not necessary to go lower than the peat, and the hurdle foundation was continued as before; but as the excavation proceeded along the rising ground the sand was encountered, and here it was found necessary to adopt a foundation, consisting of 4in planks spiked to the sleepers and covered with concrete; the same modifications were observed in this instance, the concrete being carried up perpendicularly at the side, and a layer one foot thick tipped in over the planking. Proceeding still further the strata sunk through peaty clay and peat to a depth of 6ft.; under this a hard stiff blue clay quite impenetrable to water, and upon. excavating this, it was thought our difficulties were over as it seemed probable that the clay continued to a considerable depth; such hopes proved delusive, for when about 18in. of the clay had been excavated water showed itself oozing from the bottom and sides, and when another 6in. had been removed the excavators found themselves in a quicksand; the water being under pressure here owing to the impermeable stratum overlying the permeable, was more abundant and more difficult to deal with than before, and we not having been so well prepared for it, it caused some mischief. 1st. The timbering had been put in separate frames 4ft. deep, the wailings were placed across the centre of the runners, and the struts 6ft. apart. The peat on the surface necessitated the runners being placed close; had the clay continued only 2 or 3ft. deeper this would have been amply sufficient, but (for misfortunes never comes alone) it happened that on the very evening this artesian spring of sand and water was tapped there came a thunderstorm and heavy fall of rain, which soon found its way from the steep slopes on each side of the valley to the works, down behind the timbers, joining the springs below. Pumps were kept constantly at work in the trench, but in spite of all, the lower frame of timber gave way and the sand burst in, the surface of the road at each side of the excavation sunk at the same time about 4ft, owing to the sand having been drawn from underneath, adding to the strain in the top frame and breaking many of the struts. The men, however, though drenched with rain, stuck bravely to their posts all night, fresh runners 14ft. long, extending the full depth of the excavation were obtained and driven outside the walings, and by dint of the most creditable and untiring exertions on the part of the foreman, the trench was kept open, and the water kept under until the morning. Of course, after this the system of timbering with separate frames was abandoned, runners the full depth of the excavations were used, and the thickness of the timbers increased to 4in.; these, of course, projected a great height above ground until the excavation was carried down to a considerable depth, for which reason, as well as because the material could not be taken out by shoveling it on to the stages, owing to the quantity of water it contained, shear legs were erected of sufficient length to clear the tops of the runners, a horse gear attached and the sand drawn up in backets. As may be supposed, some difficulty was experienced in getting the brickwork dry, and even when one length had been completed, and the pumps removed preparatory to getting in the planked foundation for the next, the water as it rose would force its way through the concrete, and in some cases through the joints of the brickwork while the cement was green; to reduce the pressure behind the brickwork drain-pipes were at first inserted a few courses from the bottom of the sewer, which reached across the concrete to the side timbers, and admitted a considerable portion of the water into the sewer, where it flowed to the outfall; these it was found, did not admit the sand, although the contrary might have been anticipated, and it may be generally remarked that, although where there is a free surface exposed, water will carry a large quantity of sand, yet a moderate amount of friction will retain the latter. Thus it was always noticed that although so much sand was drawn through the pumps as to require them to be frequently stopped for repairs, before the planking could be got in, yet directly that was accomplished the water was thrown out of the pump holes comparatively clear, and when the length of brickwork had been got in, perfectly so, and the quantity of water remaining the same. To diminish the chance of the entrance of sand through the safety vents (as they may be termed), the author adopted the following expedient:

As soon as a length of planking had been got in, and before the concrete was laid, vertical pipes were placed at intervals at each side of the trench, these were generally 6in. earthenware socket-pipes, which from the presence of fire cracks, or from other defects had been rejected. They were placed socket downwards resting on the planking, and were filled with gravel, the concrete was then tipped in and the brick sewer carried up as usual until it reached as high as the tops of the pipes. 2in. agricultural drain-pipes were laid connecting these vertical pipes with the sewer (the edge of the pipe being chipped to receive them); they were laid with a slight fall pointing in the direction of the flow; the remainder of the sewer was then completed and the tops of the vertical pipes covered in with concrete when the pumps were moved on, and the water allowed to rise through the vertical pipes and thence into the sewer. After this method was adopted we had no case of a joint being injured by the pressure of the water underneath. The whole length of the main sewer where these inlets were inserted, has been examined at different times by the author, particularly after heavy rains, and found to be entirely free from any trace of sand. It may be remarked here, that the admission of subsoil water into a a sewer is in all cases recommended by Mr. Rawlinson, though it has been objected to by some engineers on the obvious ground of the dilution of the sewage; this objection only partially applies; first the water admitted by this means is inconsiderable compared with sewage, which ordinarily flows even in dry weather in our case; as was before shown, it only amounts to about one-fifth; second it must be borne in mind that spring water is not distilled water, that it holds in solution a variety of fertilizing salts; and thirdly, the evil of dilution is in many instances overrated, for if the sewage is so applied to the land, so as to leave there all its fertilizing matter to be utilized, it seems to the author to be of no great consequence (within certain fixed limits), whether that fertilizing matter is conveyed there by a greater or lesser amount of water, the principal object being that the water as it leaves the land should contain a minimum of organic matter. The author wishes it to be clearly understood that he would on no account recommend means to be provided in a main sewer for the admission of subsoil water properly so called, that is water percolating from the surface, and intermittent in its flow; for when such means of ingress were not employed in letting in water, they would be in letting out sewage, and sewage gases; but it is otherwise with deep-seated and constant springs, especially as they happen to be artesian springs, derived from a water-bearing stratum underneath an impervious one, and acting under pressure, in such cases, it is better to admit it, or part of it, than go to increased trouble and expense in excluding it, providing only that nothing but water is admitted. Excepting these inlets, the sewer was practically speaking water tight, the brickwork being laid in cement, and both rings of the arch rendered on the top with a coating of cement. That it was so was proved by sending a man through from one manhole to another after some heavy rains had fallen, the back of his coat was somewhat dusty from contact with the arch, but was perfectly dry.

The remainder of the 3ft. 6in. × 2ft. 6in. outfall sewer, after getting through the quicksand, presented no peculiar difficulty; upon leaving the road the peat was again encountered, and the same foundation used as that described for the larger outfall sewer near the temporary outfall. One thing, however, should not be omitted to be noticed in connection with these springs. Several new houses were in the course of erection on the side of the hill, west of the Brighton-road, and to supply these with water, deep wells had been sunk through the dry upper sand into the quicksand below, some of these wells were upwards of 60ft. deep, and the nearest about 200 yards from the sewer. So rapid is the flow of water in the stratum that all the wells were dried within two or three days after the trench was opened to its full depth, the bottom of these wells were exactly 10ft. above the invert of the sewer, and by levelling from them the author determined the approximate inclination of the water bearing stratum, which was about one in twenty.

The general arrangement of the sewers is what may be called the modern rectilineal system, *i.e.*, in straight lines from point to point, having a man-hole or lamp-hole at every change of direction, and, with very few exceptions, at every change of gradient. The advantages derived from this method of construction need not be referred to here; but in addition to recognised utility, the author would direct attention to the facilities it affords for determining questions relating to the flow of sewage, for testing or correcting the accuracy of general formulæ and tables; for, possessing a uniform rate of inclination, a constant sectional area, and a given length in a straight line between every two man-holes, we have so many so many independent data for basing general conclusions on. The sewer-pipes were 15in., 12in., 10in., and 9in. in diameter, the largest size were supplied by Messrs. Doulton and Sons, Lambeth, the others by Mr. Thompson, Nettlebed Potteries, Oxfordshire; they were specified to be of fire-clay or stoneware, to be moulded under pressure, and the socket of every pipe to be pressed on or formed with the body of the pipe, and to be truly concentric with the pipe. Pipes were to be rejected which were, first, not well or uniformly glazed; second, not properly burnt; third, which contained injurious fire-cracks; fourth, not true in section; fifth, not perfectly straight in the direction of their length. The thickness of the material of the pipes of the several sizes were to be as follows:—

| STONEWARE. | | FIRECLAY. | |
|---|---|---|---|
| Diameter. | Thickness. | Diameter. | Thickness. |
| 4in. | ½in. | 4in. | ½ in. |
| 6 ,, | ⅝ ,, | 6 ,, | ¾ ,, |
| 9 ,, | ¾ ,, | 9 ,, | ⅚ ,, |
| 10 ,, | ⅞ ,, | 10 ,, | 1 ,, |
| 12 ,, | 1 ,, | 12 ,, | $1\frac{1}{10}$ ,, |
| 15 ,, | 1⅛ ,, | 15 ,, | 1¼ ,, |
| 18 ,, | 1¼ ,, | 18 ,, | 1½ ,, |

The pipes supplied were in all cases stoneware, and of the thickness specified for that class of pipe. They were whole socketted. In laying the pipes great care was taken that each pipe was supported at every point by cutting cavities to bed each socket in, and in cases where planked foundations were required under the pipe sewers, the planks were covered with sufficient material, well trodden down and consolidated, to allow of this most important point being attended to. The jointing was executed with well tempered clay, which was forced into the joints by means of a wooden tool made for the purpose, and rendered the same water tight. Under the railway, which was crossed at two points, cast-iron pipes were laid, jointed with lead, and a man-hole constructed in both cases on the railway at the up-side of the crossing.

The ventilation of sewers by means of charcoal the author believes first took its rise from the investigations of Dr. Stenhouse, F.R.S., who, in 1853, directed attention to the subject of charcoal in connexion with the ventilation of impure atmospheres. He showed that charcoal was not an antiseptic, as it was at that time represented to be, but, on the contrary, was a great agent in promoting decomposition, from its capability of absorbing large quantities of gas, and retaining it within its pores until it was gradually oxidised. Keeping this principle in view, the author ventures to throw out a suggestion which he cannot help thinking would be worth a trial, and which might be found to increase the efficiency of the charcoal immensely, and render the smallest escape of mephitic gases almost an impossibility. He proposes to use, instead of ordinary charcoal, oxygenated charcoal. If charcoal is exposed to an atmosphere of pure oxygen it quickly absorbs it, retaining in its pores a quantity equal to 9¼ times its bulk. The gas, being thus condensed, acts with magnified force in effecting the oxidation of gases exposed to its influence; compared with oxygen in an uncondensed state, *a fortiori*, compared with the oxygen of the atmosphere, which is five times diluted. That this is no mere theory may be proved by bringing sulphide of hydrogen (H S) (a gas once smelt not soon to be forgotten) in contact with oxygen gas at ordinary temperatures. No action takes place; but if a bit of charcoal which has absorbed the latter gas be introduced into a jar containing the former, it (the H S) is immediately oxidised, sometimes with detonation, water and sulphuric acid being produced. The expense of this oxygenating even a larger quantity of charcoal would be comparatively trifling; and we may conclude that a much smaller quantity of charcoal than is at present used in the ventilators would be sufficient to effect the complete deodorisation of the gases. It must be remembered also that charcoal will not part with its absorbed oxygen except on the influence of heat, or being placed in vacuo; and we may reasonably infer it would retain its properties a considerable length of time before requiring reoxidisation.

The author had hoped to have brought before the notice of the society a series of experiments on the flow of water in these sewers; he has only been able, however, to conduct very few, as he was called away from Redhill to superintend the new irrigation works at Rugby. He, however, submits the few experiments he did try in a tabular form, and hopes at some future period to be able to bring forward a much more extended series on a similar plan.

EXPERIMENTS ON THE FLOW OF WATER IN EGG-SHAPED SEWERS, COMPARED WITH FORMULÆ.

| | i | m | V in ft. per min. | | | Q cube ft. per min. | | |
|---|---|---|---|---|---|---|---|---|
| | | | Rankine. | Molesworth. | Experimental. | Rankine. | Molesworth. | Experimental. |
| Man-hole A to B, mean of 3 experiments .. | $\frac{1}{253}$ | 0.195 | 154 | 157 | 180 | 40·81 | 41·6 | 47·7 |
| Man-hole C to D, mean of 3 experiments .. | $\frac{1}{1753}$ | 0·29 | 78 | 79¾ | 76 | 34·81 | 35·26 | 33·58 |

*i* = height divided by length or sine of the angle of inclination.
*m* = hydraulic mean depth.

It would seem by this table that the experimental velocities and capacity of discharge approach nearer the theoretical, where the flow of water is slow, and the inclination of the bed slight, but the author is very far from wishing to base any definite conclusions on such limited experiments, and will now conclude this paper by giving a detailed statement of the cost of the works.

REDHILL SEWERAGE WORKS.—PARTICULARS OF COST.

| Description of Work. | Quantities. | Average Cost per Yard. | Cost. |
|---|---|---|---|
| Brick Sewers in Cement. | Yards linear. | £ s. d. | £ s. d. |
| 3ft. 9in. × 2ft. 8in, 9in. thick .. | 224 | 2 15 10 | 621 18 0 |
| 3 ,, 6 ,, × 2 ,, 9 ,, 9 ,, ,, ... | 754 | 1 16 2 | 1364 0 0 |
| 2 ,, 0 ,, 9 ,, ,, ... | 225 | 1 5 9½ | 290 0 0 |
| 2 ,, 0 ,, 4½ ,, ... | 176 | 0 15 2½ | 134 0 0 |
| Total Brick Sewers ...... | 1324 | | 2409 18 0 |

SMALL ARMS FACTORY, ENFIELD. The accounts for the financial year 1866-67 show that there were fabricated that year at Enfield, and sent into store, 17,[illegible] cavalry carbines, Richards' patent breech-loading; 8,1[illegible] muskets, smooth bore, with bayonets, 2,[illegible] fusils ditto; [illegible] musket rifles, pattern 51, converted to breech loaders on Snider's system; 10,012 short rifles, also converted, and 1,008 naval rifles ditto. The value or cost of the small arms and implements for small arms sent into store from Enfield in the year is estimated according to several modes of computation; by the lowest it is £147,921, and by the highest £[illegible],120.

## ROYAL INSTITUTION OF GREAT BRITAIN.

### ON THE PROPOSED WATER SUPPLY FOR THE METROPOLIS.

By Edward Frankland, Ph. D. F.R.S. Professor of Chemistry, Royal Institution.

Out of every thousand people existing upon this planet at the present moment, three live in London. Any matter, therefore, which intimately concerns the health and comfort of this vast mass of humanity, cannot but merit earnest attention; and, moreover, if that matter be connected with scientific research, I feel sure that the members of this Institution will require no apology even for its being brought under their notice a second time.

A year ago, I discoursed to you about the chemical considerations respecting the present Metropolitan Water Supply, and I mentioned the five schemes then proposed to remedy its obvious and serious defects—excessive contamination with sewage, and great hardness—the first rendering it unfit for drinking, and the second disqualifying it to a certain extent for washing and cleansing purposes. Those schemes to which I alluded on the last occasion were the following. First, the sources of the Severn, proposed by Mr. Bateman; second, the Cumberland Lakes, proposed by Messrs. Hemans and Hassard; third, the Thames water filtered through the Bagshot sands, suggested by Mr. Telford Macneill; fourth, extensive reservoirs constucted near the sources of the Thames, the scheme of Mr. Bailey Denton; and fifth, the waters flowing down the slopes of the Derbyshire and Staffordshire hills, proposed to be brought to the metropolis by Mr. Remington.

At that time the quality of the waters obtainable by any of these schemes had been but little investigated, and that remark still applies to the last three schemes. But in the interval, the water yielded by the two first-named districts has been, at the instance of the Royal Commission on Water Supply, submitted to a searching chemical investigation by Dr. Odling and myself, and I am therefore enabled on the present occasion to speak with confidence as to the quality of the water from both these districts.

There are also one or two points of general scientific interest which have been brought to light during this inquiry, and which I also propose to touch upon:—these are, first, the curious effect of detritus from mines upon the quality of the water with which it is mixed; and secondly, the conditions which determine action or non-action of water upon lead.

During the past year the processes of water analysis have undergone a complete revolution. It is one of my duties to report monthly to the Registrar-General upon the quality of the metropolitan waters, and in carrying out this work I found the methods of water analysis hitherto employed so untrustworthy as to render an almost entire remodelling of them absolutely necessary.

I propose, therefore, first to glance shortly at some of the innovations which have been made in this branch of chemical analysis. When water is to be submitted to chemical examination, it is of the utmost importance to have a a sufficient and well-collected sample. On this occasion the completeness of the investigation, as regards the two proposed schemes, has been very materially assisted by the judicious choice of samples supplied by Dr. Pole, F.R.S., who went down to the districts and collected the samples which were afterwards submitted to chemical analysis by my colleague and myself.

The first thing to be determined in a water analysis is the "total solid impurity," as it is termed, *i.e.* the total amount of solid matter with which the water has been contaminated since it was submitted to the natural process of distillation. This quantity of solid impurity is determined by taking a known volume of the water and evaporating it down to dryness in a previously weighed platinum vessel. The solid impurity contains both organic matter and inorganic or mineral matter. The most important of these two classes of substances contained in the solid residue is undoubtedly the organic matter. Now, even at the present moment, the actual weight of this organic matter cannot be determined by chemical analysis; in fact there is no process known to science by which its weight can be even approximately estimated; but it is possible to determine, in a given bulk of water, the quantity of the two principal constituents of this organic matter, viz., the carbon and nitrogen which enter into its composition. For this purpose a separate quantity of the water is evaporated down to dryness; but in this case the process is conducted in a glass vessel, and before evaporation the water is mixed with sulphurous acid in order to expel the carbonic acid, which is partly dissolved in the water and partly combined with lime magnesia. Other percautions also have to be taken, but I hesitate to enter into the details, which I fear would only weary you. However, I think that it is desirable just to show you the general plans on which the determination of the organic carbon and nitrogen, in the residue thus obtained by evaporation in the glass dish, is effected. The operation is performed in the following manner:—The contents of the glass vessel are very carefully scraped out and rubbed off the sides of the vessel by a substance known as chromate of lead, a finely powdered somewhat gritty material, which very completely effects this object, and enables us to transfer the water residue gradually into a piece of hard Bohemian glass tube closed at one end. This tube is then filled up to within about four inches of the mouth with coarsely granulated oxide of copper, and upon that is placed a small quantity of bright metallic copper to decompose oxidized compounds of nitrogen. The tube is then laid in a gas furnace, called "the combustion furnace." Before combustion commences the entire tube is made perfectly vacuous, all the air is pumped out of it, so as to get rid of the atmospheric nitrogen which would vitiate our result. This is done by means of a mercurial pump invented by Dr. Sprengel, by means of which we can extract almost the last trace of atmospheric air contained in the tube. The latter is then gradually heated to redness, during which process the carbon and nitrogen of the organic matter in the water residue are converted, the first into carbonic acid gas, and the second into nitrogen and nitric oxide gases. From the volume of each of these gases the weights of carbon and nitrogen can be calculated with great precision.

Now the nitrogen in the result of the analysis is also derived from any ammonia present in the water, and it is therefore necessary to determine how much is due to that source. This estimation of ammonia is perhaps the only rapid and easy process connected with water analysis which may at the same time be regarded as satisfactory. For these simple processes of analysis when they come to be rigorously tested generally prove to be very incorrect; but this has survived the test of experience, and is capable of determining the result with great precision and readiness. I have here five glass cylinders. The water in the first contains no ammonia at all: the second contains a certain small quantity; the third twice as much as the second; the fourth three times as much, and the fifth four times as much as the second. To each of these vessels I shall now add an equal volume of a test solution, which strikes a peculiar yellow or orange-yellow colour with the ammonia in the vessels. This is known as the Nessler test, having been invented by a German chemist of that name. (The experiment was performed, the water in the four last vessels assuming different shades of orange colour, in proportion to the quantity of ammonia contained in them; the water in the first vessel remaining colourless.)

Now we have still one other process at which it is necessary to glance for a moment, viz.—the process for determining the nitrogen existing as nitrates and nitrites. It is called combined nitrogen, but it is not organic nitrogen, although it has in most cases been derived from organic matter. The water residue used for the determination of the amount of solid impurity is dissolved in a small quantity of water; sulphate of silver is then added, by which the chlorides are converted into sulphates. The resulting liquid after filtration is transferred to the upper part of a glass tube filled with mercury. It requires to be mixed with rather more than its own weight of sulphuric acid, which is introduced in the same way. It is then only necessary to shake up this mixture, the mouth of the tube being closed with the thumb. Very soon the mercury begins to act on the nitric acid, converting it into a colourless permanent gas called nitric oxide, which only requires to be measured in order to determine the amount of nitrogen originally present in the water in the shape of nitrites and nitrates.

There is only one other determination I will trouble you with, and this I do principally for the purpose of introducing to your notice a very ingenious piece of apparatus, an application of the Sprengel pump, which has just been contrived by my assistant, Mr. McLeod. It is designed to extract the gases which are dissolved in waters. By this instrument we can not only measure the whole of the gases present in the water, but we can determine how much of the gases can be expelled at the ordinary temperature, and how much more will come off when you boil the water in vacuo. This gas is then submitted to the usual eudiometrical investigation, to ascertain the quantity of carbonic acid, nitrogen, and oxygen,—the three gases which almost invariably occur in the waters submitted to analysis.

Now it is not necessary for me on the present occasion to go at all into the details as regards the sources of the two proposed water supplies for London. This I did on the former occasion pretty fully. I will only refer you for a moment to the large map before you, which shows the districts from which the supplies would be taken and the course of the conduits to the metropolis. By the Welsh scheme, the water would be collected on the slopes of Cader Idris and Plynlimmon, from whence it would be brought by a conduit to within ten miles of London, where it would be stored in reservoirs 400 feet above high-water mark. The other scheme proposes to bring the water from the lakes of Cumberland, past several large towns, laying under contribution the Bala Lake, in Wales, if necessary, and the combined waters would then be brought to the metropolis after distributing a certain amount to the large town on their route.

It is, perhaps, necessary just to say a word or two in order to disabuse your minds of the idea that these schemes are intended to inflict any injury upon the present water companies. Ample provision is made in these schemes for the complete compensation of the existing companies, and the only conceivable mischief in this respect which can be done by the adoption of one scheme or the other, would be the abolition of certain Boards of Directors which now exist, for the administration of the affairs of the eight or nine companies which supply London.

These schemes are of course very costly. It quite staggers one at first to think of the amount it is proposed to expend upon them. Thus, Mr. Bateman's scheme, which is to bring water from the mountains of North Wales, is calculated to cost, for a supply of 220,000,000 gallons per day, the sum of £10,850,000; whilst the scheme for bringing water from the lakes of Cumberland is put down, for 250,000,000 gallons a-day, at £13,500,000. Now these are startling figures; but I imagine that all we have to look at is the simple question, How much shall we have to pay for the water when these schemes are carried out? If you go into that matter you will find, according to the calculation of the engineers—I will not say they are always to be implicitly relied upon, perhaps a certain percentage must be allowed—but taking their calculations as correct, it actually follows that after compensating the exisiting companies, and after expending this enormous amount upon the works, we shall be supplied with this very pure water at a less cost than that which we pay at the present moment. We pay at present about 1s. 5d. in the pound of rent for water. By Mr. Bateman's scheme we should be charged a domestic rate of 10d. in the pound, or two-thirds of what we now pay, plus a public rate of 2d. Messrs. Hassard and Heman's scheme would be met by a domestie rate of 1s. 1d. in the pound. Now I think, if we are actually to be gainers by this transaction, the enormous sums necessary to be expended upon these works need not frighten us, and need not prevent us from taking them into our serious consideration.

Let us just pause for a moment to consider the purely mechanical relations of the proposed to the present metropolitan supply, because this will somewhat help you to comprehend how it is that, having expended all this money upon the works, we shall still have water cheaper. In the first place, every gallon of water which is now delivered in London has to be pumped up from nearly the sea level, to an average height of about 250 feet. Then, again, the present supply is intermittent; the proposed will be constant. With regard to the pumping part of the process, that in the proposed scheme would be replaced by the work of gravitation. The gigantic and magnificent engines employed at the present moment in London for raising this vast volume of water—100,000,000 gallons daily—are painful for the philosopher to contemplate. You have here a stupendous waste of power employed in doing over again an amount of work which was previously executed for us gratuitously. The sun, in his prodigality of power, flings up far above the cross of St. Paul's this daily supply of 100,000,000 gallons, and we, in our imbecility, allow it to soil itself by flowing down again nearly to the level of the sea, and then we erect immense pumping engines and expend 200 tons of coal daily to raise this water a fraction of the height from which we had previously allowed it to fall. All this will be saved by the proposed schemes.

We talk of the exhaustion of our coal fields and of the necessity of conserving our supply as much as possible, and although the amount thus saved would make but a poor figure in Mr. Jevon's 100,000,000 tons a year, yet this is a kind of work which can be done better by solar heat than by the action of coal; and it is not very often that we are thus able to substitute, with advantage, natural for artificial force.

Now with regard to the quality of these waters which it is proposed to bring to London, you have in the following Tables a comparative statement, showing the results obtained by the analysis of the proposed Welsh and Cumberland waters, and of the present metropolitan water supply :—

TABLE A.—RESULTS OF ANALYSIS OF WELSH, CUMBERLAND, AND LONDON WATERS.

100,000 *Parts of Water gave*—

| — | WELSH. | | | CUMBERLAND. | | | LONDON. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Max. | Min. | Mean. | Max. | Min. | Mean. | Max. | Min | Mean. |
| Total solid impurity ... ... ... ... ... | 9.60 | 2.79 | 4.85 | 13·60 | 2·14 | 4·74 | 59·20 | 23·12 | 32.66 |
| Organic Carbon ... ... ... ... ... ... | 1·040 | ·200 | ·460 | 1·059 | ·066 | ·276 | 1·020 | ·064 | ·270 |
| Organic Nitrogen ... ... ... ... ... ... | ·013 | ·000 | ·006 | ·068 | ·000 | ·010 | ·082 | ·000 | ·025 |
| Ammonia ... ... ... ... ... ... ... | ·008 | ·000 | ·003 | ·006 | ·000 | ·002 | ·120 | ·000 | ·003 |
| Nitrogen as Nitrates and Nitrites ... ... ... | ·068 | ·000 | ·017 | ·045 | ·000 | ·009 | ·564 | ·054 | ·323 |
| Total combined Nitrogen... ... ... ... ... | ·069 | ·002 | ·025 | ·088 | ·003 | ·021 | ·578 | ·059 | ·354 |
| Previous sewage or manure contamination ... ... | 360 | 0 | 47 | 140 | 0 | 6 | 5330 | 230 | 2930 |
| Hardness ... ... ... ... ... ... ... | 3·0 | ·4 | 1.4 | 8·0 | ·7 | 2·2 | 30·0 | 15·4 | 20·13 |
| Lime ... ... ... ... ... ... ... | 1·126 | ·217 | ·599 | 3·096 | ·361 | 1·113 | 16·3 | 8·170 | 9·822 |
| Magnesia ... ... ... ... ... ... ... | ·404 | ·144 | ·288 | ·727 | ·111 | ·272 | 1·048 | ·754 | ·890 |
| Potash ... ... ... ... ... ... ... | ·243 | ·053 | ·126 | ·267 | ·063 | ·158 | ·964 | ·734 | ·851 |
| Soda ... ... ... ... ... ... ... | ·916 | ·490 | ·679 | ·683 | ·356 | ·532 | 2·240 | ·834 | 1·666 |
| Sulphuric Acid ... ... ... ... ... ... | 1·746 | ·290 | 1·093 | 1·941 | ·020 | ·969 | 4·650 | 2·683 | 3·674 |
| Carbonic Acid ... ... ... ... ... ... | ·614 | ·000 | ·201 | 2·276 | ·163 | ·691 | 8·524 | 5·517 | 7·187 |
| Silica ... ... ... ... ... ... ... | ·581 | ·026 | ·254 | ·221 | ·061 | ·133 | ·899 | ·715 | ·834 |
| Chlorine ... ... ... ... ... ... ... | 1·487 | ·573 | ·876 | ·653 | ·130 | ·490 | 1·526 | 1·413 | 1·480 |

TABLE B.—ANALYSIS OF LONDON WATERS, 1867-68.

100,000 *Parts of Water contained*—

| — | Total solid Impurity. | | | Organic Carbon. | | | Organic Nitrogen. | | | Previous Sewage Contamination. | | | Hardness. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Max. | Min. | Mean. | Max. | Min. | Mean. | Max. | Min. | Mean. | Max. | Min. | Mean. | Max. | Min. | Mean. |
| THAMES. | | | | | | | | | | | | | | | |
| 1867 ... ... | 32·8 | 27·7 | 28·5 | 1·020 | ·164 | ·272 | ·082 | ·000 | ·013 | 3290 | 1050 | 2062 | 22·8 | 16·0 | 19·3 |
| January, 1868 ... | 32·2 | 29·2 | 30·9 | ·542 | ·271 | ·309 | ·062 | ·027 | ·048 | 3360 | 2920 | 3150 | 19·7 | 15·4 | 17·3 |
| February, „ ... | 32·6 | 30·0 | 31·4 | ·360 | ·324 | ·330 | ·055 | ·031 | ·043 | 3130 | 2790 | 3010 | 21·1 | 18.4 | 19·3 |
| March, „ ... | 32·6 | 28·8 | 30·0 | ·289 | ·136 | ·216 | ·044 | ·012 | ·028 | 2830 | 2150 | 2388 | 21·4 | 18·3 | 19·3 |
| RIVER LEA. | | | | | | | | | | | | | | | |
| 1867 ... ... | 35·7 | 24·1 | 27·5 | ·382 | ·104 | ·196 | ·015 | ·000 | ·005 | 2950 | 230 | 1611 | 24·1 | 16·3 | 19·3 |
| January, 1868 ... | 36·0 | 30·2 | 33·1 | ·147 | ·115 | ·131 | ·024 | ·014 | .019 | 3300 | 2760 | 3030 | 22·8 | 20·5 | 21·6 |
| February, „ ... | 34·4 | 30·8 | 32·6 | ·272 | ·217 | ·244 | ·037 | ·026 | ·031 | 3400 | 3240 | 3320 | 20·5 | 20·5 | 20·5 |
| March, „ ... | 30·0 | 27·4 | 28·7 | ·118 | ·059 | ·088 | ·022 | ·010 | ·016 | 2240 | 1900 | 2115 | 20·5 | 18·5 | 19·5 |
| KENT CO. | | | | | | | | | | | | | | | |
| 1867 ... ... | 42·0 | 31·8 | 39·3 | .254 | ·088 | ·131 | ·004 | ·000 | ·002 | 4820 | 2800 | 3619 | 29·1 | 21·1 | 25·6 |
| January, 1868 ... | ... | ... | 44·8 | ... | ... | ·064 | ... | . | ·013 | ... | ... | 3770 | ... | ... | 26·2 |
| February, „ ... | ... | ... | 59·2 | ... | ... | ·081 | ... | ... | ·013 | .. | .. | 5330 | ... | ... | 30·0 |
| March, „ ... | ... | ... | 70·2 | ... | ... | ·093 | . . | . | ·209 | ... | . | 3080 | ... | ... | 32·3 |

The quantity of the solid impurity contained in a water is a very important matter, apart from the consideration of the quality of the substances which compose this impurity. Waters leaving a small amount of residue upon evaporation are usually well fitted for domestic use. They are invariably the best for manufacturing purposes, as they effect a great saving in heat when used for steam boilers. I was shown the other day some cakes of carbonate of lime, a quarter of an inch thick, which had been removed from a locomotive boiler at the Deptford Railway Station, in which they had been formed in forty-eight hours; through this substance heat passes with extreme slowness, so that a considerable quantity of fuel is wasted. It will be seen from the first of the above tables that, on an average of all the samples, the total solid impurities amount in the two schemes to about 1-7th of those in the present water supply; but if we might venture to take the water in the proposed large storage reservoirs as equal in this respect to the water now stored in the lakes, it would be about 1-10th of that which is found in London waters.

Now this solid residue is partly mineral and partly organic. Let us glance first at the organic portion. This organic matter present in the original water may be either living or dead. The detection of the former class of impurities belongs more to the province of the naturalist than to that of the chemist; but it may be remarked in passing, that this form of organic impurity must necessarily be in suspension and not in solution. We cannot conceive of organized beings existing in solution—it is impossible. But it does not from this follow that these suspended matters can be removed from water by filtration.

It is well known that the ova of many species of animalculæ cannot be removed thus, they pass through the best filters; and it has also been proved that what is believed to be the cholera poison passes through filters, and cannot be arrested. This is a most important consideration in connection with water which is contaminated with sewage and manure matters; and it is necessary that such water should, at all events, be as well filtered as possible. The present water companies supplying London cannot possibly be blamed for the original quality of the water which they supply. They cannot hinder the 600,000 persons who live on the banks of the Thames from pouring their refuse into the river; but they can filter this impure water. They can, and indeed by Act of Parliament they are supposed to be compelled to deliver this water in a bright, transparent, and filtered condition; and they can in this way, as far it is possible by filtration to do it, remove these suspended organic contaminations from the water.

But how does the matter stand? Here is a sample of water which I drew from the Lambeth Company's main on the 4th of March. You see that the water is not filtered. It is filtered by Act of Parliament! but it is curious to observe that so much pollution can pass through an Act of Parliament. Here too is a sample of the same company's water collected on the 21st of January; and it is a fact, that during the whole of that interval and almost up to the present time, this water has been much in the same condition. Those of my audience who are supplied by the Lambeth Company, or the Southwark and Vauxhall Company, or by the Chelsea Company, will bear me out as to the condition in which those companies have delivered water during the past two months. In fact, not only for the past two months, but during the entire year, water is often delivered in London very imperfectly filtered. The Southwark Company during the whole of last year, with one exception, delivered from its mains, when the samples were drawn for analysis, turbid water, imperfectly filtered—most of the other companies were to a less extent guilty of the same thing. Of the companies which draw from the Thames, the West Middlesex and the Grand Junction are the two which filter their water best; but the only company which delivered water uniformly transparent and well filtered was the New River Company.

I have stated that the absolute quantity of the organic matter in solution in water cannot be ascertained, but the amount of carbon and nitrogen contained in this organic matter can be estimated by the process of combustion which I have exhibited to you. The amount of organic carbon and nitrogen in the several waters I have referred to, is represented in the second and third lines of table A, and in the second and third columns of tabe B you will see that, with regard to these elements of the organic matter in solution, there is not a very striking difference between the three different classes of waters. There is an excess of organic nitrogen in the case of the London water, and of organic carbon in the case of the Welsh waters.

The organic matter, of which the elements are thus determined, may be either animal or vegetable, and the nature of it has much to do with probability of its being noxious or innocuous. The animal or vegetable source of the organic matter may be judged of by the proportion of nitrogen to carbon, as determined by analysis: that from animal sources contains a larger proportion than that derived from vegetable sources; and in this way it is easy to see that the organic matter in the Welsh and Cumberland water is of a different character from that contained in the London waters. The London river-waters, especially when turbid, contain a much larger proportion of nitrogen to carbon than is contained in other waters, thus proclaiming the animal origin of some portions of the organic matter.

When I addressed you on this subject last year I stated that by operating upon one litre of water, one per cent. of unchanged sewage could be detected with certainty, but that smaller percentages ought, in operations upon such a small quantity of water, to be considered as falling within the possible errors of experiment. In like manner, by operating upon 10 litres of water 1-10th of a per cent. of unchanged sewage could be detected. During the past year, however, this process of analysis has been so improved that an amount of organic nitrogen corresponding to at most 3-100ths of a per cent, of unchanged sewage can now be detected with certainty in one litre of water. Now about 4-5ths of the organic nitrogen contained in perfectly fresh sewage exists there as urea which undergoes such rapid decomposition, into the mineral compound carbonate of ammonia, that little or none of it ever reaches the Thames from the towns whose sewers debouch into this river. As average London sewage contains 10 parts of combined nitrogen in 100,000 parts, it follows that 100,000 parts of this sewage as it flows into the Thames will contain only 2 parts of organic nitrogen. Further, if the sewage of the 600,000 persons who drain into the Thames above the point whence the water companies draw their supply have the strength of average London sewage, it will amount to 18,000,000 gallons daily, and if the average flow of the river at Teddington be taken at 800,000,000 gallons daily, it follows that the river will there contain 2,255 parts of sewage in 100,000 parts, or $2\frac{1}{4}$ per cent. This quantity of sewage, if in the condition as delivered at the sewer outfall, would contaminate the whole volume of the river, only to the extent of .045 part of organic nitrogen in 100,000 parts of water. Now on the 21st of January last the water delivered by the five companies drawing their supplies from the Thames contained the following amounts of organic nitrogen in 100,000 parts:—

| | |
|---|---|
| Chelsea (turbid) | .058 |
| West Middlesex (clear) | ·027 |
| Southwark (turbid) | ·061 |
| Grand Junction (clear) | ·031 |
| Lambeth (turbid) | ·062 |

It will be seen, therefore, that three out of the five samples of water actually contained more organic nitrogen than would be due to the admixture of the 18,000,000 gallons of sewage which are poured into the Thames above the point from which these samples came. But Thames water holds in solution a certain amount of peaty matter which contains organic nitrogen; a sufficient proportion of this substance, however, to furnish the above larger quantities of organic nitrogen would render the water brownish-yellow when viewed in a quart decanter, whilst these samples of Thames water were, when filtered, colourless or nearly so. I am therefore of opinion that the Thames water delivered in London by the Chelsea, Southwark, and Lambeth Companies on the 21st of Jonuary last contained unoxidised sewage. This opinion is confirmed by the results of some experiments which I have recently made in my laboratory, and which show that, contrary to the generally received opinion (which is, however, based upon no reliable experimental data), sewage in which the urea is already decomposed undergoes further change with extreme slowness, even when freely exposed to the air and mixed with large volumes of water. Thus I find that a mixture of weak sewage from one of the London sewers with nine times its volume of water (containing bicarbonate of lime in solution) at a temperature of 20° to 25° C., and well agitated every day by being made to flow in a thin stream through three feet of air, oxidizes but to a slight extent in the course of eight days. Immediately after mixture this sewage-contaminated water contained ·267 parts of organic carbon and ·081 part of organic nitrogen in 100,000 parts, whilst after 96 hours it still contained ·250 part of organic carbon and ·058 part of organic nitrogen, and even after the lapse of 192 hours the undecomposed organic matter still contained ·200 part of organic carbon and ·054 part of organic nitrogen.

In connection with the organic matter in water, the investigation of the Welsh and Cumberland samples revealed a very curious effect produced by the admission of the detritus from lead and other mines into the waters of the streams and lakes. It was found, upon analysis, that water thus mixed with the milky streams from the crushing-engines of mines contained a wonderfully small quantity of nitrogenous organic matter. You will see this brought out in the following table:—

Effect of Detritus of Lead Mines upon the Organic Matter in Water.

| | Organic Carbon in 100,000 parts of Water. | Organic Nitrogen in 100,000 parts of Water. |
|---|---|---|
| Cumberland Waters. | | |
| Glenridding Beck | ·116 | ·000 |
| Stream flowing into Thirlmere | ·066 | ·001 |
| Goldrill Beck | ·262 | ·001 |
| Welsh Waters. | | |
| Ceryst | ·209 | ·000 |
| Upper Clywedog | ·544 | ·000 |
| Lower Clywedog | ·242 | ·001 |
| Tarannon and Ceryst | ·304 | ·001 |

This table shows that whilst some of these waters exhibit a rather large quantity of organic carbon, they contain very little or no organic nitrogen. And further, these waters, though they hold in solution a considerable amount of peaty matter, are perfectly colourless when seen in a quart decanter; but when viewed through a stratum fifteen feet thick they exhibit the magnificent blue-green tint of absolutely pure water, a tint which is brought out when water is passed through animal charcoal. We may illustrate the action of this crushed quartz of lead mines and of animal charcoal, by three samples of the water delivered to this Institution by the Grand Junction Company, and which are contained in the tubes before you, each of which is fifteen feet long. The centre tube contains the water just as it passes into the cistern, the water in the second tube has been shaken with powdered flint, whilst the water in the third tube has been passed through animal charcoal. If we now send through each tube a parallel ray of electric light, which ray will have to pass through a stratum of about fifteen feet of water, you will perceive that the first gives a yellow-brown tint upon the screen; the second, a beautiful green tint, and the third, a turquoise colour; the last two powerfully reminding the observer of the lakes of Lauerz and Zug, as seen from the summit of the Rigi. In fact this is doubtless the chief cause of that magnificent colour which we witness in many of the Swiss lakes, and which we see for instance in the Rhone when it leaves the lake of Geneva, and the Limmat as it flows from the lake of Zurich. The streams running into the heads of these lakes come in turbid and filled with finely-crushed quartz and other minerals, the detritus from the glaciers which are the source of those streams. In the lakes these fine particles of mud subside and attract to themselves the peaty colouring matter which is to be found in almost all waters.

We see in two of the English lakes some indications of this blue-green tint appearing, and it is precisely in the localities where the streams from the lead mines come down into the lakes. You see near the mouths of those milky streams which come down into Ulswater from Glenridding, and from the "Old Man," into Coniston Lake, the indications of this precipitation and removal of those brown substances which discolour the natural waters of our lakes. We have thus here, perhaps for the first time, evidence of improvement of the quality of water by the admission into it of manufacturing refuse. Hence the diversion of these waters coming from lead and other mines, which would seem at first sight to be necessary, need not be effected; on the contrary, their admission into the lakes would be of great benefit to the waters, they would to some extent decolorise them, and would tend to reduce the nitrogenous organic matter to the lowest possible amount. There appears to be no need to fear that such streams will carry anything into the lakes which will be deleterious to the drinker.

All these streams have been carefully examined for lead, arsenic, copper, &c., and only in two cases has the faintest trace of lead been discovered, and the quantity was so minute that it is absolutely impossible it could be deleterious, even if the water coming from the mines themselves were to be drunk, but mixed with the large quantities of the lake water, it becomes utterly inappreciable.

The fatal effect said to be exerted upon fish by these milky streams from mines is most probably due to a mechanical action of the finely divided quartz upon their organs of respiration—an effect analogous to that (but of an exaggerated kind) from which the Sheffield grinders notoriously suffer.

Having thus discussed the organic portion of the solid impurity of these waters, let us now turn to the inorganic or mineral portion, which may be conveniently divided, as regards its most important constituents, into three subdivisions, viz.:—

1. Soap destroying substances.
2. Mineral compounds, constituting chiefly the skeleton of decomposed sewage or manure.
3. Poisonous substances, such as arsenic, copper, and lead.

The first or soap destroying category of substances communicate to water the quality called hardness. These substances are the salts of lime and magnesia; and the quantity of them contained in the proposed, as compared with the present, metropolitan water supply will be seen on reference to the above analytical table. The hardening effect of these substances is also given in a separate line of the same table, from which it will be seen that the proposed is only about 1-10th as hard as the present water supply.

Tastes differ as regards hard or soft water for drinking purposes, and medical arguments have from time to time been advanced, now in favour of and now against each. It has been asserted in this country, for instance, that hard water is necessary for the formation of bone, and that the finger of Providence points to the advantage of hard water by the profusion of calcareous strata occurring in the earth's crust, whilst M. Belgrand states that the inhabitants of the hard-water districts of France notoriously suffer from carious teeth. It would probably be extremely difficult to prove either of these assertions. As regards the enormous advantages of soft water for washing, cleansing, and manufacturing purposes, there is, however, no difference of opinion. In Glasgow alone the annual saving of soap only, by the introduction of Loch Katrine water, for a previous supply of very moderately hard water, has been estimated at £36,000.

Having had the opportunity of comparing a six years' experience of the soft water supplied to Manchester, with a subsequent ten years' experience of the hard water of London, I can state that the soft water was for all purposes preferred by every member of my family. On removing from Manchester to London, the repugnance to drink the hard water of the latter city was at least as marked as that which I have sometimes noticed in persons making the transition in the opposite direction.

The hardness of the London waters is chiefly what is termed temporary hardness; that is, it is caused by the carbonates of lime and magnesia, the greater portion of which is gradually deposited on boiling the water for half-an-hour. By reason of this softening of such water by boiling, temporarily hard water is considered to be less objectionable than water of the same degree of permanent hardness. My own experience leads me to the conclusion that the advantages of temporary over permanent hardness have been considerably overrated. In reality, water used for domestic purposes is, even when used hot, either not heated to the boiling point, or is boiled for too short a time to remove more than a small proportion of its temporary hardness. Thus, water drawn from the kitchen boilers of a dwelling house and of the Athenæum Club was usually almost as hard as the cold water with which they were supplied, as is seen from the following table:—

| Date and Hour. | Hardness of Cold Water. | Hardness of Hot Water. |
|---|---|---|
| Sept. 30th, 1867, 8 p.m. | 14°·6 | 13°·6 |
| Oct. 1st „ 8 p.m. | 14·4 | 13·9 |
| „ 2nd „ 8 a.m. | 14·4 | 13·4 |
| „ 3rd „ 9 p.m. | 14·6 | 11·6 |
| „ 4th „ 8 a.m. | 14·6 | 7·6 |
| „ 7th „ 8 p.m. | 14·4 | 11·7 |
| „ 8th „ 9 a.m. | 14·4 | 12·1 |
| „ 9th „ 8 p.m. | 15·4 | 14·3 |
| „ 10th „ 8 p.m. | 15·9 | 11·9 |
| „ 11th „ 8 a.m. | 15·9 | 8·4 |
| „ 12th „ 8 a.m. | 16·1 | 11·9 |
| Nov. 8th „ 5 p.m. | 18·7 | 18·4 |
| „ 11th „ 5 p.m. | 18·7 | 18·6 |
| „ 12th „ 6 p.m. | 18·7 | 18·4 |

The amount of soap destroyed by the use of various waters for washing purposes is seen from the following table, in which certain Welsh and Cumberland waters are introduced for the purposes of comparisons:—

Soap destroyed by 100.000lbs. of various Waters.

| | lbs. of Soap destroyed. |
|---|---|
| *Metropolitan Waters.* | |
| Thames Water | 212 |
| River Lea | 204 |
| Kent Company's Water | 265 |
| *Other Waters.* | |
| South Essex Company's Water | 253 |
| Caterham Company's Water | 84 |
| Water supply of Worthing | 285 |
| „ „ Leicester | 161 |
| „ „ Manchester | 32 |
| „ „ Preston | 80 |
| „ „ Glasgow (Loch Katrine) | 4 |
| „ „ Lancaster | 1 |
| Bala Lake | 5 |
| Thirlmere | 8 |
| Haweswater | 16 |
| Ulleswater | 23 |

In the recent supply of water to Paris from new sources, the importance of soft water attracted the attention of the eminent engineer M. Belgrand; a close investigation of the available sources, however, soon showed that he had unfortunately but little choice, as the really soft streams of the Fontainebleau sands (the minimum hardness is however 6°) and of the granite of Morvan (minimum hardness 2·2°) were mere dribblets. Of the latter M. Belgrand says—"Sources qui donnent les eaux les plus pures du bassin de la Seine; déviations vers Paris impossible, en raison du peu d'importance des sources." Hence the river Vanne (17°—20°), somewhat softer than the Thames, was the softest available source, and having first conclusively demonstrated this, he consoles the Parisians by saying—"Les eaux du granite, du greensand et des sables de Fontainebleu, qui sont chimiquement plus pures, sont beaucoup moins agréables à boire."

The second category of inorganic substances contained amongst the solid impurities of waters, consists of the mineral compounds constituting chiefly the skeleton of decomposed sewage or manure. The putrescible nitrogenous organic matters present in water, or in the soil through which water percolates, undergo gradual oxidization and decomposition, by which their carbon and hydrogen are converted into carbonic acid and water, and their nitrogen into ammonia, nitrous and nitric acids. The last three remain in the water, constituting a record of previous contamination with putrescible nitrogenous organic matter. But rainwater always contains ammonia, and, as Dr. Bence Jones has shewn, also nitrous and nitric acids. The nitrogen in these forms in rainwater, as it finds its way into rivers and springs, amounts in the aggregate to ·032 part in 100,000 parts of water, therefore this amount must be deducted from that found on analysis, as nitrogen derived from aerial sources. The remainder, if any, represents the nitrogen derived from putrefied nitrogenous organic matters with which the water has been in contact. To express this in terms of some known standard, I employ average filtered London sewage, which contains 10 parts of nitrogen in the form of putrescible organic matter in 100,000 parts. Thus, a water which contained one part of nitrogen in 100,000, as nitrous acid, nitric acid and ammonia would contain in 100,000 parts, the nitrogenous remains or skeleton of an amount of putrescible organic matter equal to that contained in 10,000 parts of average filtered London sewage. Such a water therefore is said to have a previous sewage contamination of 10,000 parts in every 100,000 parts. But it may be asked, is this a true record of the previous history of the water in this respect? I believe it to be so, as far as it goes. I believe that this nitrogen as truly represents a quantity of previously existing putrescible organic nitrogenous matter, as that the bones of a megatherium demonstrate the previous existence of an individual of that species; but as the geological record of previously existing organisms is imperfect, so is the nitrogenous record, just as chemical and mechanical agencies have broken up and dissipated the remains of millions of animals during long geological periods, so does the action of growing plants, and perhaps also of living animals, remove from water, in a few hours or days, some portion of this skeleton of previous putrescible organic matter. Thus by storage in large reservoirs, the East London Company reduced the previous sewage contamination of the River Lea last summer from about 2000 down to 230 parts in 100,000. The previous sewage contamination of a water as determined by analysis is therefore a minimum quantity.

But in addition to the aerial for which due allowance is made, can there not be some other source of this skeleton than putrefied sewage or manure matter? Can it not be derived from putrefied vegetable matter—from peaty matter for instance? Without utterly denying the possibility of this, I venture to assert that nowhere, in this country at least, nor probably on the continent of Europe, is there such a quantity of nitrates, nitrites, or ammonia produced from vegetable sources as to appreciably affect the truth of my proposition that the nitrogen in these forms obtained by water from terrestrial sources is substantially due to the putrefaction and oxidation of sewage and manure matters.

It has been objected to this view of the origin and significance of these forms of combined nitrogen, that waters derived from comparatively deep wells, in the chalk for instance, contain them in large quantities; thus the Kent Company's water exhibits a previous sewage or manure contamination of from 3,000 to 5000 parts in 100,000. It is difficult to understand how such an objection could have originated, and it certainly disappears on examination; for instance in the above case, it is well known that a very large proportion of the water collected in the London chalk basin consists of the drainage from manured land, and it is doubtless from this source that the large proportion of nitrates existing in this water is derived.

According to Mr. Way's analysis, the drainage water from cultivated land contains an amount of nitrates corresponding to the following proportions of previous sewage contamination in 100,000 parts:—

| | Maximum. | Minimum. | Mean. |
|---|---|---|---|
| Previous sewage contamination of drainagewater from manured land......... | 54,490 | 7,040 | 20,370 |
| Ditto from pasture-land, unmanured...... | 2,100 | 180 | 830 |

The results of the examination of various well-waters contained in the following table, further illustrate this point:—

Previous Sewage or Manure Contamination in 100,000 parts of various Well-waters.

| Names of Water. | Ammonia. | Nitrogen as Nitrates an Nitrates. | Previous Sewage Contamination |
|---|---|---|---|
| Artesian Well at Grenelle ................ | ... | ·006 | 0 |
| Chalk Well at Caterham .................... | ·009 | ·000 | 0 |
| Water delivered by Kent Company ...... | ·001 | ·408 | 3770 |
| Water supplied to Worthing .............. | ·000 | ·426 | 3940 |
| Water delivered by the South Essex Co. | ·006 | ·848 | 8205 |
| Shallow Well at Reyland, near Preston | ·003 | 2·466 | 24360 |
| „ at Ledbury ................. | ·001 | 1·575 | 15440 |
| „ at Redhill.................. | ·002 | 1·446 | 14160 |
| „ in Aldgate ................. | ... | 3·840 | 38080 |
| „ in Minories ................. | ... | 5·738 | 57060 |
| „ in Leadenhall Market...... | ... | 5·769 | 57370 |
| „ in St. Nicholas Olave, Chyd. | ... | 7·596 | 75640 |
| Well in the Rue Traversine, Paris......... | ... | 30·029 | 299780 |
| Royal Institution Well-water............... | ·001 | 4·355 | 43240 |

With two remarkable exceptions the above results show the greatest previous sewage contamination precisely in those places were it would be predicted; thus the shallow well-water of Leyland, near Preston, consists almost entirely of the drainage of cesspools and market-gardens, through a sandy soil, the latter being heavily manured with night-soil, stable manure, and guano. It need therefore excite no surprise that nearly 25 per cent. of this water has been in a condition equivalent to average London sewage. The quality of the waters taken from four of the city pumps and from the well in the Royal Institution* needs no comment; these shallows wells are now recognized as being fed by oxidized and somewhat diluted sewage. It is, however, in the well of the Rue Traversine, in Paris, that this kind of contamination reaches perhaps its maximum. The cesspool system is still in full activity in Paris, and the soil of that city is saturated with liquid manure of such a strength that one gallon of it is equivalent to three gallons of average London sewage.

As already mentioned there are in the above table two remarkable exceptions to the general previous sewage contamination of well-waters. These are the artesian well at Grenelle and the chalk well of the Caterham Water Company. With regard to the first, it is evident that the pressure of water which supports a column of 122 feet above the surface of Grenelle, precludes the possibility of admixture with the drainage of Paris, still there can be little doubt that the water supplying the chalk of the Paris basin is, to some extent at least, contaminated by manure, although the land through which it drains is far less generally cultivated than that through which the water supply of the London chalk percolates. The water from the Caterham Company's well, comes, I believe, from a greater depth than that of the Kent and South Essex Company's, and this circumstance, coupled with the observation of Mr. Dugald Campbell that the water of the deep chalk wells, unlike that of the shallower chalk-wells, is free from nitrates, and taken in connection with the fact that there is free water-communication between the upper and lower chalk, points to the conclusion that the chalk possesses the property of abstracting nitrates from water. If this be the case, it would also account for the circumstance that the water of the shallow chalk-wells exhibits much less previous sewage contamination than might be expected; the average amount of nitrates found by Mr. Way in drainage water would indicate a previous sewage contamination in the chalk-water, equal to about 20,000 parts in 100,000, whilst the contamination actually exhibited in the case of the Kent, Worthing, and South Essex Companies waters is only: Kent 3,770, Worthing 3,490, and South Essex 8,205 in 100,000 parts.

I have extended this investigation to various river and lake waters, as well as to spring waters, and have been here much indebted, as regards the non-British waters, to M. Boussingault's researches on the presence of nitrates in waters. The following tables exhibit the results of this investigation:—

Previous Sewage, or Manure Contamination, in 100,000 parts, of various River and Lake Waters.

| Names of Water. | Ammonia. | Nitrogen as Nitrates and Nitrates. | Previous Sewage Contamination |
|---|---|---|---|
| *River Waters.* | | | |
| Nile.............. .............................. | ... | ·102 | 700 |
| Rhine, at Bâle ............................ | ... | ·026 | 0 |
| Seine, at Notre Dame .......................... | ... | ·152 | 1200 |
| Ourcq ............................................ | ... | ·223 | 1910 |
| Thames ........................................... | ·005 | ·234 | 2062 |
| Lea ................................................ | ·002 | ·220 | 1901 |
| Severn (near source)................................ | ·003 | ·007 | 0 |
| Lower Clywedog ........................... | ·004 | ·006 | 0 |
| Tarannon ...... ............................ | ·008 | ·024 | 0 |
| Ceryst ................................................ | ·001 | ·052 | 210 |
| Carno .............................................. | ·003 | ·049 | 190 |
| Banw and Eira .................................. | ·004 | ·023 | 0 |

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* As this water enjoyed for a long time a very high reputation in the domestic department of this Institution, and as I have been frequently and very earnestly requested to withdraw a prohibition which I placed upon its use in the cholera year, 1866, I append, for my own justification, a more complete analysis.

| | In 100,000 parts. |
|---|---|
| Total solid impurity ... ... ... ... | 93·7 |
| Organic carbon ... ... ... ... | ·440 |
| Organic nitrogen ... ... ... ... | .085 |
| Nitrogen as nitrates and nitrites ... ... | 4·355 |
| Ammonia ... ... ... ... ... | ·001 |
| Total combined nitrogen ... ... ... | 4·441 |
| Previous sewage contamination ... ... ... | 43240 |
| Actual contamination with unoxidized sewage ... | 4250 |
| Hardness ... ...... ... ... ... | 32·5 |

The gases dissolved in this water contained scarcely a trace of oxygen. A half-pint glass of it contains nearly a quarter of a pint of water which has previously been in the condition of average London sewage, besides a dessert spoonful of actual or unoxidized sewage. It seems, therefore, highly probable that filtered and tolerably well-oxidized sewage, in its undiluted condition, would furnish the most popular water supply for London. Such is the reliability of instinct in these matters.

| Names of Waters. | Ammonia. | Nitrogen as Nitrates and Nitrites. | Previous Sewage Contamination |
|---|---|---|---|
| Vyrnwy | ·003 | ·011 | 0 |
| Tylwcb | ·003 | ·004 | 0 |
| Upper Rothay | ·003 | ·002 | 0 |
| Lowther | ·002 | ·003 | 0 |
| Kent | ·001 | ·045 | 140 |
| Sprint | ·000 | ·021 | 0 |
| Fourteen other Cumberland Streams | ... | ... | 0 |
| *Lake Waters.* | | | |
| Bala Lake | ·001 | ·000 | 0 |
| Thirlmere | ·003 | ·002 | 0 |
| Haweswater | ·004 | ·000 | 0 |
| Ullswater | ·003 | ·005 | 0 |
| Watendlath Tarn | ·002 | ·006 | 0 |
| Loch Katrine | ·002 | ·031 | 0 |
| 5 Lakes and Tarns examined by Boussingault | ... | ... | 0 |

Previous Sewage, or Manure Contamination in 100,000 parts, of various Spring-waters.

| Names of Waters. | Ammonia. | Nitrogen as Nitrates and Nitrites. | Previous Sewage Contamination |
|---|---|---|---|
| Mother Ludlaw's Cave | ·001 | ·034 | 30 |
| Water supplied to Ferette (Haut Rhin | ... | ·039 | 70 |
| Spring near Durmenach (Haut Rhin) | ... | ·114 | 820 |
| Source of the Roppensviller (Haut Rhin) | ... | ·168 | 1360 |
| ,, ,, Arcueil | ... | 1·111 | 10790 |
| ,, ,, But at Montmartre | ... | 8·563 | 85310 |
| ,, ,, Martinet | ... | ·557 | 5250 |
| ,, ,, Trois Meules, St. Etienne | ... | ·210 | 1780 |
| Spring at Nimes | ... | ·129 | 970 |
| Ebersbronn (Bas Rhin) | ... | ·417 | 4150 |
| Water supplied to Woerth-sur-Sauer (Bas Rhin) | ... | ·259 | 2270 |
| Source of the Ill, nr. Winckel (Haut Rhin) | ... | ·104 | 720 |
| Liebfrauenberg Spring (Bas Rhin) | ... | ·005 | 0 |
| Seltz (Bas Rhin) | ... | ·008 | 0 |
| Mineral Spring of Bussang (Vosges) | ... | ·003 | 0 |
| Water supplied to Thann (Haut Rhin) | ... | ·010 | 0 |
| Source of the Boelacker (Haut Rhin) | ... | ·018 | 0 |
| Spring at Castle Fleckenstein (Bas Rhin) | ... | Traces. | 0 |
| Thermal Spring at Baden | ... | ·016 | 0 |
| ,, ,, Dax | ... | ·013 | 0 |
| Source of the Presle (East Pyrenees) | ... | ·013 | 0 |

The results embodied in the above tables throw considerable additional light upon this form of water contamination. They show in the first place that waters which have not been in suspicious company exhibit little if any previous sewage contamination, thus in the whole of the Cumberland and Westmorland district it only occurs in one instance (the Upper Kent which, as every tourist knows, has a little cultivated land on its banks), and that to a small extent only, In the Welch waters again there are only three instances. The spring water which issues from the Greensand beneath an uncultivated but heather-covered surface at Mother Ludlaw's Cave, near Farnham, exhibits a mere trace of this contamination, whilst the waters of nine springs on the Rhine, in the Vosges, and in the Pyrenees, examined by M. Boussingault, exhibit no indications of previous sewage contamination. On the other hand, the spring forming the source of the But and issuing not far from the cemetery at Montmartre at once discloses its antecedents, and exhibits a previous sewage contamination of 85,310 parts in 100,000. It will be seen that the watrr of the Ourcq, which is now used only for watering the streets of Paris, exhibits a previous sewage contamination somewhat less than Thames water.

But what is the import of this previous sewage contamination? These skeleton compounds are inocuous, why trouble ourselves about them? True, they are inocuous, or nearly so; but inasmuch as they show that the water has been in contact with animal refuse they bring a heavy charge of suspicion against it. These refuse animal matters are known to contain that which is hurtful to human life. This hurtful matter is believed, on very strong evidence to consist of spores, or germs of organisms, which are capable, under favourable circumstances, of producing in man such diseases as cholera, typhoid fever, and dysentery. Now such spores or germs, endowed as they are with vitality, will be likely to resist the oxidizing agencies which convert the rest of the animal refuse into carbonic acid, water, nitric acid, nitrous acid, and ammonia. For instance, if the contents of an egg were beaten up with water and poured into the Thames at Oxford, the organic matter would probably be entirely oxidized and converted into mineral compounds before it reached Teddington; but if the egg were thrown whole into the Thames at Oxford, it would, if it retained its vitality, be carried down to Teddington without any decomposition of its organic matter. There can be no doubt that the spores or germs of many organisms are in like manner capable of resisting for a long time the decomposing action of water. Now no practicable process is known by which these spores, once introduced into water, can be again removed or can have their vitality destroyed. Filtration will not do it; in fact it is well known to engineers that water is often contaminated with visible suspended matter which cannot be separated by filtration; thus M. Belgrand says, " Lorsque l'eau est troublée dans le fleuve, elle sort louche de nos filtres." And again, speaking specially of the London water supply, " Le mode de dégrossissage employé par les grandes compagnies anglaises, trés convenable à Londres, où l'on ne boit pas d'eau, ne vaut rien á Paris, ou les femmes, les enfants, les veillards de la classe ouvrière n'ont pas d'autre boisson. J'ai constaté par moimême, et les ingénieurs anglais n'en disconviennent pas, que l'eau sort des filtres très chargée de matiére organique." Again, in the account of his highly remarkable researches on vaccine and small-pox poisons, recently communicated to the Academy of Sciences, M. Chauveau says regarding the organic germs contained in these poisons, that they " ne se déposent jamais complètement dans les couches profondes du milieu ambient, et passent à travers tous les filtres."

Boiling even for several hours cannot be relied upon for the destruction of such germs, some of which have recently been shown to retain their vitality after four hours boiling; in fact there can now no longer be any doubt, that as contended by M. Pasteur, the cases of so-called spontaneous generation have all had their origin in ignorance of the excessive tenacity of life in the germs of the lowest organisms.

Nothing short of distillation, therefore, as it is carried on in nature, can be relied upon to free, completely, sewage-contaminated water from its noxious constituents. Excessive filtration is doubtless to some extent a safeguard, and hence previous sewage contamination in chalk-water, if we could be certain that the water had been fairly filtered through some 100 feet of chalk, and that none of it gained access to the wells through fissures or swallow-holes, would have far less significance than it has in the case of a river water where the fine suspended and noxious matters of sewage have but a comparatively slender chance of removal before the water reaches the consumer. We must also not forget that mere dilution fails, in the case of these suspended germs, to destroy their noxious quality, differing as they do in this respect remarkably from soluble poisons. The daily casting of a thousand fatal doses of strychnine into the Thames at Oxford ought not to occasion so much alarm amongst the London water-drinkers as the present flow of of the Oxford sewage into the river, because the excessive dilution of the soluble strychnine would effectually prevent its producing any physiological effect. Each noxious living germ, on the other hand, contains within itself the power of indefinite multiplication and mischief. One such germ may be present in a wineglass-full of water, whereas it would be necessary to drink many thousand gallons of water to imbibe a noxious amount of strychnine, under the conditions just alluded to. I am therefore of opinion that water once contaminated with sewage or manure matter ought never again to be used for domestic purposes, if any other supply can be obtained; and I endorse the advice of M. Belgrand and the principle which guided him in the selection of his new water supply for Paris.—" On a dit des eaux potables, qu'elles étaiens comme la femme de César, qu'elles ne devaient pas même être soupçonnées, et c'est mon avis."

A few words will now suffice regarding the third class of mineral matters that may be present in the solid impurities of waters, viz., poisonous substances such as arsenic, copper, and lead. These substances are only likely to occur in waters connected with mineral workings—one of them only, lead, has been detected in the proposed supplies, and that only in two streams in Cumberland, and in quantity far too minute to require any further notice.

The following table exhibits a comparative view of the amount and quality of the gases contained in the proposed and present supplies:—

Gases expelled on Boiling 100 volumes of various Waters.

| Names of Gases. | Welsh Waters. | | | Thames Waters. | | | Cumberland Waters | | | Distilled Water |
|---|---|---|---|---|---|---|---|---|---|---|
| | Max. | Min. | Mean | Max. | Min. | Mean | Max. | Min. | Mean | |
| Nitrogen | 1·112 | 1·220 | 1·323 | 1·551 | 1·310 | 1·124 | 1·723 | 1·588 | 1·656 | 1·133 |
| Oxygen | ·612 | ·566 | ·612 | ·719 | ·607 | ·726 | 0·832 | 0·771 | 0·801 | ·617 |
| Carbonic Acid | ·335 | ·107 | ·227 | ·793 | ·085 | ·281 | 4·121 | 3·182 | 3·652 | ·105 |
| | 2·389 | 1·899 | 2·162 | 3·063 | 2·002 | 2·131 | 6·676 | 5·541 | 6·109 | 1·855 |

You will find that the gases contained in the Welsh and Cumberland waters are very similar in quantity and proportion to those found in recently distilled water. Collected as these waters are near the mountain ranges which constitute the great condensers of natural distillation, this is exactly the result we should expect. The London waters differ mainly in containing more carbonic acid in solution which makes them more sparkling in appearance. Sparkling waters are generally preferred by the public, although they commonly owe their briskness to extensive contact with decaying organic matter. It is thus that the highly sparkling pump water of London are still preferred by many. On the other hand, soft waters are not necessarily vapid; no draught of water could be more delicious than that which is obtained from the public drinking fountains of Glasgow, supplied from Loch Katrine, although I find that 100 volumes of this water contain only the following gaseous constituents:—

| | | |
|---|---|---|
| Nitrogen | 1·731 | vols. |
| Oxygen | ·704 | „ |
| Carbonic Acid | ·113 | „ |
| | 2·548 | |

### Action upon Lead.

The conditions which determine the action or non-action of water upon lead, have hitherto been involved in much obscurity. Messrs. Graham, Miller, and Hofmann, the Government Commission of 1851, on the supply of water to the metropolis, established the fact that the presence of dissolved oxygen and the absence of more than three volumes of carbonic acid in 100 volumes of water, are amongst the conditions necessary for the attack of lead.

The whole of the present water supply of the metropolis is perfectly protected from acting upon lead by the large quantity of carbonic acid which it contains. Still there are obviously other conditions involved in the problem; for all the samples of water from the Welsh and Cumberland districts contain, as shown in the above analytical results, dissolved oxygen, whilst not one of them possesses an amount of carbonic acid even remotely approaching that which is necessary to protect it, and yet some of these waters act violently upon lead, whilst others are entirely without action upon the metal. Having recently had occasion to observe that a sample of distilled water, which acted powerfully upon lead, completely lost this quality by momentary contact with animal charcoal, I found on further investigation, that a minute quantity of the chief constituent of bone-black, viz., phosphate of lime, completely protects water from action upon lead. I then carefully examined for phosphate of lime, the water of the River Kent (Upper Kent) which is eminently distinguished for its violent action upon lead, and the water of the River Vyrnwy, which, although nearly as soft as distilled water, has not the slightest action upon lead, even when placed in contact with a bright and freshly-cut surface of the metal for 24 hours. This examination established the fact that the water of the Vyrnwy contained an appreciable amount of phosphate of lime, whilst not the slightest trace of this substance could be detected in that of the Upper Kent. The waters from both the proposed districts have been carefully examined as regards their behaviour towards lead, and, as the result of this examination, it may be safely affirmed thet no danger on this score need be apprehended from the introduction of water from either district into the metropolis. I here exhibit to you samples of lead in various waters exemplifying the points upon which I have just spoken.

Lastly, I place before you in these large cylinders, holding more than a gallon each, samples of the Welsh and Cumberland waters, side by side with a similar sample of Thames water, which fairly represents the condition of more than 3-5ths of this water as it has been delivered in London since the 21st of January last. But it may be asked, will these waters from Wales or Cumberland reach the metropolis in this colourless, transparent, and soft condition after passing through a conduit from 180 to 280 miles in length? Let me tell you what I conceive will be the effect of such a conduit upon the water. For the first two or three years a certain amount of lime from the surface of the cement in the conduit will dissolve in the weter, communicating at first an amount of hardness probably not exceeding 5°; this effect will gradually subside, and after two or three years the water will be delivered in London in a slightly better condition than that in which it leaves the storage reservoirs—a slightly better condition because it will be somewhat better aerated than when it starts on its journey. At the present moment the water of Loch Katrine passes through a conduit 26 miles long, and I have lately carefully taken its hardness as it leaves the lake and as it is delivered to consumers in Glasgow. Its hardness on delivery in Glasgow is only 0·3°, exactly the same as in the lake, and its transit through 26 miles of conduit has therefore added no hardening constituent to the water. Now, if 26 miles of conduit fail to alter the hardness, I can only conclude that 180 or even 280 miles of conduit, if properly constructed, will also, after the lapse of a few years, be equally incompetent to produce any substantial increase in the hardness. At the time the above experiments were made, Loch Katrine water had flowed through the conduit for seven years.

These are the principal points I have to bring before you in connection with the proposed supply, and as a summary of the chemical investigation of the present water supply on the one hand, and of the samples furnished by the Welsh and Cumberland districts on the other, I may state the following conclusions to which these investigations have led me:—

1. The present water supply of the metropolis is largely contaminated with sewage. Both analysis and statistics concur in the statement that each glass of Thames water taken from the river by the companies, contains one tea-spoonful of sewage.
2. Although this sewage is generally to a great extent oxidized before the delivery of the water in London; yet there is no guarantee whatsoever that all its noxious qualities are, in all probability, contained in the mechanically suspended and least oxidizable portion of the sewage.
3. The river water supplied in London is often very imperfectly filtered; and thus even the visible suspended matters of sewage are not wholly excluded from the water supply. Only on one occasion the whole year 1867, have I obtained a transparent sample of water from the Southwark Company's mains. The Grand Junction Company's water was turbid, four times out of twelve, the Chelsea thrice, the West Middlesex, Lambeth, and East London each twice, out of the twelve occasions when the samples were drawn for analysis. The New River Company alone delivered perfectly filtered water during the whole year.
4. The quality of the water supplied to London is greatly inferior to that of any other town in the United Kingdom, whose supply I have examined.
5. The distribution of water in the metroplis still continues, with but slight exceptions, on the intermittent system, a system which has been abolished in almost every town of importance in the United Kingdom.
6. The water which it is proposed to supply either from the Welsh or the Cumberland districts is of an excellent quality. It is equal or superior to that supplied to any town in Great Britain.
7. The water from each of the proposed districts is extremely soft, pleasant to drink, and of good aeration.
8. These waters have never been contaminated with sewage, and are therefore above all suspicion.
9. They can be distributed in the present system of supply pipes without any danger of lead contamination.

The choice between the present and proposed supply rests virtually with the intelligent inhabitants of the metropolis. Will you go to a source of pure water uncontaminated with sewage, or will you continue the existing supply? I can anticipate your verdict, but you must not delay to record it. These splendid sources now available will not remain much longer within your reach.

In conclusion, I beg to quote the opinion of one of our highest medical authorities on the dangers of sewage-contaminated water. Unpleasant as the theme may be, this opinion is in the highest degree deserving the earnest attention of every individul who has progressed beyond the state of savagery. In his Report on the Cholera Visitation of 1866, Mr. Simon, the medical officer of Privy Council, says:—" It cannot be too distinctly understood that the person who contracts cholera in this country is ipso facto demonstrated with almost absolute certainty to have been exposed to excremental pollution: that what gave him cholera was (mediately or immediately cholera-contagium. discharged from another's bowels; that, in short, the diffusion of cholera among us depends entirely upon the numberless filthy facilities which are let exist, and especially in our larger towns, for the fouling of earth and air and water, and thus secondarily for the infection of man, with whatever contagium may be contained in the miscellaneous outflowings of the population. Excrement-sodden earth, excrement-reeking air, excrement-tainted water, these are for us the causes of cholera. That they respectively act only in so far as the excrement is cholera-excrement, and that cholera-excrement again only acts in so far as it contains certain microscopical fungi, may be the truest of all true proposition; but whatever be their abstract truth, their separate application is impossible. Nowhere out of Laputa could there be serious thought of differentiating excremental performance into groups of diarrhœal and healthy, or of using the highest powers of the microscope to identify the cylindro-taenium for extermination. It is excrement, indiscriminately, which must be kept from fouling us with its decay.

"And thus it is that my practical advice remains substantially what it has been for years. The local conditions of safety are, above all, these two:—(1) that, by appropriate structural works, all the excremental produce of the population shall be so promptly and so thoroughly removed, that the inhabited place, in its air and soil, shall be absolutely without fœcal impurties; and (2) that the water supply of the population shall be derived from such sources, and conveyed in such channels, that its contamination by excrement is impossible.

"What good results are got even by rough approximation to those sanitary standards has already been abundantly shown here. The way in which the southern districts of London. with their three-fourths of a million of population, have gradually gained comparative immunity from cholera in proportion as their two water companies have ceased to distribute sewage-tainted water among them, is a matter of familiar history.

"That cholera is still a terror to Europe shows how scantily such illustrations are yet understood. Even here in England the objects which I have named as essential are at best but rarely fulfilled: indeed for vast numbers of our population scarcely rudimentary endeavours have been made to attain them. Town after town might be named, with myriad on myriad of population, where there is little more structural arrangement for the removal of refuse than if the inhabitants were but tented there for a night. The case of the water supply is no better: my reports are incessantly showing the too frequent foulness of private supplies; while, as regards public water supplies, such as generally are in the hands of commercial companies, it has again and again been shown (and seldom more pointedly than in the present volume), that their conveniences and advantages are countervailed by dangers to life on a scale of gigantic magnitude, unless those who administer the supplies act under a very deep sense of responsibility.

"Cholera, ravaging here at long intervals, is not Nature's only retribution for our neglect in such matters as are in question. Typhoid fever and much endemic diarrhœa are, as I have oftened reported, incessant witnesses to the same deleterious influence; typhoid fever which annually kills some 15,000 to 20,000 of our population, and diarrhœa which kills many thousands besides. The mere quantity of this wasted life is something horrible to contemplate, and the mode in which the waste is caused is surely nothing less than shameful. It is to be hoped that, as the education of the country advance, this sort of thing will come to an end that so much preventible death will not always be accepted as a fate; that for a population to be thus poisoned by its own excrement, will some day be deemed ignominious and intolerable."

## ON THE RATE AT WHICH CHEMICAL ACTIONS TAKE PLACE.

By A. Vernon Harcourt, Esq., M.A., Secretary of the Chemical Society.

The science of Chemistry may be defined as the science which investigates the relations of the different kinds of matter one to another. The conception of different kinds of matter—each of which has its particular character, its own colour and crystalline form, its own hardness and brittleness or the reverse, its own conducting powers, its own specific heat and specific gravity, and many other peculiarities of its own, and each of which is homogeneous, the smallest particle having all these properties equally with the largest mass—is the fundamental conception of chemistry.

And the whole world to a chemist is only a mixture of such different kinds of matter, whose mode of aggregation has been and is being determined by physical and vital forces which are foreign to his science, but whose resemblances and differences, and whose changes under changed conditions or by contact one with another, form the subject of his study.

In the study of any chemical change there are two things to be discovered: first, the *result* of the change—what kinds of matter have ceased to exist and what have come into existence; and secondly, the *course* of the change; as to which such inquiries as the following present themselves—at what rate does the change occur, and under what conditions? Is it simple, or does it consist of several changes? Are these dependent or independent, successive or simultaneous?—with many others of a more hypothetical kind as to the molecular nature of the change. A familiar example of this twofold nature of chemical inquiry may be drawn from the case of a fire, a chemical change which has been more watched than any other. We know all that is to be known as to the result of the change, when we have discovered that the coals are a mixture of a various hydrocarbons with a small quantity of metallic salts, that the air is a mixture of oxygen and nitrogen, and that when the fire has burnt out, there exists, instead of so much coal and so much air, a quantity of carbonic acid and water, the salts, which form the ash, and the nitrogen remaining as they were. But there is still much besides this to be found out as to the burning of the fire. How, for example, is the rate at which it burns affected by the draught, or by the density of the air, or by the breaking up of the fuel, or by access of the sun's rays? What are the substances, formed from the heated coal, which actually burn? Does the reduction of the products of combustion by carbon play an important part in the phenomenon? Such questions as these relate to the course of the chemical change.

The two lines of inquiry thus indicated have been pursued with very unequal vigour. The study of the results of chemical action has engrossed the attention of chemists almost to the exclusion of the study of their course. And, indeed, so great is the number of different kinds of matter, all capable of undergoing a multitude of changes by the action of heat or electricity or by contact with others, giving rise thus to new kinds of matter capable of similar changes, that this part of the science appears absolutely boundless. The direction which chemistry has taken in consequence of this superabundance of materials, may, perhaps, be contrasted with that taken by physical science. If the number of distinct physical forces met with in nature, such as gravity, magnetism, electricity, heat, light, &c., instead of being quite a small number, had been a large number, and these forces had proved to be convertible not only one into another but into an infinite variety of other distinct forces, physical experimentalists might have occupied themselves wholly with establishing the transmutations of one kind of force into another and creating new modes of force, instead of studying minutely, as they have done, the conditions under which the existing forces are produced, and the laws which govern their distribution and transformation.

It is, however, not only the vastness of the chemical field, and the particular satisfaction which so solid a result as the creation of a new kind of matter brings to the mind of the investigator, which has led to the neglect of the study of the course of chemical changes. This study is beset with peculiar difficulties, and indeed, out of the vast number of chemical changes whose results are known, there are but very few whose course can readily be observed. The principal reason of this is the velocity with which such changes take place; and this velocity is apt to be the greatest in the case of the simple chemical actions which are most suitable for investigation. Either, then, we must contrive some mode of estimating a very great velocity, as has been done for the measurement of the rate at which light and electricity travel, or we must select a change—and this the variety of chemistry makes possible—which proceeds at a rate convenient for observation.

Examples of the different velocity of chemical changes are furnished by the by the precipitation of a barium and of a calcium salt from their solution upon the addition of a sulphate. With the former, the change is apparently instantaneous. The result is known, but the course cannot be observed. With the latter, the change is gradual, and it would be possible to determine its rate at different temperatures and with different quantities of the two salts in solution.

The decomposition of a hyposulphite in an acid solution is another example of a gradual, observable change.

We may compare, also, the reduction of a chromate by a sulphite and by an oxalate. The former occupies no appreciable time; the actual time is, doubtless, greater in a more dilute solution and at a lower temperature, but we cannot discern any difference. But with an oxalate for reducing agent, though the final result of the change is the same, the action takes a long time to accomplish itself, and it would be quite practicable to observe in what way different circumstances affect its rate.

But in order to discover the laws which govern the rate of any chemical change, some exact mode of measuring the rate is necessary. It remains to show how this may be accomplished in certain cases.

A solution of ammonium nitrite, heated to a temperature of about 80 C. in a flask provided with a gas delivery tube, gives off a quantity of nitrogen, which may be collected over the pneumatic trough. By keeping the temperature constant, and collecting the gas evolved during successive equal intervals of time in similar cylinders, it is possible at once to show the regular diminution in the volume of gas which is caused by the constant diminution of the quantity of salt in solution. And by making the experiment and measuring the quantities of gas with accuracy, it would be possible to discover the relation between the amount of change going on at any moment and the amount of salt in solution, and also, by making the experiment at different temperatures, to discover how the temperature of the solution affects the rate at which the action takes place.

The reduction of a permanganate by an oxalate in an acid solution furnishes another case of a gradual measurable change, and has been more fully studied. Here it is possible to start the change at any moment by adding the measured quantity of permanganate to the other ingredients and mixing rapidly. It is also possible to stop it at any moment by adding a solution of iodine to the mixture; and the iodine which is set free by the action of the residual permanganate corresponds to it in quantity and can readily be estimated. By making a number of such experiments, differing from one another only in the time during which the gradual change is allowed to proceed, its course may be traced throughout with any required degree of minuteness. The results obtained in many series of such experiments are given in the "Philosophical Transactions for 1866," p. 206. The general conclusion to which they lead is that the total amount of change occurring at any moment is directly proportional, all other conditions being alike, to the amount of permanganate in the solution.

The last chemical change which has been investigated from this point of view, is that which takes place when dilute acid solutions of an iodine and a dioxide, such as barium or sodium dioxide, are mixed together. By arranging suitably the dilution, acidity, and temperature of the solution, the change may be made to proceed at any rate that is most convenient for measurement. One of the products of the change is iodine, a substance for which we have, in its action on starch, a most delicate test. By bringing a small known quantity of hyposulphite into the liquid, all the iodine that is formed by the gradual reaction of peroxide and iodide is reconverted into iodide, and this continues till iodine enough has been formed to remove all the hyposulphite. As soon as the last particle of hyposulphite has been removed (converted into tetrathionate), free iodine appears in the solution, and the moment of its appearance may be noted by carefully watching the colour of the liquid. By adding successive quantities of hyposulphite, and observing the interval which elapses between successive reappearances of the blue colour of the iodide of starch, it is possible accurately to determine the rate at which the change is proceeding. An account of a number of experiments made in this way, and of their results, is to be found in the "Philosophical Transactions for 1867," p. 117. Each set of observations determines at what rate the dioxide is reduced under certain definite conditions; and by making different series of experiments, in which the several conditions affecting the rate of change are systematically varied, it is possible to discover the laws of connection between each of the conditions and the amount of change. Having discovered these laws, our knowledge of the change is so far complete, and we can predict with certainty the time that would be required for any given amount of change under any given circumstances.

The following propositions embody the principal conclusions to which the examination of these cases of gradual chemical change has led:—

1. The rate at which a chemical change proceeds is constant under constant conditions, and is independent of the time that has elapsed since the change commenced.

2. When any substance is undergoing a chemical change, of which no condition varies, excepting the diminution of the changing substance, the amount of change occurring at any moment is directly proportional to the quantity of the substance.

3. When two or more substances act one upon another, the amount of action at any moment is directly proportional to the quantity of each of the substances.

4. When the rate of any chemical change is affected by the presence of a substance, which itself takes no part in the change, the acceleration or retardation produced is directly proportional to the quantity of the substance.

5. The relation between the rate of a chemical change occurring in a solution, and the temperature of the solution, is such, that for every additional degree the number expressing the rate is to be multiplied by a constant quantity.

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## MANCHESTER ASSOCIATION FOR THE PREVENTION OF STEAM BOILER EXPLOSIONS.

The last ordinary monthly meeting of the Executive Committee of this Association was held at the offices, 41, Corporation-street, Manchester, on Tuesday, May 26th, 1868, Charles F. Beyer, Esq., C.E., in the chair, when Mr. L. E. Fletcher, chief engineer, presented his report, of which the following is an abstract:—

During the past month [illegible] visits of inspection have been made, and 698 boilers examined, 532 externally, 14 internally, 6 in the flues, and [illegible] entirely, while in addition 3 have been tested by hydraulic pressure. In these boilers 102 defects have been discovered, [illegible] of them being dangerous, thus:—Furnaces out of shape, 4; fractures, [illegible]—2 dangerous; blistered plates, 6; internal corrosion, 27; external ditto, 6; internal grooving, 8; water gauges out of order, 6; blow-out apparatus ditto, 8; fusible plugs ditto, 1; safety valves ditto, 1; pressure gauges ditto, 14—2 dangerous; boilers without pressure gauges, 2; without feed back pressure valves, 6; cases of deficiency of water, 1.

### Explosions.

On the present occasion I have a long list of explosions to report, six having occurred during the past month, resulting in the death of six persons, and injury to seven others. In addition to these, reference may be made to an explosion which ranks as No. 11, and occurred during last month, but particulars of which were not received in time to be included in the last report. Not one of the exploded boilers was under the inspection of this Association.

No. 11 Explosion, by which one person was injured, occurred at a paper mill, at a quarter before two o'clock on the afternoon of Wednesday, April 15th. The boiler was No. 3 in a series of four, set side by side, all of them being internally-fired, and of plain single-flued Cornish construction, while the one in question was 15ft. long, by 4ft. 7in. in diameter in the shell, and 2ft. 8in. in the furnace tube, the thickness of the plates in the latter being a quarter of an inch, and the steam pressure 60lb.

The boiler failed through collapse of the furnace tube, the crown of which came down and rent near the firebridge, when the rush of steam and water blew up the brick flue at the back of the boiler and severely scalded one of the workmen, but did not disturb the boiler from its seat.

The cause of the collapse has been attributed to shortness of water through the neglect of the attendant. As the furnace tube was removed at the time of my examination, I am not prepared to offer a positive opinion on this point, but I was assured at the works that the glass guage showed an ample supply of water at the time, while it may be pointed out that the furnace tube being made of plates only a quarter of an inch thick was quite unfit for a pressure of 60lbs. on the square inch, constructed as this one was without any strengthening rings or other appliances, while further, there was no feed back pressure valve, so that there was nothing to prevent the water's being vomited from one boiler to the other, which would have laid bare the furnace crowns in a few minutes. Whether, therefore, the attendant had been neglectful or not, the furnace tube was weak and the complement of fittings defective, and however convenient it may be throw the blame on the attendant, the boiler makers cannot be exonerated in the present instance, and the explosion affords an additional illustration of the necessity of competent periodical inspection to check the construction and equipment of boilers, as well as their condition.

Tabular Statement of Explosions, from April 25th, 1868, to May 22nd, 1868, inclusive.

| Progressive Number for 1867. | Date. | General Description of Boiler. | Persons Killed. | Persons Injured. | Total. |
|---|---|---|---|---|---|
| 12 | April 30 | Plain Cylindrical, egg-ended. Externally-fired …… | 1 | 3 | 4 |
| 13 | May 1 | Single-flue, or Cornish, Internally-fired …… | 1 | 0 | 1 |
| 14 | May 9 | Single-flue, or Cornish, Internally-fired …… | 0 | 0 | 0 |
| 15 | May 11 | Plain Cylindrical, camber-ended.—Externally-fired | 1 | 1 | 2 |
| 16 | May 11 | Multitubular marine Internally-fired …… | 1 | 0 | 1 |
| 17 | May 12 | Plain Cylindrical, camber ended.—Externally-fired | 2 | 3 | 5 |
| | | Total……………… | 6 | 7 | 13 |

Nos. 13 and 14 Explosions, the first of which occurred on May the 1st, and the second on May the 6th, are both so similar that they may be treated together. They both occurred at mines, and resulted from the collapse of the furnace tube of ordinary internally-fired single-flued Cornish boilers, while in neither case were the flues strengthened as they should have been with encircling hoops, or any other suitable provision. One person was killed by the first explosion, but fortunately no one by the second.

I have not yet received full particulars of No. 13 Explosion, but in the case of No. 14, it appears that the length of the flue tube was 32ft., the diameter 4ft., the thickness of the plates not more than three-eighths of an inch, and the pressure of steam 40lbs., while the furnace crown was uninjured for a length of 10ft. from the firing tube. From this, it is clear that the flue gave way from simple weakness, consequent on malconstruction, while it can scarcely be doubted from the general similarity of the circumstances that the other explosion was due to the same cause.

Both these explosions occurred in the neighbourhood of the Land's End, where there seems an inveterate prejudice against adopting the simple precaution of strengthening the tubes with rings or other suitable means, in consequence of which, fatal explosions constantly occur in the locality, and the single-flued Cornish boiler, though so safe if properly constructed, numbers almost, if not quite, as many explosions as any other. Thus, through persistent mal-construction, its character is seriously damaged. Strange that this should occur in the county that gave this class of boiler birth, and from which it takes its name.

No. 15 Explosion, by which one person was killed and another injured, occurred at about half-past ten o'clock on the morning of Monday, May 11th, and shows that fatal disaster may arise from a very small boiler.

The boiler, which was of the plain cylindrical externally-fired class, with cambered ends, was extremely diminutive, being but 3ft. 5in. long, 1ft. 7in. in diameter, and made of plates a quarter of an inch thick in the sides, and five-sixteenths in the ends. It was set in the back kitchen of a dwelling-house, and employed to drive a lathe in a room up stairs, the boiler being attended and the steam kept up by a woman, while the lathe was worked by her brother, so that it was rather an amateur affair.

The boiler failed on the left-hand side at the back end, where a small fracture occurred about 6in. long by three-eighths of an inch at the widest part. Through this opening the steam and hot water rushed out, blowing up part of the brickwork seating, though the boiler was not removed from its place. It appears that the woman was just in the act of firing up when the explosion occurred, and, being alarmed by the noise, rushed to the door to effect her escape. Unfortunately the position of the fracture in the boiler was such that the steam and hot water played directly on the doorway, so that in her confusion she ran right into the stream, and was not extricated till so severely scalded that she died a few hours afterwards, and her brother was so injured in coming to the rescue that he was unable to attend the inquest.

As to the cause,—the cambered end plate was flanged at its attachment to the shell, and just in the bend of the flange, which was somewhat abrupt, an old flaw appears to have existed for some time, while in addition the thickness of the plate had been much reduced at that part by external corrosion, consequent on leakage from the ring seams of rivets. It may also be stated that the owner had been in the habit of taking considerable liberties with the safety valve, and of wedging it down; but it is not thought that this was the immediate cause of explosion, as the pressure at that time does not appear to have exceeded 45lbs. The flaw and corroded part were concealed by the brickwork, and needed uncovering and examination to be detected, so that this explosion shows that small boilers require inspection and care as well as large ones, or fatal explosion may result.

Explosions No. 16 and 17.—The scene of the catastrophe has been visited by one of the Association's staff in both cases, and the particulars obtained, but reference is deferred till the next report.

## INSTITUTION OF CIVIL ENGINEERS OF IRELAND.

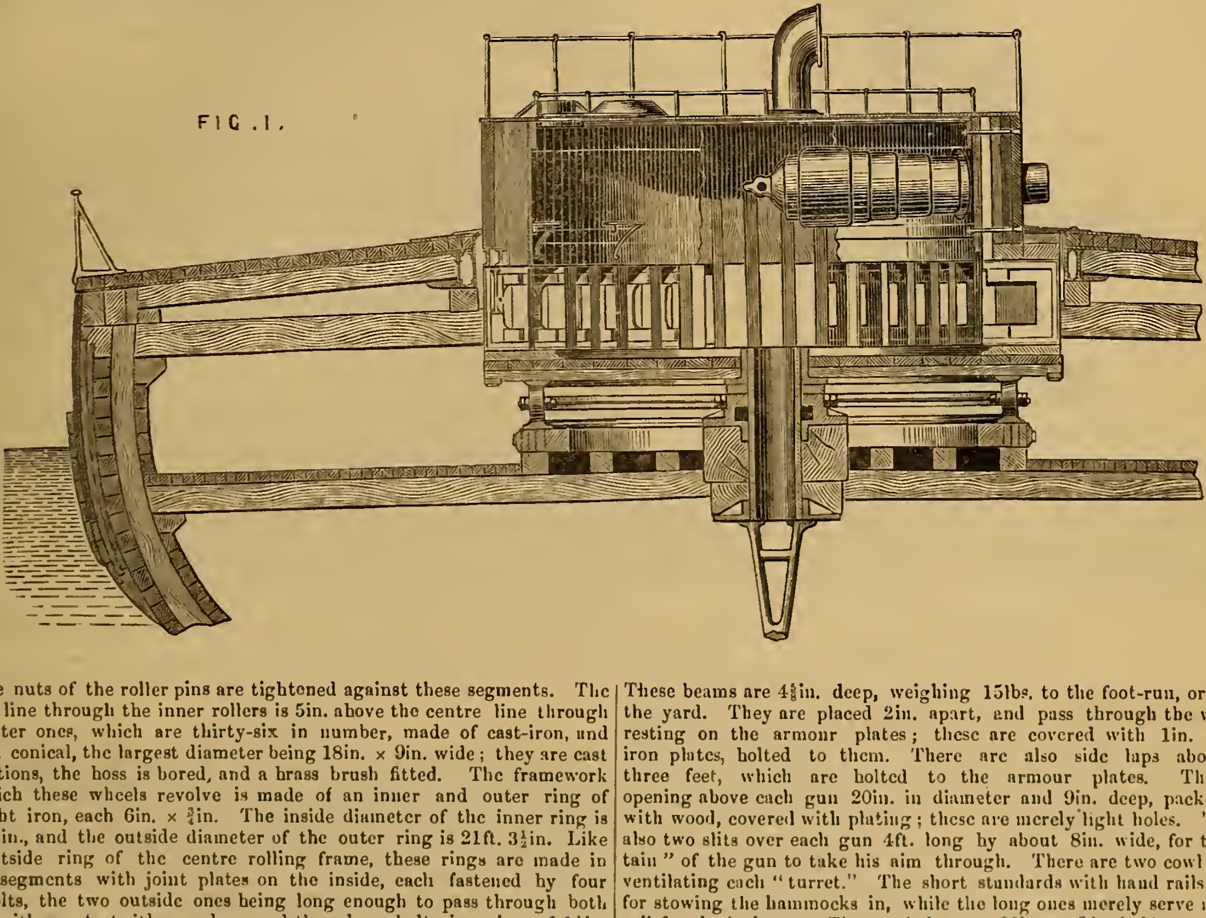
### DESCRIPTION OF CAPTAIN COLES' (R.N.), TURRETS, AS FITTED ON BOARD H.M. SHIP "ROYAL SOVEREIGN."

By J. Bailey, Member.

It is not my intention this evening to offer any opinions or provoke discussion on that interesting and important question of "Turrets" *versus* "Broadside" or "Battery" ships, but simply to lay before the members of this institution, as plainly as I can, the general arrangement and details adopted by Captain Coles, R.N., in the construction of cupolas or turrets on board H.M.S. *Royal Sovereign.*

The *Royal Sovereign* carries four turrets, mounting in all five 300lb. Armstrong guns—two in the forward and one in each of the after turrets. We will take this evening the forward or twin-gun turret, which is 22ft. 9in. in diameter, and 18ft. 9in. outside (Fig. 1). First, we have a massive framework of wood constructed on the main deck, and supported by the deck beams and wrought iron columns. The centre is formed of two large rectangular blocks of English oak, making a square of 6ft. 3in. × 2ft. 6in. deep, with a round hole in the centre 26in. in diameter. Immediately under this is placed two balks of English oak 18in. × 15in. × 30ft. in length, running fore and aft, and bolted down to the deck beams; on this segments of English oak are placed, cut to an inner radius of 9ft., and forming a ring of 9ft. 6in. outside diameter, which is firmly bolted to the fore and aft beams just mentioned; round the outside of this ring three bands of American oak are bent, each 12in. deep × 4in. in thickness, and bolted to the segment forming the inner ring by 1in. bolts. Six arms or spokes radiating from the centre, each 18in. × 12in., like the centre and inner ring, are made of English oak; on this substantial and massive framework is bolted a turned cast-iron roller path. In the centre is a hollow tube of wrought iron, 2ft. 2in. outside diameter, 3in. in thickness, and 7ft. 3in. in length, forming the pivot on which the turret revolves, and acts as a safe communication with the magazine below. A large casting, which forms the centre, round which a live wrought iron ring lined with brass revolves, is placed round this pivot, and sits upon the wooden framework bolted through to a somewhat similar casting below, which is supported by a forked wrought iron column resting on the keelson. We are now come to the turn-table or platform on which the turret is built. It is a large disc of woodwork 24ft. 8in. in diameter, and 12in. in thickness, built of oak slabs 14in. × 6in., bolted together, the top layer being placed at right angles to the bottom one. Near the outside the thickness is increased 4in. by a circle of oak 3ft. 9in. in width × 6in. in thickness let into the other portion 2in. On the underside of this platform is fixed the cast iron upper rolling path, fastened by 1in. bolts which pass through the frame to rings of wrought iron 9in. × ⅝in. let into the top to which they are secured by nuts. In the centre of this table is fixed a large kind of angle iron ring of cast iron, with the flange on the bottom side, and bolted through in the same manner as the path. This casting is bored out, and a brass brush let in ¾in. in thickness × 15in. in depth, which forms the moving rubber surface round the axes. Between this casting and the lower one are arranged twelve brass conical rollers, 5½in. in diameter at their largest part, and 5½in. wide, supporting the centre weight of the turret. These rollers are placed in a live ring of brass, the pins round which they revolve are 1¼in. in diameter, and screwed into the inner part of the brass ring with a jamb-nut screwed up to prevent the pin turning. A ⅞in. washer is then put on, and segments of wrought iron 4in. × ¾in. are fastened over the whole thing by 1in. square-headed wood screws; the outside nuts of the roller pins are tightened against these segments. The centre line through the inner rollers is 5in. above the centre line through the outer ones, which are thirty-six in number, made of cast-iron, and turned conical, the largest diameter being 18in. × 9in. wide; they are cast H sections, the boss is bored, and a brass brush fitted. The framework in which these wheels revolve is made of an inner and outer ring of wrought iron, each 6in. × ¾in. The inside diameter of the inner ring is 19ft. 2in., and the outside diameter of the outer ring is 21ft. 3½in. Like the outside ring of the centre rolling frame, these rings are made in short segments with joint plates on the inside, each fastened by four ¾in. bolts, the two outside ones being long enough to pass through both rings, with a nut at either end; round these long bolts is a piece of 1½in, gun-barrel tube, which acts as a stay or distance piece, to which the rings are screwed home. There are 36 segments to each ring. The radius rods are 2in. in diameter, increased to 2¼in. at the ends. The inner end is screwed into the live ring before described with a jamb nut on the outside; the opposite end passes through the roller and large rings, with two jamb nuts on the inside and one nut, with a pin through it, on the outside.

FIG. 1.



On this turn-table is built the "turret," a little eccentric to the platform, that is to say, the centre of "turret" is 9in. from the centre of the platform, and is formed of 30 upright frames made of T irons, angle irons, and plates. The T rons which form the inside circle are 6in. × 10in. × ½in. The plates on the outside are 10in × ½in., with an angle iron riveted on either side 3in × 3in. × ½in. The T irons extend from the platform to the top of the "turret," a height of 9ft. 6in, whereas the ½in. plates and angle irons only extend 3ft. 7in. in height, and are then brought round to form the support for the woodwork and armour plating. Between the vertical T irons, and beginning at 3ft. 7in. from the platform, are nicely fitted balks of teak 18in. × 10in. × 6ft. in height; round this and let in flush with the outside of the teak, are systems of diagonal bracing or trellis work, with one hoop top and bottom 6in. × ¾in., which is also the scantling of the diagonal bars. Over this is built another ring of teak balks 18in. × 10in. × 6ft. and on the outside of this is the armour plating, consisting of twenty plates 5ft. 4in. × 3ft. 6in. × 5½in. in thickness, secured to the framework of wood and iron by four 2in. countersunk galvanized bolts to each plate, passing through to the inner lining, consisting of ½in. plate irons. In addition to this lining there are two wrought-iron rings in the inside, through which the bolts pass, and to which they are secured by an ordinary nut. The upper hoop is 14in. deep × 2in. in thickness, and the lower one 6in. wide × ¾in. in thickness. There is a double thickness of armour plating 12 feet long on the port-hole side of the "turret," the inner plate being 4½in. in thickness, making a total thickness of 10in. solid plating. The roof is formed of wrought-iron rolled beams, something like a double-headed rail, except that the top flange is an inch wider than the bottom one, the top being 3¾in., and the bottom 2¾in. These beams are 4⅝in. deep, weighing 15lbs. to the foot-run, or 45lbs. to the yard. They are placed 2in. apart, and pass through the woodwork resting on the armour plates; these are covered with 1in. wrought-iron plates, bolted to them. There are also side laps about every three feet, which are bolted to the armour plates. There is an opening above each gun 20in. in diameter and 9in. deep, packed round with wood, covered with plating; these are merely light holes. There are also two slits over each gun 4ft. long by about 8in. wide, for the "captain" of the gun to take his aim through. There are two cowl pipes for ventilating each "turret." The short standards with hand rails are used for stowing the hammocks in, while the long ones merely serve as a hand rail for the look-out. The portholes are 20in. × 3ft., half round top and bottom, and lined in the inside with iron ¾in. in thickness.

We now come to the turning gear, which consist of four winch handles and gearing, working two vertical shafts, one on each side of the cupola, 2½in. in diameter. Two of these handles work inside the "turret," the other two on the outside. As they are all four alike, I need describe only one, which consists of a common winch handle (Fig 2) 15in. radius, attached to a spur pinion 10in. in diameter, 1½in. pitch of teeth, 3¾in. breadth of same, 21 in number. This pinion works into a spur-wheel 30·4in. in diameter, 1½in. pitch of teeth, 3¾in. breadth of same, 63 in number. To this is attached a bevil pinion 6in. × 1¾in. × 4in. × 11 teeth, working into a bevil wheel 18in. × 1¾in. × 4in. × 33 teeth. This wheel gives motion to the upright shaft, to the end of which is fixed a spur-pinion 10in. × 2¼in. × 6in. × 14 teeth, working into the large wheel bolted to the framework, the size of which is 22ft. × 2¼in. × 6in. × 371 teeth.

The mechanical advantage gained by the gearing up to the periphery of the pinion which works into the rack = 27 to 1.

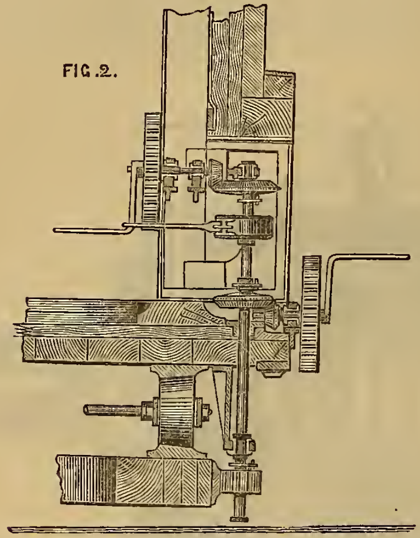
If we suppose the whole weight of the "cupola" and guns (140 tons) to be concentrated on a circle of 15ft. in diameter, we have :—

$$\frac{30 \times 30{\cdot}4 \times 18 \times 264}{10 \times 6 \times 10 \times 180} = 40{\cdot}1 \text{ to } 1.$$

Eight men are the full complement for working the gearing, four inside and four outside the "turret," the speed = 1 revolution per minute. Four men can work it, but, of course, they take double the time.

In addition to the four winches just described, there is what is termed the deck turning gear, consisting of two winch handles, each 15in. radius, working a bevil pinion 11·1in. × 1$\frac{3}{4}$in. × 5in. × 20 teeth working into a bevil wheel 32·25in. × 1$\frac{3}{4}$in. × 5in. × 58 teeth. At the other end of the shaft to which this wheel is attached is a face pinion 10in. × 2$\frac{1}{4}$ × 6in. × 14 teeth working into face rack on "turret" 24ft. 6in. × 2$\frac{1}{4}$in. × 6in. × 412 teeth the mechanical advantage gained by this gearing from the winch handle up to the periphery of the pinion which works into the rack = 8·7 to 1. But, assuming as before, that the weight it concentrated in a circle 15ft. diameter, we have—

FIG. 2.



$$\frac{30 \times 32{\cdot}25 \times 294}{11{\cdot}1 \times 10 \times 180} = 14{\cdot}2 \text{ to } 1.$$

There are three small crab winches attached to the revolving platform, two of which are used for working the guns, and one for lifting the shot.

There is a clear space of 3in. all round between the "turret" and the well or hole in the deck, and this space is covered by a leather flap or ring attached to the "turret," and bearing on a brass ring fixed upon the deck; this leather flap is weighted with a strip of iron round the outside, in order that it may fit close to the deck.

The edge of the hole in the deck, within which the "turret" is placed, is strengthened by a wrought-iron well-ring weighing about 1$\frac{1}{2}$ tons, and formed of 1in. plate of wrought iron, 2ft. deep, with angle-irons on the outside top and bottom. From this ring radiate iron beams, some leading transversely to the sides of the vessel, and the others to the deck beams, to which they are firmly attached. On these beams are laid the 1in. plates forming the deck, and upon these is placed around the "turret" a "glacis plate" consisting of a ring 30in. wide, and tapering in thickness from 3in. at the inner to nothing at its outer edge.

Over the "glacis plate" comes the deck tapering in the opposite direction from 6in. to nothing, and upon this is laid round the "turret" a ring of $\frac{3}{8}$in. stamped wrought iron plates 2ft. 6in. wide, which serves to protect the deck from being scorched by the discharge of the gun.

The deck of the vessel rises at the angle of 5° from the sides towards the centre, and is formed of 1in, wrought iron plate covered down the centre for a width of 26ft. with 8in. teak planking; the remainder of the surface is covered with 6in. planking. The deck is carried by wrought iron rolled beams placed 12in. apart between the main wooden deck beams and the 1in. plating is laid on in strips about 12ft. long by 2ft. 6in. wide joined together by $\frac{3}{4}$in. rivets, and covering strips 4in. × 1in. The 1in. plating is doubled round the openings for the "turrets," hatchways, and funnel, and a double thickness is also carried, fore and aft, between the "turrets" and the sides of the ship. The armour plates are bedded upon crossed diagonal planking, which was added to the original sides of the vessel on her conversion from a three-decker, making the total thickness of the timber backing 3ft., as shown in Fig. 1.

In conclusion I may add that the "turrets" are now made concentric in place of eccentric to the platform; that in place of the small winches before mentioned, they put a much larger one, with an endless chain to work the guns; and I believe Captain Coles intends making the platform in future of iron.

## REVIEWS AND NOTICES OF NEW BOOKS.

*Notes on the history, methods, and technical importance of descriptive Geometry.* By Alexander W. Cunningham. Edmonston and Douglas, Edinburgh.

In these notes the importance of the study of descriptive geometry is urged with considerable skill and great earnestness. There is no doubt a great deal of truth in what he says respecting this subject, though we think he is rather hard upon poor Euclid.

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*Examples of Modern Steam, Air and Gas Engines.* By John Bourne, C.E. Longmans, Green, Reader, and Dyer, Paternoster-row.

We have received the first monthly part of another new work from the able and prolific pen of Mr. Bourne, which promises to be of considerable utility to engineers, as according to the title page it will be "accompanied by working drawings, and embody a critical account of all projects of recent improvements in furnaces, boilers, and engines." This first number contains a large steel plate engraving of the engines of the monitor Dictator, by J. Ericsson, which, together with the wood cuts and letter press appear exceedingly well got up. We must wait however until some more numbers appear before giving a more complete notice of such an important work.

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*Land and Marine Surveying.* By B. W. Davis Haskoll, C.E. Lockwood and Co., Stationer's Hall-Court, London.

This very useful treatise both upon surveying and the various instruments employed therein, is more especially designed for beginners. It appears to be thoroughly practical, and consequently the somewhat peculiar style of diction may be readily forgiven. It treats upon the various descriptions of surveying from simple chain surveying to the more elaborate plans when the theodolite is necessary. Altogether we can confidently recommend this work to the engineering student.

## NOTES AND NOVELTIES.

### MISCELLANEOUS.

Trial of Mowing Machines.—A large gathering of farmers assembled on the 12th ult. at Winchester, to witness a trial of English and American mowing machines, instituted by the Hampshire Agricultural Society. Seven machines, each drawn by a pair of horses, competed for the prizes. Mr. Wood, jun., who was over from America, and Mr. Cranstone, represented the machine of Walter A. Wood. The American Clipper mower was exhibited by the Reading Iron Works Company. Mr. Phillips, from Grantham, had charge of Messrs. Hornsby's Paragon mower. The partner of Mr. Samuelson, of Banbury, managed the Eclipse machine. Mr. Kearsley, of Ripon, was also a competitor. Mr. James Howard, of Bedford, entered the list for the first time with Messrs. Howard's new British mower. After the machines had gone a few rounds it was evident to the spectators that the first prize would fall either to Wood's American or Howard's British mower. At the completion of the plots the judges selected the two latter as the best, and ordered a second trial between them. The work of both was so perfect that the judge had great difficulty in coming to a decision. However, as the Americans finished the work in a few minutes less time, they placed Wood's first, and Howard's second, giving Messrs. Burgess and Key the third prize.

Collision in the Channel.—The iron screw steamers *Gibraltar*, Harris master from London to Lisbon and Gibraltar, and the *Blonde*, Catmur, master, from Ibrail and Falmouth, bound to Antwerp, arrived in Portsmouth Harbour on the 7th inst., with each of their bows smashed in from collision in the Channel. Both vessels had a hole in their bows near the stem-piece, large enough for a good-sized boat to go through, the iron plates round the apertures being bent and twisted into all kinds of eccentric forms. The figurehead and bulwarks forward of the *Gibraltar* appeared to have sustained but little injury, but below the level of the upper deck her fore body was entirely destroyed. The *Blonde's* damage was exhibited more in the upper part of the fore body. The remains of her bowsprit lay thrown back on the forecastle, and a V piece of the *Gibraltar's* fore body remained sticking up through her upper deck from the gap below in her bows, where it must have broken off at the time of the separation of the vessels after collision. From the reports made by the masters of both vessels, it appears that the collision occurred about 10.30 on Saturday, during a thick fog, off Selsea Bill, the Owers Lightship bearing at the time N.N.E. from both vessels, at a distance of ten miles. The speed of each vessel at the time of the collision has been differeely estimated, but it has been stated to have been seven knots, and that it cannot have been less is evident by the tremendous effects produced upon each vessel. They met as nearly as possible stem to stem, the *Gibraltar's* stem entering the *Blonde's* port bow, 2ft. from the stem edge of the latter. Being the higher vessel of the two, the *Gibraltar's* bows, or rather their wreck, after entering those of the *Blonde*, rode over the latter, and the two thus became interlocked in a tangled mass of iron plates and framing. Luckily the sea was perfectly smooth, with no wind, and both vessels had good sound water-tight compartments 20ft. inboard from their stems; but for five and a-half hours they lay thus grappled, and grinding each other in the grim solitude of a still, foggy night at sea.

At a meeting of the Metropolitan Board of Works it was resolved that the works at Abbey Mills Pumping Station be publicly opened about the 23rd of this month, and that his Royal Highness the Duke of Edinburgh be invited to perform the ceremony.

## MILITARY ENGINEERING.

Some interesting practice was carried on the other day at Shoeburyness with the 12in muzzle-loading rifled-gun of 23 tons, firing common shell of 600lb. weight, with the ordinary charge of 60lb. of powder. The gun is mounted on a wrought iron carriage and platform placed on a turntable in rear of a wooden structure representing an iron fort through the portholes or embrasures of which the gun is laid and fired. The object was to ascertain how quickly the gun could be loaded, aimed, and fired by an ordinary detachment of one officer, one non-commissioned officer, and seventeen gunners. The gun was carefully laid each round at a small target at 1,000 yards distance, and five rounds were fired in 7 minutes and 39 seconds, or at an average of 1 minute 30 seconds for each round. The practice was excellent.

The Prussian Government have just concluded an extensive series of experiments with dynamite, and next month the French Government will follow suit. The verdict given by the Prussian Military Commission regarding dynamite is that it is at least equal in power to ten times its weight in gunpowder, and that it is certainly the safest blasting agent known. Experiments with the new explosive are being made in the Scotch quarries.

## STEAM SHIPPING.

The Screw Gun Vessel "Staunch."—The experimental ironbuilt unarmoured twin screw gun vessel *Staunch*, 200 tons, 25 horse-power, carrying one 12 ton 9in. rifled muzzle-loading gun, was put through her official of speed over the measured mile in Stokes Bay, Portsmouth, on the 9th ult. Under the most favourable circumstances of weather, and at a draught of water of 5ft. 10in. forward, and 6ft. [illegible]in. aft, a speed of 7·543 knots was realised as the mean of six runs on the mile, the load on the safety valve being 25lbs., and the mean revolutions of the engine 139. The temperature on deck was 70°, in the engine room 76°, in the stokehole, starboard side, 103°, port side 94°. The most efficient and interesting part of the trial of the *Staunch*, as a miniature fighting machine, was her performance in circling, thus exhibiting most satisfactorily the extreme facility with which twin screws can be made to manœuvre the vessel as the carriage of the gun, and train the latter rapidly upon any desired point. The subjoined numbers give the time occupied in making the circles, and the conditions under which each circle was made:—No. 1 circle: Both engines going ahead, and the rudder in use. To starboard half circle 1 min. 15 seconds; full circle, 2 min. 35 seconds. To port half circle, 1 min. 16 seconds full circle, 2 min. 22 seconds. No. 2 circle, one engine going ahead, and the other astern, the rudder in use. To starboard half circle, 1 min. 0 seconds; full circle, 1 min. 47 seconds To port half circle, 56 seconds; full circle, 1 min. 52 seconds Nos. 1 and 2 circles timed at starting with the vessel going at full speed. No 3 circle, vessel started on circle with both hull and engines previously motionless, port engine going ahead, starboard engine stopped, rudder in use. To starboard half circle, 1 min. 36 seconds; full circle, 2 min. 57 seconds. To port half circle, 1 min. 37 seconds; full circle, 2 min. 53 seconds. No. 4 circle vessel started on the circle as before, with both hull and engines previously motionless, rudder fixed amidships, starboard engine going ahead, port engine stopped; half circle, 2 min. 9 seconds; full circle, 3 min. 56 seconds. Port engine going ahead, starboard engine stopped; half circle, 2 min. 3 seconds; full circle, 3 min. 57 seconds.

The *Elk*, 2, twin screw (unarmoured, composite-built) gunboat, 465 tons, 120 horse-power, just completed in her outfit by the Portsmouth Steam Reserve for her first commission, was put through her light draught trial over the measured mile in Stokes Bay. on the 17th inst., drawing 8ft. 5in. of water at the stern, and 7ft. at the bows. Six runs over the mile, with the engines condensing, gave her a mean speed of 10·069 knots per hour, and the same number of runs, non-condensing, gave her a mean speed of 10·137 knots per hour.

The monitor *Heiligerlee*, just built by Messrs. Laird Brothers, of Birkenhead, for the Dutch Government, after taking in her additional coal and stores, left Birkenhead on the 10th, and arrived at Nieuwiediep (Holland) on the 15th ult., having behaved most satisfactorily in all respects throughout the voyage. The distance is about 840 miles.

## LAUNCHES.

The London and Glasgow Engineering and Iron Ship-building Company (Limited) launched on the Clyde, on the 26th May a paddle steamer for the Bristol Steam Navigation Company. The vessel was named the *Juno*, and is of the following dimensions:—Length of keel and forerake, 269ft. breadth of beam, 29ft. 6in.; depth of hold to spar deck, 22ft. 6in.; and will be handsomely fitted up with accommodation for 60 first-class passengers. Her engines, which are to be supplied by the builders, are oscillating cylinders, 66in. in diameter, and 72in. stroke; feathering floats, and all the most recent improvements, from which a high rate of speed is expected.

On the 2nd ult., Messrs. Palmer and Co., of Jarrow, launched an iron screw yacht named the *Cornelia*, for Earl Vane. The length of the *Cornelia's* keel and forerake is 158ft.; breadth, 29ft. 9in.; tonnage, B.M., 315 tons; hold, 12ft. in depth; and she is fitted up with engines of 50-horse power, which are capable of being worked up to 250-horse power. The engines, which were designed by Mr. F. C. Marshall, chief engineer to Messrs. Palmer and Co., are direct acting, high-pressure, and surface condensing.

## TELEGRAPHIC ENGINEERING.

The Anglo-Mediterranean Cable is now in full course of manufacture by the Telegraph Construction and Maintenance Company, and will be laid in August under the superintendence of Sir S. Canning. It is stated that a decided effort will soon be made to continue this line to India by way of the Red Sea.

The cable across the Straits of Messina in connection with the direct line between Susa and Alexandria has been successfully laid.

The dispatch from China received on the 15th ult., announcing the wreck of the Peninsula and Oriental Company's steamer *Benares*, was the quickest telegraphic despatch ever received from China. The telegram came from Shanghai by way of China and Russia in nineteen days.

## DOCKS, HARBOURS, BRIDGES.

The New Dock at Leith.—It is fully expected that the new dock at Leith will be ready for opening in time for the autumn trade of the port. According to the engineer's report, the works will be in such a forward state as to admit of the inauguration taking place about the end of August next.

Proposed New Graving Dock at Dundee.—The Dundee Harbour Board at their meeting were unanimous that it was expedient to provide additional graving dock accommodation. Clarke's system of hydraulic lift graving dock now in use at the Victoria Dock, London, was highly approved of by the Board, and Mr. McOwer, the engineer, is just waiting for information regarding the cost of such a dock, with a lift capable of raising a vessel of 2,000 tons register, and especially as to the expense of upholding and working, and of the rates for the use of the dock.

## LATEST PRICES IN THE LONDON METAL MARKET.

| | From | | | To | | |
|---|---|---|---|---|---|---|
| | £ | s. | d. | £ | s. | d. |
| **COPPER.** | | | | | | |
| Best selected, per ton | 81 | 0 | 0 | 83 | 0 | 0 |
| Tough cake and tile do. | 80 | 0 | 0 | ,, | ,, | ,, |
| Sheathing and sheets do. | 82 | 0 | 0 | 83 | 0 | 0 |
| Bolts do. | 83 | 0 | 0 | ,, | ,, | ,, |
| Bottoms do. | 88 | 0 | 0 | 90 | 0 | 0 |
| Old (exchange) do. | 70 | 0 | 0 | ,, | ,, | ,, |
| Burra Burra do. | 83 | 0 | 0 | ,, | ,, | ,, |
| Wire, per lb. | 0 | 1 | 0 | ,, | 1 | 0½ |
| Tubes do. | 0 | 0 | 11½ | 0 | 1 | 0 |
| **BRASS.** | | | | | | |
| Sheets, per lb. | 0 | 0 | 9 | 0 | 0 | 10 |
| Wire do. | 0 | 0 | 8½ | 0 | 0 | 9½ |
| Tubes do. | 0 | 0 | 10½ | 0 | 0 | 11 |
| Yellow metal sheath do. | 0 | 0 | 7½ | ,, | ,, | ,, |
| Sheets do. | 0 | 0 | 6¾ | 0 | 0 | 7 |
| **SPELTER.** | | | | | | |
| Foreign on the spot, per ton | 20 | 7 | 6 | ,, | ,, | ,, |
| Do. to arrive | 20 | 7 | 6 | ,, | ,, | ,, |
| **ZINC.** | | | | | | |
| In sheets, per ton | 25 | 10 | 0 | ,, | ,, | ,, |
| **TIN.** | | | | | | |
| English blocks, per ton | 96 | 0 | 0 | ,, | ,, | ,, |
| Do. bars (in barrels) do. | 97 | 0 | 0 | ,, | ,, | ,, |
| Do. refined do. | 98 | 0 | 0 | ,, | ,, | ,, |
| Banca do. | 94 | 0 | 0 | ,, | ,, | ,, |
| Straits do. | 92 | 0 | 0 | ,, | ,, | ,, |
| **TIN PLATES.*** | | | | | | |
| IC. charcoal, 1st quality, per box | 1 | 6 | 0 | 1 | 8 | 0 |
| IX. do. 1st quality do. | 1 | 12 | 0 | 1 | 14 | 0 |
| IC. do. 2nd quality do. | 1 | 4 | 0 | 1 | 5 | 0 |
| IX. do. 2nd quality do. | 1 | 10 | 0 | 1 | 11 | 0 |
| IC. Coke do. | 1 | 2 | 0 | 1 | 3 | 0 |
| IX. do. do | 1 | 8 | 0 | 1 | 9 | 0 |
| Canada plates, per ton | 13 | 10 | 0 | ,, | ,, | ,, |
| Do. at works do. | 12 | 10 | 0 | ,, | ,, | ,, |
| **IRON.** | | | | | | |
| Bars, Welsh, in London, per ton | 6 | 5 | 0 | ,, | ,, | ,, |
| Do. to arrive do. | 6 | 2 | 6 | 6 | 5 | 0 |
| Nail rods do. | 6 | 15 | 0 | 7 | 0 | 0 |
| Stafford in London do. | 7 | 7 | 6 | 8 | 10 | 0 |
| Bars do. do. | 7 | 5 | 0 | 9 | 10 | 0 |
| Hoops do. do. | 8 | 2 | 6 | 9 | 15 | 0 |
| Sheets, single, do. | 9 | 0 | 0 | 11 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. mrch. Tyne or Tees do. | 6 | 10 | 0 | ,, | ,, | ,, |
| Do. railway, in Wales, do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. Swedish in London do. | 10 | 0 | 0 | 10 | 5 | 0 |
| To arrive do. | 10 | 0 | 0 | 10 | 5 | 0 |
| Pig No. 1 in Clyde do. | 2 | 12 | 6 | 2 | 15 | 6 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | ,, | ,, | ,, |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 7 | 0 | 0 | 7 | 10 | 0 |
| **STEEL.** | | | | | | |
| Swedish in kegs (rolled), per ton | 14 | 5 | 0 | ,, | ,, | ,, |
| Do. (hammered) do. | 14 | 15 | 0 | 15 | 0 | 0 |
| Do. in faggots do. | 16 | 0 | 0 | ,, | ,, | ,, |
| English spring do. | 17 | 0 | 0 | 23 | 0 | 0 |
| QUICKSILVER, per bottle | 6 | 17 | 0 | ,, | ,, | ,, |
| **LEAD.** | | | | | | |
| English pig, common, per ton | 19 | 7 | 6 | ,, | ,, | ,, |
| Ditto. L.B. do. | 19 | 12 | 6 | ,, | ,, | ,, |
| Do. W.B. do. | 21 | 5 | 0 | ,, | ,, | ,, |
| Do. sheet, do. | 20 | 5 | 0 | ,, | ,, | ,, |
| Do. red lead do. | 20 | 10 | 0 | ,, | ,, | ,, |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 10 | 0 | 22 | 15 | 0 |
| Spanish do. | 18 | 10 | 0 | 18 | 15 | 0 |

* At the works 1s. to 1s. 6d. per box less.

## 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 May 21st, 1868.

1665 C. Chapman and J. Lilley—Instruments used in the navigation of ships
1666 W. Hammant—Aerial apparatus
1667 W. Palliser and F. J. Bolton—Ordnance, &c.
1668 E. A. Chameroy—Liquid or gas meter
1669 W. Hadfield—Looms
1670 J. E. Poynter—Soap
1671 J. Booth—Fastenings for bags of paper
1672 J. Crofts, R. Dawson, and J. King—Combing wool
1673 E. E. Allen—Packing materials wound upon spools, &c.
1674 S. Perry, B. J. B. Mills, and F. Brampton—Letter clips
1675 T. G. Messenger—Fire engines
1676 J. J. Revill—Revolving shutters
1677 R. and J. Fryer—Tilling land
1678 J. Starley—Sewing machinery
1679 J. R. Batty—Saddles for frames used in the spinning of flax, &c.
1680 W. E. Newton—Governors for steam engines
1681 H. Hall and J. A. Mason—Propelling vessels
1682 F. E. B. Beaumont and C. J. Appleby—Drilling rock
1683 J. W. Whittaker—Carding engines
1684 R. Rayner—Frictional gearing
1685 M. A. Clark—Differential gearing

### Dated May 22nd, 1868.

1686 C. Fusnot—Central-fire cartridges
1687 C. D. Abel—Drawing cop through shuttle holes
1588 C. Mole—Boots
1689 W. E. Newton—Grate bars
1690 C. J. Foster—Reaping machines
1691 A. M. Clark—Rotary steam engines
1692 J. Oury—Liquid gas meter
1693 C. Delafield—Furnaces
1594 R. K. Bewley—Floral devices

### Dated May 23rd, 1868.

1695 E. Jones—Shadowless lamps
1696 J. J. Harrop and W. Corbett—Production of iron and steel from ores, &c.
1697 J. Higgins—Machinery for spinning
1698 J. Fletcher—Revolving retorts
1699 E. W. de Rusett—Engines
1700 T. Ashford—Gas tube hooks
1701 W. Seck—Kilns
1702 J. S. Richard—Spinning machinery
1703 F. Wirth—Circulation of water in boilers
1704 C. Windhausen and H. Bussing—Cowls

### Dated May 25th 1868.

1705 T. J. Baker—Manufacture of flour
1706 H. W. Everard—Braces
1707 E. Hunt—Motive power
1708 T. Craig—Hanging windows, &c.
1709 P. Cameron—Ships' compasses
1710 F. Hargreaves and J. R. Collins—Looms
1711 S. A. Smith—Carding engines
1712 A. M. Clark—Rotary engines
1713 A. M. Clark—Obtaining motive power
1714 H. Ferguson—Cutting tenons, &c.
1715 W. H. Kent—Fluting fabrics
1716 W. W., R., and M. W. Johnson—Sheets of lead, &c.
1717 J. Scoffern—Treating paper
1718 J. E. Hulmes—Cutting stone
1719 H. L. A. Lippens—Looms
1720 H. A. Dufrene—Railway wheels
1721 W. R. Lake—Harness

### Dated May 26th, 1868.

1722 J. Ferrabee—Feeding carding engines
1723 H. J. Bakewell—Steering ships
1724 J. Adams—Washing casks
1725 C. E. Brooman—Decolorising tannin juices
1726 J. A. Joynar and J. H. Jenkins—Screw propellers
1727 A. and C. Edmeston—Printing hanks of yarns
1728 A. S. Macrae—Removing ink from paper
1729 J. Morgan—Ventilating hothouses
1730 J. R. Williams—Printing, &c.
1731 T. Smedley—Brakes for carriages
1732 W. E. Newton—Rotary engines
1733 W. Buttery—Turning and closing cartridges
1734 I. B. Miller—Packing for steam engines
1735 W. E. Debenham—Wrist bands, &c.
1736 B. Burton—Breech loading firearms
1737 W. R. Lake—Ploughs, &c.
1738 W. B. Lord—Portable filters
1739 W. Adkins—Stocks and dies
1740 A. M. Clark—Dressing millstones
1741 F. Wirth—Regulator for steam engines

### Dated May 27th, 1868.

1742 J. Dixon—Coupling link
1743 H. A. Bonneville—Permanent way
1744 H. A. Bonneville—Breech loading firearms
1745 W. Cooper—Sliver cans
1746 J. Morris—Finishing printed paper
1747 J. Vidie—Ornamentation of glass, &c.
1748 H. and G. Kearsley—Mowing machines
1749 H. E. Mines—Register stoves, &c.
1750 M. Gray—Electric conductors
1751 J. Scholl—Gas burners

### Dated May 28th, 1868.

1752 J. Reidy—Pickaxe
1783 H. and F. Bailey—Valves
1754 R. Fell—Preventing waste of water
1755 W. Dalziel—Combination of cock and valve
1756 W. Alexander—Applying auxiliary power to sailing ships
1757 T. Drake—Receiving communications
1758 F. Handucœur—Malaxating butter
1759 W. E. Newton—Horse rakes
1760 W. E. Newton—Hopping beer
1761 T. Greenwood—Assorting fibres of silk
1762 J. and J. B. Palmer—Matches, &c.
1763 J. R. Hambling—Thrashing machines
1764 R. H. Bentham—Facilitating flow of liquids
1765 T. Shore, J. Eastwood, and W. W. Brealey—Steam generators
1766 T. S. Horn—Miners' safety lamps
1767 H. Haines—Lead pipe

### Dated May 29th, 1868.

1768 F. N. Gisborne—Signalling apparatus
1769 W. Maclean—Producing designs on textile fabrics
1770 J. Turnbull—Connecting carriages, &c.
1771 J. Drabble and J. S. Raworth—Tobacco
1772 H. Griffiths and F. A. Wishart—Shearing the hair of horses
1773 J. B. Gardner—Sifting tobacco
1774 E. Newton—Applying motive power
1775 J. Neullens and M. Neuhaus—Cooling wine
1776 L. Hamel—Clipping lace
1777 G. T. Bousfield—Plating spoons
1778 P. Buchan—Preparation of hemp and flax

### Dated May 30th, 1868.

1779 H. A. Bonneville—Stitching button holes, &c.
1780 A. Smith—Manufacture of sugar
1781 R. Luthy—Hydrostatic presses, &c.
1782 T. Burrow and S. Keith—Weaving
1783 Sir I. B. Guest, Bart.—Cutting lawns
1784 J. Harman—Drawing board
1785 H. Hirzel—Inflammable gas
1786 N. D. Spartali—Consuming hydrocarbon oils
1787 I. B. Harris—Pumps
1788 M. Chavagnat—Closing vessels
1789 R. Turner—Umbrellas
1790 T. Field—Manœuvring gunboats
1791 C. E. Brooman—Cartridges
1792 Rev. O. Reynolds—Steam ploughing
1793 W. R. Lake—Spirit levels

### Dated June 1st, 1868.

1794 S. Walker—Pocket timekeepers
1795 J. B. Farrar—Spinning
1796 D. Jones—Furnaces
1797 G. P. Reed—Watches
1798 R. W. Page—Garden engines
1799 C. D. Abel—Alum, &c.
1800 C. H. Wells—Impregnating wood with oleaginous matters

### Dated June 2nd, 1868.

1801 E. P. H. Vaughan—Preventing incrustation in steam boilers
1802 J. Tate—Points for railways
1803 T. Christy—Paper staining machines
1804 J. Oakden and J. Pickin—Enamelling iron
1805 J. Avery—Raising venetian blinds
1806 L. G. Mure—Line carrier
1807 G. A. H. Lillie—Street paving
1808 W. E. Newton—Lever escapements
1809 W. E. Newton—Cans and other vessels
1810 J. Law—Drawing corks
1811 L. Sterne—Driving belts, &c.
1812 F. Schafer—Removing wax from the tops of corks, &c.
1813 F. Rue—Smoking pipes

### Dated June 3rd, 1868.

1814 R. Soans—Removing dirt from currants
1815 A. Crestadoro—Navigating the air
1816 J. H. Johnson—Pipe joints
1817 J. H. Johnson—Railway trucks
1818 L. W. Wright—Meters for water
1819 C. D. Abel—Production of iodine
1820 H. J. Crockett—Venetian blinds
1821 J. H. Johnson—Decorating walls
1822 G. W. Reynolds—Sewing machines
1823 E. Fairburn—Condensers for working wool
1824 W. E. Everitt—Tubes for marine boilers
1825 W. Pidding—Reels or receivers, &c.

### Dated June 4th, 1868.

1826 W. Rye—Supplying fuel to furnaces
1827 D. Foster—Combining and casting various qualities of metal in the manufacture of anvils
1828 G. Hartley and P. Robertshaw—Construction of steam boilers
1829 W. E. Gedge—Ploughs
1830 M. Rives—Ships' block
1831 C. E. Brooman—Carbonic oxide
1832 F. Schafer—Holding a stick of sealing wax
1833 C. E. Brooman—Manufacture of iron, &c.
1834 R. Woinar—A tube of a metallic cartridge with central prime
1835 J. Ashton—Horse shoes
1836 J. Worth and A. Barker—Covering rollers
1837 J. Petrie and J. Fielden—Hydraulic motive power
1838 N. Salamon—Mounting pictures
1839 W. Firth—Deodorising petroleum

### Dated June 5th, 1868.

1840 M. Theiler—Telegraph instruments
1841 M. Aenry—Converting basic phosphates of lime into soluble acid phosphates of lime
1842 A. M. Clark—Combination locks
1843 J. Page—Corkscrews
1844 C. D. Abel—Stopping motion for spinning machinery
1345 H. A. Bonneville—Feeding sugar factories
1346 R. B. Sawers—Weaving ornamental fabrics
1347 T. C. Gregory—Springs to be applied to railway rolling stock
1848 F. Reddicliffe—Arrangements applicable to pump buckets
1849 A. Prince—Useful metallurgical process
1850 W. J. Addis—Carts
1851 O. T. and G. A. Newton—Steam boiler furnaces
1852 J. Wadsworth—A new fabric for boots
1853 E. A. Dana—Projectile for rifled cannon
1854 R. Elsdon and A. Stein—Glass
1855 A. Stephen—Ventilating buildings

### Dated June 6th, 1868.

1856 J. Gerrard—Facilitating escape from fire
1857 A. Kerney—Treating spun silk waste
1858 M. Rae—Lamps
1859 H. A. Bonneville—Levelling and measuring distances, &c.
1860 J. Dewar—Preserving and arresting decay in certain vegetable substances
1861 G. Maw—Garden tallies
1862 A. V. Newton—Storing petroleum
1863 S. Wilkerson—Scattering manure
1864 G. Finnegan—Band-saw machines
1865 H. Riviere and F. T. Baker—Machines and hand tools used for closing the ends of central fire and pin cartridges when loaded
1866 T. Metcalf and T. Longfellow—Looms
1867 T. A. Weston—Raising, &c., heavy bodies
1868 J. Young—Treating hydrocarbons
1869 W. Broughton—Kitchen ranges
1870 F. Waenzel—Cartridges
1871 A. M. Clark—Forging metals

### Dated June 8th, 1868.

1872 G. Watson, W. J., and S. T. Baker—Artesian tube well, &c.
1873 S. Willetts—Double barrel firearms
1874 D. Coffey—Locks

### Dated June 9th, 1868.

1875 W. Langan—Steam boilers
1876 R. Husband—Ventilating hats
1877 F. F. Benvenuti—Inkstand
1878 J. Bourne—Motive power
1879 J. S. Wilson—Mills for grinding corn, &c.
1880 T. D. Clare—Moulds
1881 R. B. Boyman—Aerial navigation
1882 G. Howard—Parquet flooring
1883 J., J. W., and D. S. Stafford—Carriages used with apparatus for elevating straw
1884 A. Munro and W. B. Adamson—Tools for hewing stone, &c.
1885 J. H. Johnson—Treatment of oxide of iron

### Dated June 10th, 1868.

1886 G. Davis—Lounging chairs
1887 P. Frave—Musical instrument
1888 W. Ferrie—Smelting furnaces
1889 J. T. Ladyman—Working wood
1890 W. Hamer and J. Davies—Furnaces of salt pans
1891 J. Carter—Portable closet
1892 C. W. Siemens—Cast steel
1893 J. and E. Firth—Reaping machines
1894 C. E. Brooman—Breech-loading firearms
1895 A. M. Clark—Pipes used for smoking
1896 H. A. Bonneville—Shuffling cards
1897 E. P. J. L. Terrell—Heating wine, &c.
1898 W. F. Proctor—Embroidery apparatus
1899 W. Barton—Kitchen ranges, &c.
1900 C. R. E. Grubb—Match box
1901 T. E. Williams—Tin and other plates
1902 W. H. Westwood—Gas holders, &c.

### Dated June 11th, 1868.

1903 H. Turner—Privies
1904 S. Barlow, T. Edmeston, and T. Beeley—Furnaces for steam boilers
1905 W. Unsworth—Sail brake
1906 J. Rodgers—Belts, &c.
1907 A. M. Clark—Manufacture of bricks
1908 S. J. Paris, D. Drummond, and D. Hamer—Valves
1909 E. R. Southby—Utilising oleaginous acid waste
1910 W. Henderson—Finishing woven fabrics
1911 J. S. Cockings and A. Umbach—Sewing machines
1912 W. E. Newton—Uniting china, &c.
1913 J. Lord—Applying soap to cotton, &c.
1914 A. E. G. Thenaro—Combustion of fuel
1915 F. Warner—Obtaining water
1916 T. Morris—Application of buoys, &c.
1917 A. S. Stocker—Infants' feeding bottles

### Dated June 12th, 1868.

1918 D. la F. Chase—Governors for steam engines
1919 J. H. Johnson—Miners' safety cages
1920 A. L. Fleury—Treating quartz, &c
1921 A. L. Fleury—Treating gold and silver ores
1922 J. Gray and R. Weir—Treating ores, &c.
1923 J. Anderson—Preparing and spinning hard waste or cop bottoms
1924 G. Davies—Cranes
1925 L. and A. Pyke—Shirt studs, &c.
1926 G. W. Cutmore—Cooling liquids
1927 N. D. Spartali—Burning hydrocarbon oils for the generation of heat
1928 W. R. Lake—Improved anchor
1929 S. S. Bent—Poultry houses or coops
1930 C. Rostaing and E. Vivet—Steam, water, and gas tight joints
1931 W. Richards—Breech-loading firearms

### Dated June 13th, 1868.

1932 C. Humphrey—Flexible compound applicable to waterproofing
1933 J. Toft—Lathes
1934 C. H. Mitchell—Steam engines
1935 C. Whitehouse—Boring bits
1936 M. and J. Mackie—Steam boilers, &c.
1937 W. Muller and G. Englert—Cooling beer
1938 J. Howden—Steam or other motive power
1936 W. Yates—Furnaces to be used in metallurgical operations
1940 H. Malster—Mixture for cleaning gloves
1941 J. T. Parlour—Elevators for shovelling grain
1942 T. H. P. Dennis—Horizontal tubular boiler
1943 W. R. Lake—Hulling or scouring wheat
1944 E. Fisher—Effervescing drink
1945 C. E. Schwartz—Crystal hrocatel colours
1946 J. Ball—Cutting off the superfluous portions of threads from spots made on lace, &c.

### Dated June 15th, 1868.

1947 W. Leonard—Horse collars
1948 L. S. Thomassin—Combustible gas
1949 F. Worcester—Tuyeres for furnaces
1950 J. S. Benson and J. Von der Poppenburg—Breech-loading firearms
1951 T. Kendrick—Ornamentation of fenders
1952 J. H. Johnson—Zincing baths
1953 C. Humfrey and W. S. Webster—Waterproofing paper
1954 W. C. Sillar, G. Sillar, and G. W. Wigner—Deodorizing and purifying sewage
1955 L. B. Prindle—Chairs and rails for railroads

### Dated June 16th, 1868.

1956 W. and O. Brooke—Healds for weaving
1957 W. Rowan—Hackling flax, &c.
1968 R. Wappenstein and R. Ray—Registering the number of passengers travelling in omnibuses
1959 D. Elder—Dredging machines
1960 T. Whitehead—Combing wool, &c.
1951 J., J., and J. Booth—Cutting stone

### Dated June 17th, 1868.

1962 M. Demmer—Dial or indicating needle case
1963 J. P. Wills, E. H. Cardell, and T. F. Wills—Mowing grass, &c.
1964 D. Mitchell—Figured cloth
1965 G. B. Turrell—Coolers for beer, &c.
1966 W. Betts—Weighing carriages
1967 T. Comfield—Brakes for railway carriages
1968 J. McLeod—Dyeing yarns
1969 W. Carr—Hinges for doors of carriages
1970 J. C. Walker—Baking powder
1971 W. and J. Rhodes—Safes, &c.
1972 A. M. Clark—Purification of ceramic and other matters, &c.

### Dated June 18th, 1868.

1973 W. Thomson—Rails for railways
1974 J. and E. Lumley—Machine for the manufacture of pills
1975 A. Ridgway—Hay rakes
1976 A. Cochran—Finishing woven fabrics
1977 C. Attwood—Moulds for casting
1978 G. F. Redfern—Drawing rovings and spinning yarns of cotton, &c.
1979 T. C. Hide—Dressing flax, &c.
1980 C. Hengst and H. Watson—Manufacturing gas
1981 W. S. Carr—Waterclosets
1982 J. Hemington—Grinding the cutters of reaping and mowing machines

### Dated June 19th, 1868.

1983 E. R. Kaulbach—Producing direct rotary motion by means of a gyrometer
1984 A. Mackie—Machinery for setting and distributing type
1985 J. Perry—Improvements in packing bottles, &c.
1986 D. Graig and J. Greig—Lithographic printing machines
1987 W. E. Newton—Apparatus for aerial navigation
1988 M. P. Watt—Obtaining motive power by the combustion of inflammable aeriform fluids
1989 F. B. Doering and R. H. Twigg—Machinery for boring rock
1990 A. J. B. P. Thierry—Marine velocipedes
1991 T. Heppell—Miners' safety lamps

### Dated June 20th, 1868.

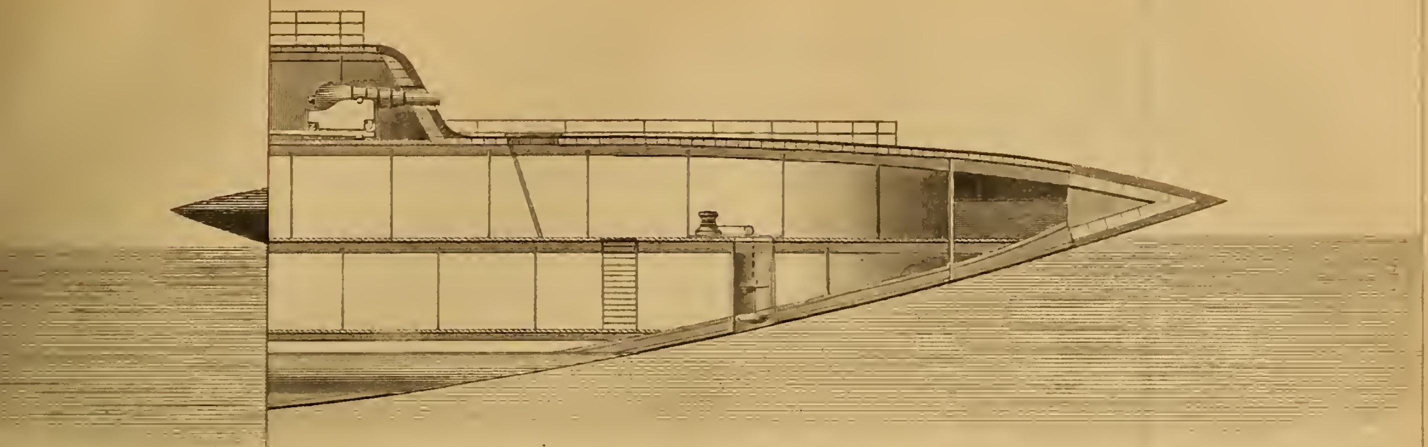
1992 G. Owen—Chess boards
1993 W. Umpherston—Steam engines for obtaining an almost uniform speed
1994 G. H. Midwood—Treatment of certain waste yarns, &c.
1995 G. Richardson—Improvements in looms for weaving
1996 A. A. Common—Manufacture of stench traps for sinks
1997 H. W. Hart—Pots and vessels for containing tea, &c.
1998 J. Hadley—Apparatus for cleaning and decorticating wheat
1999 W. L. G. Wright—Propelling of ships or vessels
2000 C. H. Murray—Device for uniting the ends of straps
2001 J. Bonnall—Thrashing machines, &c.
2002 J. Shelmerdine, W. Walker, and E. Holt—Valve gear for steam engines
2003 W. Bayliss—Wrought iron hurdles, gates, and fencing
1004 S. Bowen, C. Glover, R. H. Davis, T. Standford, T. Scott, A. M. Bell, E. Sheldon, W. Farmer, L. Maskall, E. Coburn, and J. C. Cole—Machinery for cutting or worming screws

### Dated June 22nd, 1868.

2005 V. De Stains—Construction and guidance of boats
2006 R. Austin and W. K. Austin—Rotary engines
2007 W. Tongue—Preparing fibrous materials for combing and spinning
2008 E. T. Hughes—Polishing needles
2009 E. T. Hughes—Improvements in metallic cartridges
2010 W. E. Gedge—Indicating whether the doors of railway carriages are securely fastened
2011 W. A. Gilbee—Manufacture of cards
2012 M. Gray—Covering electric conductors
2013 A. M. Clark—Winding thread
2014 C. Whitehouse—Mill bills, &c.
2015 G. Taylor—Improvements in the construction of boots and shoes
2016 J. Hayes and J. Hayes—Machinery for actuating straw shakers
2017 J. H. Johnson—Colours for dyeing

## 40FT DIAMETER,

*, GLASGOW.*



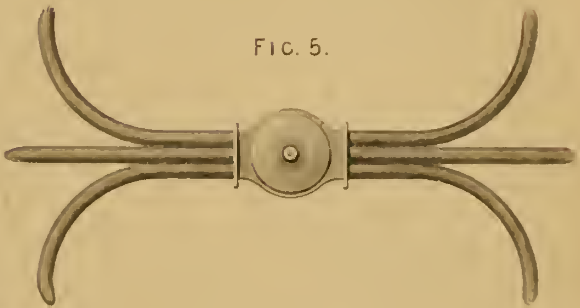
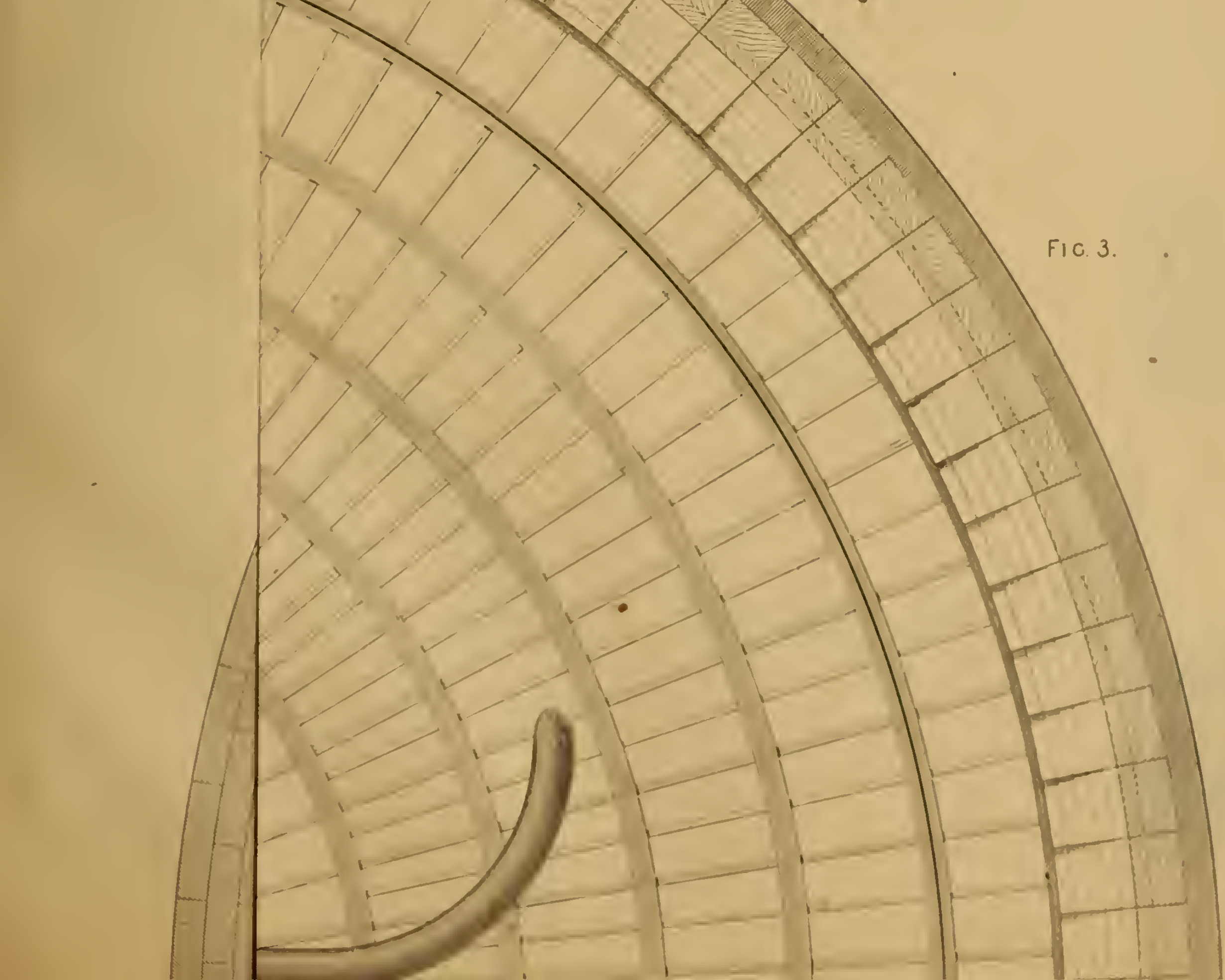


FIG. 5.

FIG. 3.



# CIRCULAR VESSEL OF WAR 240 FT DIAMETER,

*BY MR JOHN ELDER, ENGINEER, GLASGOW.*

FIG. 1

Scale $\frac{1}{16}$ Inch = 1 Foot.

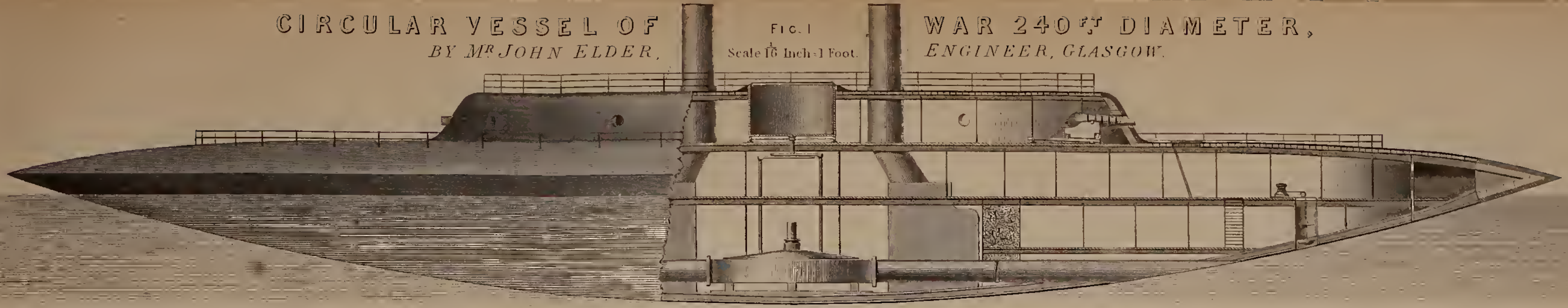


FIG. 4.

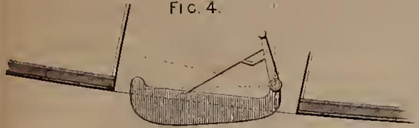


FIG. 5.

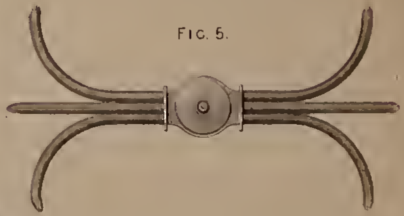


FIG. 2.

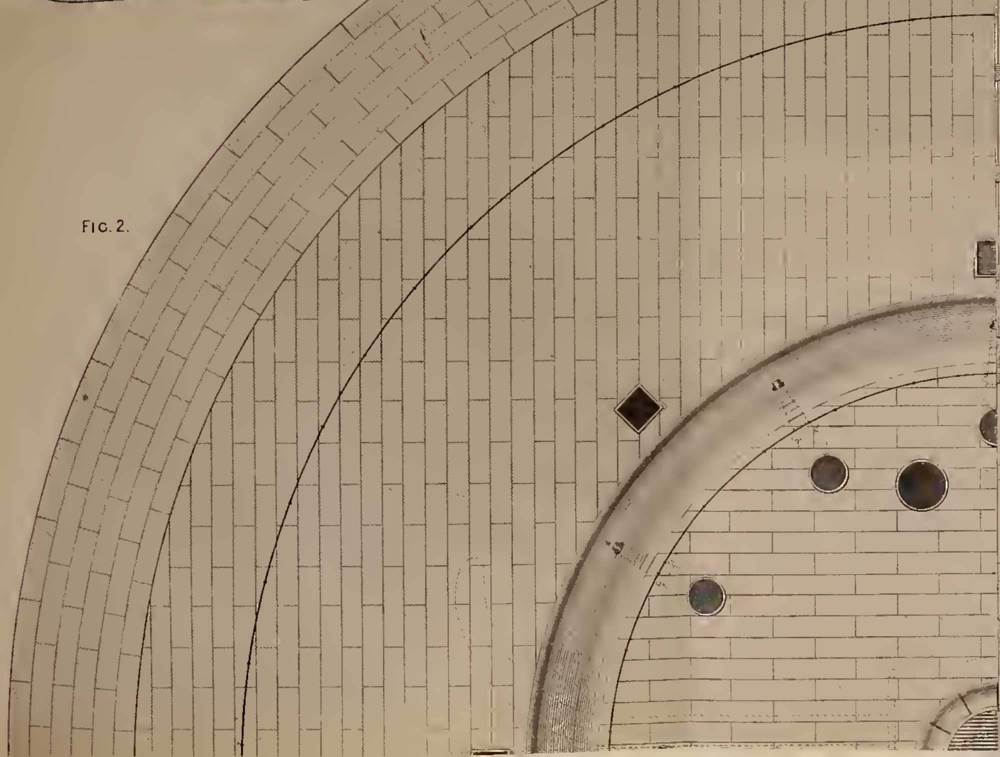
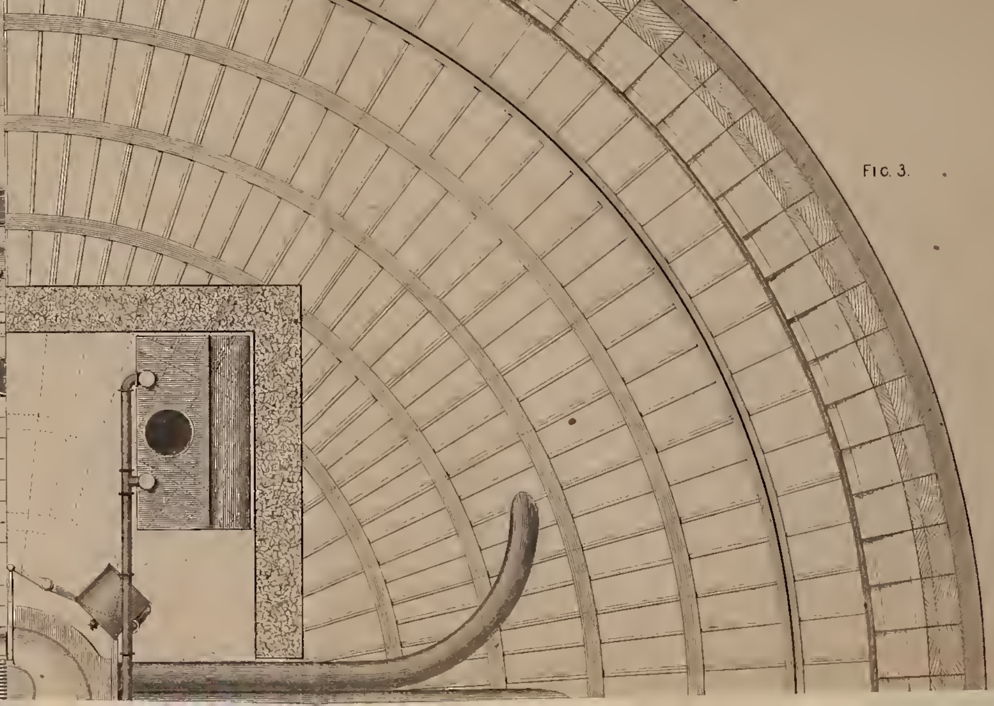


FIG. 3.



# THE ARTIZAN.

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## CIRCULAR VESSELS OF WAR.

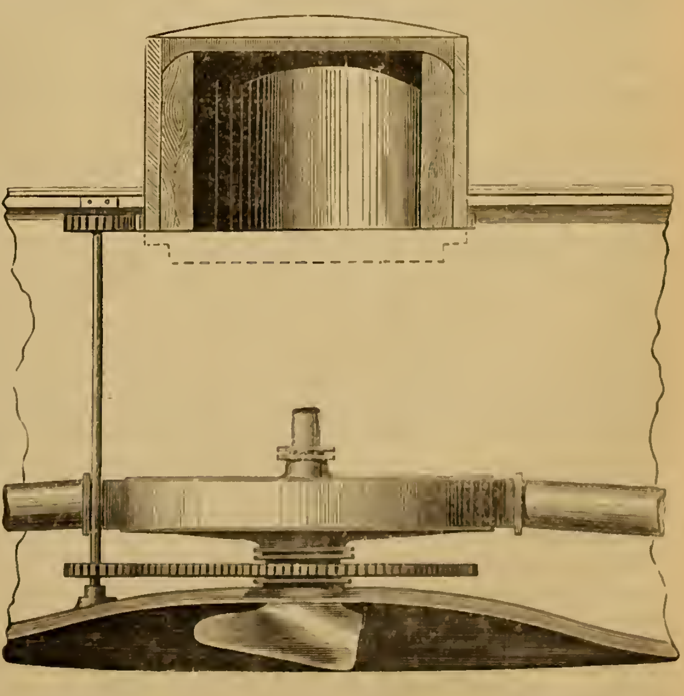
(*Illustrated by Plate* 335).

In the last number of The Artizan was given a Plate (333), in which the various forms of circular vessels as designed by Mr. John Elder, of Glasgow, were illustrated. It was there observed that the peculiar shape of the hull was well adapted for travelling at a considerable speed through the water, as also for performing the most intricate manœuvres with great facility. The question then arises as to what is the best method to be employed for propelling a vessel of this shape in order to develope to its fullest extent the advantages claimed for it. A screw-propeller, or better two screws, might be used, each being placed towards the outer edge of the vessel, but on opposite sides, and driven by means of a pair of engines fitted in a well, the connecting-rod either running into the water; or a casing might be constructed so as to run down into the water enclosing the crank shaft, and having a stuffing box for the propeller shaft to work through. In the former case long brackets would be required to carry the bearings of the propeller shaft, and in the latter considerable resistance would be offered by the casing when travelling through the water; this resistance might, however, be considerably reduced by tapering the ends of the casing so as to form a cut-water. By this means the vessel could be propelled straightforward, or it might be caused to revolve by working the screws in opposite directions. The steering might be managed by having lifting rudders somewhat similar to those fitted on the Indus steam flotilla; thus, by having two rudders each placed at equal angles to the line in which the vessel is intended to travel, but on opposite sides, the steering would be performed by lowering one or the other into the water as might be required. These and many similar methods that might be mentioned are, however, open to objection in consequence of their projecting beyond the plain surface of the portion of the sphere forming the hull of the vessel, and consequently being liable to damage upon getting aground.

Mr. Elder proposes to get rid of all these objections and, at the same time, increase the manœuvring power of his vessels, by adopting the hydraulic propeller, and has designed several different methods of applying this power: one of which is illustrated in Plate 335. In this case the centrifugal pump is placed in the centre of the ship and driven by four cylinders, placed at right angles to one another. The suction and water jet pipes are in a line with one another, so as to reduce as much as possible the friction of the water passing through them. Upon each side of these straight pipes, curved pipes of the same diameter are placed (partly shown in the plan, Fig. 3, and more fully in Fig. 5), and communication between the turbine and either of the three pipes on each side is regulated by two valves—one for each set of pipes. These valves have a single opening in them, equal in diameter to the bore of the pipes; and thus, by moving the valve horizontally this opening may be caused to come opposite to either of the three pipes, thus establishing communication between it and the turbine. By this means the vessel may be made to travel in a straight line, or to revolve at pleasure; thus, when required to travel in a straight line, communication between the two straight pipes are opened; and, similarly, when it is desired to cause the vessel to revolve, either the two curved pipes upon one side, or the two pipes upon the other side, according to the direction required, are opened. The vessel may be steered, when travelling towards any point, by moving the horizontal slide valve so that the circular opening in it is brought partially in front of one of the curved pipes, when, of course, the requisite change in the direction of the course of the vessel will at once be obtained. In order to actuate these horizontal slide valves, an eccentric may be fitted to the central shaft of the revolving pilot house, (as shown in the plan, Fig. 3), which, being connected to a crank arm on the upper end of a vertical shaft, the lower end of which has a similar arm connected to the valve spindle, will cause that shaft to turn in its bearings, and thereby to actuate the horizontal valve. From this it is evident that a partial revolution of the pilot house, and consequently of the eccentric, will actuate the slide valve regulating the flow of water through the pipes of the turbine, and cause a similar movement in the vessel. Therefore if a look-out, or line of sight, be marked upon the pilot house in a line with the straight pipes, when the valve is placed centrally, and looking towards the suction, it will only be necessary, in order to arrive at any desired place to keep that spot in the line of sight from the pilot house.

Several other plans have been proposed for steering and manœuvring these vessels, one of which, as in the case of the screw propeller before mentioned, is by means of rudders raised flush with the skin of the vessel when not in use, and which is shown at Fig. 4, Plate 335. Two or more of these rudders may be placed at equal and opposite angles, with a straight line drawn through the centre, so that when either one is lowered into the water it will tend to cause the vessel to revolve, or, in other words, will steer it in the required direction. In this case the curved pipes and the horizontal slide valve may be dispensed with, and the eccentric upon the centre shaft of the pilot house may, if desired, be made to work the rudders. This plan appears to have some advantages over the curved pipe arrangement so far as regards steering, though it would evidently be much less effective for causing the vessel to revolve rapidly.

Perhaps the simplest method of any out of the number that Mr. Elder has proposed for handling a circular vessel, is that shown in the annexed woodcut. In this case the water is taken into the turbine at its circum-



ference, through suitable pipes, and discharged through the centre to which is fitted a curved pipe which discharges the water horizontally, or nearly so, under the centre of the vessel. This discharge pipe is free to revolve, stuffing-box joints being made between it and the turbine, and again where it passes through the hull of the vessel. Upon this pipe is fitted a spur wheel, into which a pinion upon an upright shaft is geared, while upon the upper end of this shaft a similar pinion gears into a similar wheel fitted round the base of the pilot house. These wheels and pinions having precisely the same number of teeth respectively will, of course, impart a precisely similar motion to the pilot house and the discharge-pipe. Now, by having a line of sight in an exactly opposite direction to the water jet, and bringing this line to bear upon any object, the vessel will travel towards it; or, conversely, supposing a man to stand in the pilot house with his back to the water jet, and looking through a small sight hole in the armour plate opposite to him, and consequently in a line with the water jet, he will sight the place to which the vessel is travelling. This motion is very peculiar, as the ship while travelling changes its course in any direction without revolving.

A compound action, which would be invaluable in action, may be obtained by having, in addition to the revolving water jet, rudders fitted similar to those before described: when the vessel might travel in any proposed direction, and at the same time revolve independently, so as to bring her guns to bear upon required spot. In order to perform this manœuvre it would only be necessary for the man in the pilot house to turn it in an opposite direction to that in which the vessel is revolving, and at precisely the same speed, which he could easily do by keeping the line of sight always bearing upon one spot. The revolving would be performed independently, and used for the horizontal training of the guns. For ramming purposes, also, this compound motion would be very advantageous, as it would impart a cutting motion to the edge of the vessel in addition to its acting as a punch. In would also be very difficult, if not impossible, for an enemy to judge where such a shaped vessel, with such a peculiar motion, was going, and it would therefore render it by no means easy to avoid such an awkward monster.

From the above explanations, we think it will be acknowledged that Mr. Elder's idea is worthy of consideration and possesses many great advantages over the ordinary form of vessel. Whether there may be any insuperable objections to a ship constructed in this peculiar form, can only be satisfactorily proved by experimenting upon a vessel of considerable dimensions, and, consequently, at a heavy expense, but it is to be hoped that such obstacles may not prove insurmountable.

## HAVRE EXHIBITION.

This exhibition, which for some time appeared very empty, is now tolerably well filled, the floor space being mostly occupied, while the wall space is almost completely covered with diagrams and drawings. The marine department, beside occupying the best position, is by far the most important, exhibiting, as it does, specimens of the naval architecture of a great many of the first firms both in Great Britain, Europe, and America. Among the former may be mentioned Messrs. Napier and Sons, of Glasgow, who exhibit models of several vessels built by them from the fast and elegant *Queen of the Orwell* to the fine sailing ships *Roslyn Castle* and *Pembroke Castle.* Several models of vessels by the same builders are exhibited by their owners, the Compagnie Générale Transatlantique, such as the *Pereire* and the well-known *Ville de Paris.* Mr. Bishop, of Guernsey, has a very pretty model of a twin-screw yacht; and Messrs. Palmers, of Jarrow, exhibit amongst others a beautiful model of the *Brindisi,* which is being built for the P. and O. Company, besides a model of two screw-steamers *Nevada* and *Idaho,* for the Liverpool and Great Western Steamship Company. The London Engineering and Iron Shipbuilding Company have some fine models of yachts, also several other models, including a large armour-plated vessel. Messrs. Randolph, Elder, and Co., of Glasgow, show beautiful models of steam fishing vessels built for Messrs. Johnstone, of Archachon; also drawings of Elders's circular ship. Various drawings and models are exhibited by the well-known firms of Forrest and Barr, Thomas Wishart, Thomas Adamson; Henderson, Colborn, and Co., and others.

Amongst the foreign exhibitors of models and drawings of vessels, besides the Compagnie Générale Transatlantique already mentioned, are the Forges et Chantiers, of the well-known Messageries Impériales, several of whose vessels are far superior to their rivals, the Peninsular and Oriental Company. John Cockerill, of Seraing, also forwards some very fine models and drawings of vessels and and ironwork. From Holland a very delicately finished silver model is sent by Mr. Hoogendyk; and from America Mr. Beckwith, of New London, Connecticut, sends a model of a fishing smack; Mr. H. Steers, Mr. R. Quesnel, &c., also forwarding a few models and drawings.

With regard to appliances for the repairs of vessels, the patent slip by Mr. Morton, of Leith, is very well represented in a large model showing all the details; while floating docks are represented by Messrs. Chemallé et Cowran, of Lilbourne. Amongst the models of machinery, M. Eugéne Bourdon, of Paris, has a very compact arrangement for a screw propeller, the engines being placed very low in the vessel so as to give great stability; he also exhibits his anti-friction stop-cock and various useful instruments. M. Mazeline has also some very pretty models, together with a very compact donkey engine.

Several pleasure boats and canoes are shown, but there is nothing particular to recommend them. Of the various fittings belonging to a vessel, may be mentioned the excellent balanced rudder by Lumley, too well known, however, to require any description; and a rudder-head by Murray, the object of which is to keep the ironwork of equal strength throughout, and at the same time to admit of easy replacement in case of accident. Messrs. Emerson, Walker, and Co., send their patent windlass by which a quick or heavy purchase may be obtained by simply reversing the motion; also a small windlass with chain stopper. Various excellent specimens of chains, iron wire, and cordage are brought together, including some fine specimens M.M. David and Cie.; Merlie-lefére and Cie., and others, of Havre; also Messrs. Hawks, Crawshay, and Sons, of Gateshead, who show some examples of broken links of chains so that their texture may be examined. Messrs. Paw and Fawcus, of North Shields, have a portion of a gigantic chain, said to be the largest in the world, besides several other excellent samples. Amongst other curious looking objects is an apparatus for inspecting and cleaning ships' bottoms while afloat, which consists of a large telescope tube having a vertical plate of glass let in at the bottom, with a reflector behind placed at at an angle of forty-five degrees, so that a person looking down through the tube would see the side of the vessel. Large brushes are fixed in frames in such a manner that they may be made to scrub any part that may be seen through the telescope to be foul.

The collection of apparatus for saving life is very large, almost every description, from the simple cork jacket and life-preservers, to the boats, &c., of the English and French Societies. Amongst those that have any claim to novelty may be mentioned Perry's American life-raft, similar to that which crossed the Atlantic and appeared at the Paris Exhibition; also a simple life-preserver, called a "Podoscaphe," consisting of a flat piece of buoyant material, shaped somewhat like a boat about 3ft. 6in. long, and having a hole large enough for a man's body near the centre, and a small staff for a sail or signal of distress. Amongst life-saving apparatus may be included means of lowering boats, several of which are deserving of attention, especially M. Kilner's grab link, as are also numerous diving apparatus, dresses, &c. There are also several methods exhibited of saving or protecting life in mines by using the electric light, which are thought highly of in France.

Five or six methods are shown of establishing instantaneous communication between the officer in command of a ship and the steersman and engineer, most of which are well known.

Amongst other objects of interest may be mentioned Silver's marine governor, too well-known to require description, and a wave-tracer and roll-tracer designed by Admiral Paris and his son, Lieut. Paris, and made by M. Salleron, of Paris. The first of these instruments, which its name denotes, is for the purpose of measuring the height of waves in a sea-way, is a very ingenious instrument, and has been found to answer admirably. The other instrument is for measuring the number of degrees a vessel rolls, and with the present high sided armour-plated vessels would be found very useful in comparing their different rolling propensities.

## THE DUTCH MONITOR "DE TYGER".—TRIAL TRIP.

The official trial of the armour-plated turret monitor, *De Tyger*, built by the Messrs R. Napier & Sons, took place on the 2nd ult. in Wemyss Bay. Her principal dimensions are—Length over all, 187ft.; breadth, 44ft.; depth, moulded, 11ft. 6in.; tonnage, builders' measurement, about 1,600 tons. She is built in compartments with watertight doors, and has a double bottom, it being intended that the space between the outer and inner bottoms shall be filled with water when preparing for action, so as to sink the vessel to her fighting draft, namely, 9ft. 6in., thus leaving only about two feet of the topsides exposed to the enemy. Under ordinary circumstances, however, the draft is about one foot less, thereby adding to the comfort and seaworthiness of the ship. The armour plating on the sides of the vessel is 5½in. thick, having a backing of teak 10in. thick, and an iron inner skin of one inch thick, supported by strong iron frames. The revolving turret is on Capt. Coles's plan. It has 8in. armour, with 12in. teak backing, and an inner skin of one inch thick. Her armament consists of two 300-pounders, 12½ ton Armstrong rifled guns, having the most improved iron slides and carriages. The turret is fitted with a complete set of steam winch gear, in addition to appliances for turning it by hand. She is also fitted with Gisborne's Patent Telegraph, which enables the captain to give directions to all officers in charge of the vessel. She has twin screws and has two distinct pairs of engines, being of the direct acting horizontal pattern of 140 nominal horse-power, cylinders 30in. diameter; 1ft. 6in. stroke, and with ordinary condensers. Steam is supplied by 2 boilers intended to work up to 30 lbs pressure. The accommodation for officers and men is ample, and on the most improved principles. Their sleeping and dining rooms are, like the engines, all under the water line, so that it would be impossible for the fire of the enemy to do any material damage to the ship, or cause any mishap to the crew—the only part of the vessel which is exposed being the hurricane decks, the cooking stoves, and the turret which, as already explained, is very efficiently protected. From the comparatively limited size of the vessel and her peculiar character, it is exceedingly warm work for the men employed in the engine and boiler rooms, which, in fact, are built level with and contiguous to each other. The shot and shell magazines are conveniently near to the turret, and are, of course, far below the water line. It was fair weather on the trial day, so that the effect upon the ship in a chopping sea could not be realised. But doubtless under such a circumstance, the waves will lash freely over the decks more particularly as these have nothing of the nature of bulwarks further than an iron railing, and slope gently towards the water. Of course there is a heavy weight above the deck in the shape of the turret and the two Armstrongs, but that weight is to a considerable extent balanced by all the machinery of the vessel being under decks. The monitor is furnished with a number of boats, and in fact, with all that is requisite for a ship of war of this class. Small as her dimensions are, it will take about sixty men to man her. As seen from the shore, when lying about a mile out, *De Tyger* does not present a smart aspect, being for all the world like one of the Glasgow and Greenock steam barges with a load of baled hay above deck. The course for the trial was the measured nautical mile at Skelmorlie, the vessel running with and against the tide alternately. The following is the result of the trial with full boiler power:—First run—knots, 10·084 per hour; second, 9·836; third, 9·917; fourth, 9·449; fifth, 9·445; sixth, 8·738. With respect to the last, it would not be fair to include it in any average, owing to the boilers having primed in the course of the run. Two trials were next made with one boiler, this being necessary, as the other boiler might in action be used for causing the turret to revolve. The results of these trials were—First run, 8·200 per hour; second, 7·692; mean, 7·946 per hour. The turret itself was next tried, and by the aid of steam was sent round in 45 seconds. But the revolution, when full steam is up, can be made in thirty seconds. The turret may also be turned by manual power, but, of course, the process is much slower. The two 300-pound Armstrong guns, with which the turret is mounted, are splendid specimens of ordnance. The pieces are so mounted that they can be shot all round the horizon with the exception of only about three degrees on each side of the middle line when firing aft. They run out of the turret port-holes freely, and by the aid of machinery can be handled almost as easily as small signal guns.

## A NEW ATLANTIC CABLE.

As the statement of a concession of the right of laying down a submarine telegraph cable between Brest and the United States has now been confirmed in an official manner, it may be worth while to mention a few of the particulars of this enterprise. A corresponding concession has been granted by the State of New York, and the cable will be laid direct from Brest to New York city. This concession is understood to be an exclusive one—on the French side, at any rate—for twenty years. The grounds upon which the projectors have found favour with the French and New York State Governments have been, chiefly, that the proposed cable will obviate the circuity and delay incident to the present line; and will also lessen the existing liability to casualties. By the only route we now have not less than four submarine cables have to be employed, while the electric fluid has to perform four land journeys also before a message can be sent from the Continent of Europe to New York. There intervene—1, the North Sea, or the English Channel; 2, the Irish Sea; 3, the Atlantic; 4, the sea between Newfoundland and the American continent; while the wires have also to be carried across England, Ireland, Newfoundland, and, lastly, from the coast of British America southwards to New York. It is, perhaps, surprising that with this circuity, messages are sent from Europe to the United States as quickly as they are; but there is no doubt that communication will be very much accelerated if, as is said, a merchant or banker at Paris will be able literally to speak into New York. It may possibly be a sanguine calculation that messages between those cities may then be sent and answered in half an hour, and that messages may be sent from Berlin or Frankfort to New York and answered within an hour; but the difference of time must obviously be very great. It is thought also that the directness and simplicity of this route will very much diminish the chances of communication with America being from time to time put out of gear. Ocean telegraphy has now been carried to such perfection that there is more fear of mishap by land than by sea; and, in point of fact, during the last two winters, when we have several times been alarmed by a stoppage of messages, the explanation has in each case been that storms had blown down the land telegraphs, sometimes in Newfoundland, sometimes on the American mainland. From this danger, whatever it may amount to, the new line will be exempt. As the capital it will represent will, it is stated, be only £1,000,000, and as the working expenses, with only two stations (at Brest and at New York), ought to be very small, it is probable that this project will bring the luxury of telegraphing across the Atlantic within the reach of persons of very moderate means. A cable laid across the English Channel, from Falmouth to Brest, would also give us the benefit of it. It is understood that the new Atlantic cable will be ready for laying next June.

## EXPERIMENTS AT SHOEBURYNESS.

A number of interesting and important experiments were commenced on the 16th of June and continued at intervals for several weeks, the object of which was to test the aggressive power of various guns, and the resisting power of different kinds of armoured defences. The following is extracted from the official programme:—

The object of these experiments is to test the resistance of the undermentioned structures to the fire of heavy guns:—

1. One compartment or casemate of the Plymouth Breakwater Fort now in course of construction. It is faced with three 5in. plates on the east side of the embrasure. There is an additional or fourth 5in. plate on the west side.
2. One compartment or casemate of an experimental structure faced with iron of different thicknesses, viz., 8in., 4½in., 6in., 4in., 4½in. respectively, taken from E. to W. The 8in. plate rests direct against the pier, the three central plates and 2ft. of the plate on the west are supported by hollow stringers. The backing of the shield proper is filled in with concrete
3. A 15in. rolled iron plate made by Messrs. Brown and Co.
4. A 15in. hammered iron plate made by the Thames Ironworks Company.
5. A masonry wall erected 1865, 11ft. 2in. in thickness, 7ft. 8in. high, of concrete and brick, strengthened by means of 2in. iron cramps, holding 5in. planks, and supported by 4½in. rails tied horizontally at the back, which are also held by the cramps.
6. A masonry wall, granite backed by brick, in all 10ft. thick, faced with 4½in. plates, leaving an interval of 15in. between the plates and the face of the wall, which interval is filled in with concrete. The plates are tied to vertical iron stringers by 2½in. bolts, which stringers, in their turn, are held to the wall by 2½in. bolts, which pass through five feet of granite, and are secured by screw nuts behind.
7. A gun shield commenced by the Millwall Iron Company 1865, erected 1868. It is in three thicknesses, the lower plate 9in., left upper plate 6in., right upper plate 6in., faced with three 1in. plates, the whole supported by hollow stringers and 12in. girders, and filled in with teak.

The Plymouth shield was scarcely a fair representation, as it was so far modified as to weigh 940lbs. per square foot instead of 740lbs., which is the actual weight. In spite of this, however, the guns proved too formidable for it at short range. It was against this shield that the guns, during that and the following week, were directed, and the results which are exceedingly instructive are given below:—

On Tuesday, June 16th, the practice was:—First round was fired from a 12in. rifled gun, weighing 23 tons, and consisted of a conical chilled shot, 600lbs. weight, fired with 76lbs. of pellet powder. It struck the part where the extra plate was fixed, and after penetrating 13in. the shot was broken and thrown back; damage not very great.

Second round, from the same gun, but with a 587lb. shell, with a bursting charge of 13lb. 2oz.; struck the edge of the extra plate close over the porthole, and did but little damage.

Third and fourth rounds were from the Rodman guns, with $83\frac{1}{4}$lbs. of powder, equal to 100lbs. of American, and a 430lb. spherical shot of American cast iron. The first was not very accurately aimed, but the second struck fair; neither, however, did much damage, the depth of the indentation being only about $4\frac{1}{2}$in. deep, while the shot rebounded and fell flattened but unbroken in front of the target.

Fifth round.—This was from the 12in. gun, with a charge of 76lb of powder, and a 600lb. chilled shot. It struck the extra plate and made an indent of $13\frac{1}{2}$in. deep. This shot did a great deal of damage, several bolts being broken and the frames bent.

Sixth round, similar charge to last; struck the target where it was only 15in. thick, and broke a bolt, but did not get through.

Seventh round, similar charge, but with a 586lb. shell, with a bursting charge of 13lb. 2oz. This did a good deal of damage, but the force of the explosion of the shell was wasted, the point of the shell having stuck in the plate; several bolts were broken, and the plates knocked considerably out of shape. This was the last of that day's firing, and upon carefully inspecting the target it was found that though a good deal punished it was still sufficiently strong to afford protection, and had not been penetrated.

On Wednesday, the experiments against the same target were resumed.

The first round was fired from the Rodman gun, with a round shot of 430lb., charge $83\frac{1}{4}$lb. This was aimed at the left-hand or 15in. part of the shield, and struck in front of an upright standard, making an indent of 7in., but doing little further damage, although it struck a place that had been much punished already.

The second round was fired from the 23-ton gun, with 76lb. charge. It struck below the porthole, 2ft. 3in. from the ground, 1ft. from the vertical standard to the left of the embrasure. The point of the shot penetrated about 13in., cracking the plate at the near corner of the porthole. In the rear the damage was considerable, the inner layer of 5in. iron being bulged out and torn open. Three bolts near the spot were strained.

The third round was a shell from the same gun; it struck at the 15in. side, fair between the standards 3ft. from the left hand of the target and $6\frac{1}{2}$ft. from the ground. It went through the plates, breaking and turning the inner plank against the pier behind.

The fourth round was a shell from the 18-ton gun, fired with 60lb. of powder, the bursting charge in the shell being 10lb. It was aimed at the same part of the target as the former rounds, and struck between the standards 4ft. from the ground, and about 2ft. to the left of the Rodman shot, breaking off the piece of the front plate lying between them. The shell passed through the shield and exploded inside.

The fifth round was with the same gun and projectile as the last. The shell penetrated $16\frac{1}{2}$in., and stuck in the plate, the bursting charge exploding outside. A piece of the inner plate, about 2ft. 6in. long by 15in. wide, extending horizontally between this shot and the former one, and weighing 5 cwt. or 6 cwt., was broken off and projected to the rear, striking the rope mantlet which hung down 5ft. away. It rebounded from it and fell on the ground.

On Thursday the practice was resumed against the same shield. Seven rounds were fired, consisting of one from the 12in. gun, with the full charge of 76lb., directed against the extra thickness of plates; and the second from the same gun with a charge of $57\frac{1}{2}$lbs. to represent a distance of 1,000 yards. Then came two shots from the 15in. Rodman gun, with the full charge of $83\frac{1}{4}$lbs. which in spite of the enormous charge did less damage than the two previous shots. Then two shots were fired from the 10in. rifled gun, with charges of 48lbs. of powder, and afterwards one shot with the full charge of 60lbs. The last did a considerable amount of damage, penetrating within four inches of the back of the target.

On the 17th ult. the gun shield designed by Mr. Hughes of the Millwall Iron Works engaged the attention of the committee. Gun shields, as most of our readers are aware, are intended to protect the embrasures of stone forts, or rather to replace stone where the bevilling and consequent weakening of the stone would commence, in order to allow for the lateral training of the gun. To make this most important part of the fort as strong as possible, a large piece of the wall in front of the gun, generally about 12ft. long by 8ft. high, is left out, and its place is filled by an iron shield of the same size, which is inserted into the surrounding stonework, and in the centre of which a porthole is formed for the gun to fire through. It will be evident that a gun shield must have the qualification of combining great strength with very moderate thickness, so that, while it efficiently protects the notoriously weak place immediately round the embrasure against the attack of heavy artillery, it may leave ample room behind for the extended training and the convenient working of the large modern type of gun.

The first successful shields were two experimental ones constructed in 1862 by Colonel Inglis, R.E., who has for some years devoted his special attention to this subject, and has taken the most active part in the application of iron for the purposes of fortification. These shields were tested in 1862 and 1863 by the Iron Plate Committee with the most powerful guns then obtainable, and the result was very favourable, but the matter went no further. Shortly afterwards two granite casemates were erectsd at Shoeburyness, one having a shield made upon Mr. Chalmer's system of compound iron and wood backing, the other having its gun protected by a single plate of iron, about 13in. thick, but of reduced size. Mr. Chalmers' shield stood tolerably well, but the single plate broke in two under a heavy blow. In 1865, Mr. Hughes proposed to improve this compound backing by arranging the iron into a peculiar form which he called the "hollow stringer," being a modification and extension of a plan proposed to the Iron Plate Committee by Colonel Inglis in 1863; and he was commissioned to construct an experimental gun shield on this plan. This was finished in the autumn of 1865, but no trial of it was made and the consideration of the subject seemed again indefinitely postponed.

Early in the present year Mr. Hughes taking advantage of the experience gained by the Gibraltar shield, obtained the order of the War office to strengthen his own structure by the addition of strong girders and plates, at the rear, to the extent of four or five tons' increase of weight; but by some unlucky mismanagement the authorities allowed this strengthening to be done in such an unskillful way as seriously to detract from the efficiency of the shield for its purpose.

The Millwall Shield, so strengthened, was the structure tested on the 17th ult. Its dimensions are 12ft. 2in. long and 8ft. high. The shield proper consists of three thicknesses—namely (1), an outward or front layer of armour-plating; (2) a compound backing; and (3), an inner skin. Behind these are placed (4) certain stiffening or strengthening arrangements of complicated construction. The whole are firmly bolted together and supported by side struts at the rear in the usual way.

The front or outer layer of armour-plating is in two parts, the lower divisions being formed of a single armour-plate 12ft. 2in. long, 4ft. wide, and 9in. thick, the upper division of another plate of similar length and width, but only 6in. thick. The left-hand half of this upper plate, however, is covered by covered by three layers of 1-inch iron, so as to bring up the thickness in this part to 9in., and these extend over the top of the porthole; the remainder of the plate remains in its natural condition. Thus the shield presents three varieties of front armour to be tested—*i. e.*, over the bottom half, a solid 9in. plate; on the left-hand upper quarter and over the porthole, 9in. of iron, made up of one 6in. and three 1in. plates; and on the right-hand upper quarter, a 6in. plate only.

The second part of the shield is the compound wood and iron backing which comes immediately behind the armour-plating. It is formed principally of hollow stringers, which we have already alluded to. Each of these is exactly the shape of the bridge rail used by Mr. Brunel on the Great Western Railway, but about twice the size; it is 7in. high, 4in. wide over the face, and 9in. over the base flanges, and it weighs about 62lb. to the foot. These stringers are placed horizontally, with their narrow faces bearing against the back of the armour-plating, and their flanged bases against the inner-skin. The edges of the flanges lie close together, giving consequently a distance of 9in. between the centres of the stringers. The spaces between the stringers and the hollows in the stringers themselves are filled up solid with teak; and in each intermediate space there is fitted a piece of T iron, to add the resistance.

The third part of the shield proper is the inner skin, which is formed of two thicknesses of plates each $\frac{3}{4}$ inch thick. They break joint and are riveted together, and the base flanges of the stringers in the backing are riveted to them at frequent intervals.

This completes the shield proper. It is pierced with a porthole 3ft. high and 2ft. wide, which is strengthened where it passes through the backing with wrought-iron jambs,

The back of the shield is strengthened and stiffened by additional iron stringers of the same pattern as in the backing, placed vertically on either side of the porthole, and horizontally above and below it, and riveted in each case to the back of the inner skin. In addition to these comes the further strengthening of plates and girders with wood filling round the porthole, which was added in the present year.

The various parts of the shield are strongly bolted together with 34 bolts, each $3\frac{1}{2}$ inches diameter, reduced in the shank on the principle proposed by Mr. P. M. Parsons. The bolts have conical heads, countersunk into the front armour plates, and provided with wood and indiarubber washers under the nuts.

The total weight of the shield is a little over 38 tons.

It seems to have been assumed that this shield was to be considered to a certain extent as competitive with the Gibraltar one, inasmuch as it was decided by the authorities of the War Department to test it, shot for shot, exactly in the same way. Not only were the same guns, the same projectiles, and the same charges used in the same order, but the shots were aimed exactly on the same parts of the shield. The guns were as follows:—

| | Inch. | | Tons. | | Projectile. |
|---|---|---|---|---|---|
| Rifled ................................ | 9 | ... | 12 | ... | 250lb. |
| Rifled ................................ | 10 | ... | 18 | ... | 400lb. |
| Rodman smooth bore ........... | 15 | ... | 19 | ... | 450lb. |

They were placed in battery at a distance of 70 yards from the shield. The projectiles were all sharp-pointed hard cast-iron. The first four rounds were 9in. shot with 37lb. charge, representing a distance of 400 yards. The first struck the 9in. plate, penetrating 10in.; the second the 6in. plate, penetrating 14¼in.; the third the 6in. plate where it was faced with three 1in. plates, penetrating 12¾in. and cracking the thin plates; and the fourth, the 9in. plate again, penetrating 10in. None of these did any damage at the rear beyond driving back a large bolt where one of them struck, and knocking off a few rivets from the plates behind.

The fifth round was a shot from the Rodman, with 50lb. charge; it struck the 9in. plate on the right hand, making an indent of three or four inches, slightly buckling the plate, and driving back that side of the shield bodily two or three inches, and disturbing attachments to the ground.

The sixth and seventh rounds were shell from the 9in. gun, with the full battering charge of 43lb. The former struck the 9in. plate near its top edge, penetrating 12in. the latter the six-inch plate, penetrating 10½in.; both were well resisted, bursting in front, and doing no damage behind, except driving back another bolt. The eighth round, a 9in. shell, charge 37lb., was a failure, as the shell broke up in the gun. On repeating it, it struck the 9in. plate on its top edge, penetrating 12in. and causing it to laminate for some distance around into two plates of 4½in. thick each. The ninth was a 9in. solid shot, charge 43lb., which struck on the same place as round number three—namely, on the 9in. compound thickness near the top of the left-hand edge: it entered the compound backing, breaking one of the stringers in two, and driving a piece about a foot long sideways some distance from the shield and knocking out a bolt behind. The tenth round was a 10in. shell with 54lb. charge; it struck the bottom of the 9in. plate, knocking out a piece, and passed completely under the shield without doing any other damage.

These ten rounds completed the repetition of the programme applied in testing the Gibraltar shield, but the contrast was extraordinary. The Gibraltar shield after this firing had been penetrated twice, and was really knocked to pieces; the present shield appeared to have received but little damage, except the actual shotholes, and the rear side was so little disturbed that, except for a few displaced bolts and broken rivets, it hardly exhibited any signs of having been fired at at all.

The committee then determined to give it a few additional rounds of stronger force.

Rounds 11 and 12 were 10in. shells, fired with the full battering charge of 60lb. of powder; the former struck on the joint between the 9in. solid, and the 9in. compound plates, penetrating 19in. and knocking back another bolt; the latter struck the 9in. plate near the bottom, near two other shots, knocking a piece out in front and further extending the lamination of the plate. Finally a shot was fired from the Rodman with its full charge of 83½lb. (equal to 100lb. of American powder). It struck just over the porthole, breaking in the covering plate and driving fragments inwards, which did some little damage to the iron on the lower side.

After all this the shield was not much damaged, beyond some cracks, bulges, and distortions in the plates; and on the inside no important further harm was done. The shot had not only failed to penetrate, but there not even any signs of damage or loosening of any of the important parts at the rear of the structure.

This will show that the Millwall shield exhibited great resisting power, perhaps more than any iron structure yet tried. But in comparing it with the Gibraltar shield, it must be borne in mind, that as at present constructed, it is nearly 50 per cent. heavier. The weight of the Gibraltar shield was 26½ tons, or 608lb. per superficial foot; the Millwall is 38 tons, or 871lb. per foot.

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A PROSPECTUS has been issued of the Jamaica Dock Company, with a capital of £130,000 in shares of £10. At present the nearest dock accommodation is stated to be a floating dock at Havannah, about 900 miles distant, which, although far out of the general route of the West India trade, is so eagerly sought as to be commonly engaged for eight or ten ships in advance, and the proposal at Jamaica is to construct a dock upon Edwin Clarke's hydraulic lift system.

## ROYAL AGRICULTURAL SOCIETY'S SHOW AT LEICESTER.

A very fine lot of agricultural implements was exhibited at the yearly meeting of this society, the standard of excellence appearing each year to advance. Nothing perhaps has tended more towards raising agricultural machinery to its present pitch of excellence than the competition excited by these meetings, where the various implements, steam-engines, &c., are tested and rewarded according to their several merits. The first trials of importance were commenced on the 9th ult., when the steam ploughs were pitted against each other for the society's first prize of £100 and second prize of £50 offered for "the best application of steam power for the cultivation of the soil." There were five competitors—namely, John Fowler and Co., of Leeds. J. and F. Howard, of Bedford, Aveling and Porter, of Rochester, Tasker and Sons, of Andover, and Hayes, of Stony Stratford—the four latter firms employing the system of a stationary engine and separate windlass, with ropes laid round the field. The peculiarity in Hayes' machinery was the self-acting windlass, by which the labour of one man is dispensed with, the motion of the ropes is reversed without stopping the engine, and practically without any stoppage of the implement, which turns at the end in four or five seconds, and by means of cords laid across the field the anchor-men can instantaneously stop the implement-man and the engine-driver, this apparatus can be employed with safety and despatch in foggy weather or almost in the dark. The cultivator used did some good work, but was not able to contend successfully against more powerful implements in depth of tillage.

Tasker and Sons' windlass is also constructed so that the reversal of the motion is accomplished without stopping the engine, though a windlass-man is required to work it. The Woolston cultivator used by this firm smashed up the soil very effectively; and they also exhibited a clever arrangement of corn-drill and harrows, all working in combination, also a separate steam roller.

Aveling and Porter's traction-engine has a separate windlass with two winding-drums, hauling a Fowler digger or cultivator, the ropes being carried upon travelling two-wheeled porters. The apparatus met with difficulty in some portions of its work from having used cast-iron instead of steel-pointed shares.

Howards' machinery consists of a 10-horse portable engine, with single cylinder and a treadle-brake for quickly stopping the fly-wheel, a separate two-drum windlass, ropes laid round the field upon the Bedford patent porters, and the compensating patent snatch-blocks or pulleys for holding the outgoing rope taut without loss of motive power. The implements used comprised to-and-fro cultivators of different widths and with shares for a variety of purposes, the nine tines of the broadest implement being arranged in wedge form like a flock of wild fowl, so that only one share encounters unmoved ground on both its sides; also, a four-furrow plough, a four-furrow digger (having ploughshares and prong mouldboards), a two-furrow plough for very deep work, a two-bodied ridging plough, and sets of drag-harrows of different weights and breadths. And on different days these implements executed enough work to show that in ordinary circumstances the Bedford tackle can perform with great expedition and efficiency all the heavier and some of the lighter processes of preparatory tillage requisite on tenacious or on friable soils. The difficulties of the ground was too much however for any set of stationary engine machinery, broken anchors and other mechanical debris lying about the different fields testifying that there, at least, nothing could compete with Fowler's powerful set of apparatus, which went through the entire series of severe experiments without snapping even a bolt.

Fowler and Co. brought four separate sets of movable engine tackle—namely, an ordinary eight-horse engine, with clip drum and travelling anchor; another eight-horse engine with two winding drums and a travelling anchor; a two-engine set, with single winding drums, working one implement to and fro; and another two-engine set, with double winding drums, working two implements at once. The implements included balance ploughs with three, four, five, up to eight furrows each, trench ploughs, subsoiling ploughs, diggers, cultivators (some working to and fro, others turning at the ends) up to 15ft. in breadth, drag harrows of different dimensions, and a steam clod crusher. These large two engine sets were, however, excluded from the competition, as the prizes were for "the best application of steam power adapted for occupations of a moderate size. First of all there was a comparison as to facility of removal and setting down to work. Hayes, with portable engine apparatus, drawn by horses, occupied one hour and 18 minutes. Howard, with portable engine apparatus, also drawn by horses, occupied one hour and five minutes; Aveling and Porter, with traction engine, took 18 minutes; Tasker and Sons, with traction engine took 41 minutes; Fowler, with clip drum traction engine, occupied 33 minutes; and Fowler's traction engine, with double drums, travelled with all its apparatus for a distance of 500 yards, and began work only 25 minutes after quitting its first position. The trial field was a piece of rough grassy seeds dried and scorched up, and the soil extremely hard, but with few pebbles or stones. Aveling and Porter met with so many stoppages with the cultivator employed that, for two and three-quarter hours, they got over less than half an acre per hour. Tasker and sons, with a Woolston grubber, made some good and deep work, breaking the soil into particularly small portions, leaving a good deal of it flat on the top; they accomplished about three-fifths of an acre per hour, Hayes did not finish his plot. Howards' 10-horse engine tackle with cultivator, worked by five men and two boys, broke up 4,458 square yards per hour. The work was splendidly done, and with a cleanly cut bottom. To test the depth, and, in fact, to measure and weigh the work done, the judges not only dug trenches, laying bare the solid bottom for inspection, but also sunk into the broken ground a square plank frame, enclosing exactly one square yard, and then scraped out and weighed the contents. Howards' tillage weighed 411lb. per square yard, so that 1,832,040lb. of soil were moved per hour. or 183,204lb. for each nominal horse power per hour. Fowlers' 10-horse engine, with double winding drums and travelling anchorage, worked by three men and two boys, cultivated 4,566 square yards per hour. The tool used was a balance cultivator, the work magnificently done, by far the deepest work in the field, clean cut at bottom, and so tossed about on the top that the superiority of this work to that of any other plot in the field could be seen from half a mile off; and the testing-box showed the weight of soil moved to be no less than 502lb. per square yard, so that 2,229,133lb. were moved per hour, or 229,213lb. per nominal horse power per hour.

Fowlers' eight-horse engine, with clip drum and travelling anchorage, worked by three men and two boys, achieved the maximum performance of 4,866 square yards per hour. The implement used was a level beam cultivator with prong breasts on; the work very deep, thoroughly cut at bottom, and exceedingly well tumbled about and shattered in every part; the weight of soil moved being 420lb. per square yard, so that 2,043,720lb. were moved per hour, or the maximum performance of 255,455lb. per nominal horse power per hour.

After these trials, the judges were engaged for several days testing the implements with the dynamometer. In this, however, they signally failed, after working hard for several days, a circumstance scarcely to be regretted, as such tests could be of but little value.

The following is the official list of awards in this department:—

Steam Cultivation.—The best application of steam power for the cultivation of the soil, first prize, £100, to Fowler and Son, Leeds, for their £482 pair of single winding drum and traction engine, and can be used as a double drum traction engine. This comprises two 10-horse power winding steam ploughing engines, with tank, steerage, reversing gear, and all necessary parts. May be used for traction purposes as well as steam ploughing; also 800 yards best steel rope and three porters. The second prize of £50 was divided between two of Messrs. Fowler and Sons' (Leeds) implements—£25—for their 2484 10-horse power single set of hauling apparatus, which comprises, with the above, a 10-horse power double drum steam ploughing engine. The tackle is arranged so as to work directly opposite the implement, or stationary in the corner of the field. Also 8,200 yards of rope and 20 rope porters, and one six-disc patent anchor; also £25 to their 2485 8-horse power steam ploughing engine, with windlass attached and all necessary appendages for steam cultivation, with 800 yards of rope, 20 rope porters, and patent five disc anchor.

The best application of steam power adapted for occupations of a moderate size, first prize of £50 to Messrs. J. and F. Howard, Bedford, for their 4194 set of patent steam cultivating apparatus. This has a separate windlass, rope, &c. This engine and windlass are stationed at one corner or outside of the field.

Second prize is withheld.

Implements.—The sum of £100 for the class of implements for steam cultivation, including ploughs for steam power, cultivators, harrows, windlass, anchors, ropes, porters, &c., was divided as follows: £12 to Messrs. Fowler and Co., Leeds, for their 2491 four-furrow balance plough, fitted with steel knives, and which can be used for three distinct operations, viz., ploughing, digging, and cultivating. £12 to Messrs. Fowler and Co., Leeds, for their 2498 seven-tine balance cultivator, which is intended for general purposes, is constructed very strong. £12 to Messrs. J. & F. Howard, Bedford, for their 1194 five-tine cultivator, consisting of ordinary portable engine of 10-horse power, with separate windlass, ropes, &c. The engine and windlass are stationed at one corner of or outside the field. Every variety of soil and fields of any shape can be worked with this apparatus. £15 to Messrs. Fowler and Co., Leeds, for their 2496 land cultivator. This is constructed in three pieces, and can be used from 12ft. in width to 5ft. The middle partition is strong for heavy work, and the other portions are entirely removed when doing such work. £8 to Messrs. Fowler and Co., Leeds, for their 2500 set of harrows, suitable for very heavy work, and which will do the work of cultivators where the land has been steam cultivated the autumn before. Under the steerage frame may be placed rollers and a varnisher. £7 to Messrs. J. and F. Howard, Bedford, for their 1203 set of patent steam harrows, on the zigzag principle, but fitted with steerage. £10 to Messrs. Fowler and Sons, Leeds, for part of their 2485, *i.e.*, disc-travelling anchor. £8 to Messrs. Fowler and Sons, Leeds, for part of the 2484 double-drum windlass engine. £8 to Messrs. Fowler and Sons, Leeds, for part of their 2485 clip-drum windlass on engine. £8 to J. and F. Howard, for part of their 1194 double-drum windlass on frame.

Highly Commended.—Messrs. Fowler and Co., Leeds, 2405, three furrow, balance trench plough for deep work. J. and F. Howard, Bedford, 1199, two-furrow plough for deep work.

Silver Medal.—Ransomes and Sims, Ipswich, 4361, turn-wrest or one way plough, with skim coulter, steel breasts, on two wheels. This is workable on half sides suitable for working on level land without leaving any open furrows. The judges also awarded the following prizes:—Messrs. J. and F. Howard, Bedford, £9, for a general purpose wheel plough. This plough, which is calculated for deep work, gained the first prize at the Warwick and Newcastle meeting of the R.A.S.E. Messrs. Ransomes and Sims, Ipswich, £5, also for the general purpose plough. Messrs. J. and F. Howard, £6, for a light land wheel plough, which combines the advantages of "high-cutting" ploughs with those of the rectangular "low cutting" ones. Messrs. Ransomes and Sims, £4, a light land wheel plough, to which was awarded the first and only prize at the last trials at Newcastle in 1864. Messrs. Ransomes and Sims, £6, for a deep-land wheel plough. This implement is for ploughing from 9in. to 12in. deep, and was successfully exhibited at Newcastle. Messrs. J. and F. Howard, £8, a general purpose swing plough. Messrs. Ransomes and Sims, £4, a general purpose swing plough. Messrs. J. and F. Howard, £5, light land swing plough. Messrs. Ransomes and Sims, £5 ditto. Messrs. J. and F. Howard, £6, a subsoil plough, a strong and effective implement for breaking up the hard close earth below the furrow. Messrs. Ransomes and Sims, £4, an iron ridging or subsoil plough, which can be used for subsoiling, or as a horse-hoe, for cleaning between rows of plants sown on the ridge or flat. Messrs. Ransomes and Sims, £6, a pairing plough, constructed to pare any thickness from 1in. to 3in., and 16in. to 18in. wide, leaving the soil in a condition favourable for the action of the sun and air. Messrs. J. and F. Howard, £4, pairing plough, intended for general purposes and deep work, to which was awarded the first prize at the Warwick and Newcastle meetings. The following exhibitors were highly commended:—Messrs. Hornsby and Sons, Grantham, a general purpose wheel plough, a light land wheel plough, and a digging plough. Messrs. J. Cooke and Co., Lincoln, a deep land wheel plough. Messrs. Ball and Son, Rothwell, Kettering, a paring plough. Messrs. J. and F. Howard, a digging plough. Messrs. Ransomes and Sims, ditto. The judges commended the following:—Messrs. Cooke and Co., Lincoln, a general purpose swing plough. Messrs, Hornsby and Co., a general purpose swing or light land swing plough, and a deep wheel plough. The prizes in the cultivating, clod-crushing, and harrowing classes were awarded as follows:—Mr. E. H. Bentall, Maldon, £13, a cultivator. Mr. C. Clay, Wakefield, £7, cultivator. The Beverley IronworksCompany, £11, for a clod crusher and £4 for roller. Messrs. Amies, Barford, and Co., Peterborough, £9 for ditto, and £6 for roller. Messrs. J. and F. Howard, £13, for harrows. Messrs. Ransomes and Sims, £7, ditto. The exhibitors who were highly commended were:—Messrs. Hunt and Pickering, a cultivator. Messrs. W. Crosskill and Son, Beverley, a clod crusher. Messrs. Amies, Barford, and Co., a roller. Messrs. Ashby and Jeffrey, Stamford, rotary harrows. Mr. W. F. Johnson, Leicester, drag harrows. Mr. Denton, Wolverhampton, chain ditto, with carriage. Messrs. Holmes and Son, Norwich, rotary harrow. The firms commended were:—Messrs. E. Cambridge and Co., Bristol, a clod crusher, and chain harrow. Mr. W. Lewis, Shrewsbury, a roller. Messrs. Holmes and Son, Norwich, ditto.

The trials of horse ploughs and other farm implements, which was carried on simultaneously with the steam ploughing, is scarcely so important a subject, but the following extract from the *Leicester Journal*, may be of interest.

Horse Ploughs.—The trial of the horse ploughs begun in a twelve-acre field, which had been stirred early in the spring, and harrowed and rolled down occasionally afterwards, to produce a fair consistency, that a shining surface and the angle which each plough would turn the furrows might be distinctly shown. As far as these points go, however, preliminary preparations were as good as thrown away, for the small quantity of rain and extraordinary power of the sun since the end of May had so baked the soil that it broke up in lumps and powder; consequently, there was nothing to judge from excepting the soundness of the cut and the evenness and uniformity, not the furrow slice, for there was no slice, but of the grooved mixture of clods and moulds. The first class was for general purpose ploughs, in which there was the following dozen competitors:—Mr. W. Lewis, Messrs. Page and Co., Mr. T. Hitherley, Messrs. Vickers, Snowden, and Morris, Mr. Robert Boby, Messrs. Howard, Messrs. Poole and Son, Messrs. Cooke and Co., Messrs. Ransomes and Sims, Mr. Beadesmore, Messrs. Hunt and Pickering, and Messrs. Hornsby. Among these Messrs. Howard (of Bedford), Messrs. Ransomes and Sims (Ipswich), and Messrs. Hornsby (Grantham), did some excellent work. Mr. Cooke, of

Lincoln, and Messrs. Ball and Son, of Rothwell, did some sound and good ploughing. Mr. Lewis, also, was so far successful to earn a place among the chosen six selected for a second trial. The conditions under which the first trials were made, too, were simple enough to give, but difficult to carry out. The depth of 6in. had be acquired by the end of the third furrow or 'hout, when 7½in. had to be reached by the end of three more 'houts, 9in. being the depth at which the finishing furrow was to be turned. 21ft. was the width of the space given to each plough. What part of practical farming this variation of depth would suit we are at a loss to know; for if there be anything which it is more desirable to avoid, whether for a crop or in fallowing land, it is that of beginning to plough at one depth and leaving off with a furrow some inches deeper, or as deep again. But we must pass on. The final trial of these general purpose ploughs took place at ten o'clock on Monday morning, in an adjoining field of similarly prepared land, the previous crop having been beans. The work was done in one of the upper corners, and the soil was so baked that large cracks, into which one's hand could easily be placed, were running in all directions. To say that this was a trial of ploughs would be absurd. It, however, certainly was a test to show how any instrument with a coulter and a share to cut the soil would stick to its work. For this and the surface removed was some indication, and the level and straight work of all the ploughs, and particularly the evenness of the work done by the implements of the three leading firms from Bedford, Ipswich, and Grantham, left in this respect nothing to be desired. And as the work these ploughs will do is well known, it is neither a simple nor a pleasant duty to have to put the stamp of the Royal Agricultural Society on this or that plough, that this royal approval may have its due influence till the turn for ploughs to appear before the Society again comes, at the end of four or five or six years. For our part we would not venture to pronounce any opinion on the comparative merits of the work done, and it would invidious for us to declare in favour of any particular plough; therefore we simply refer the reader to the names of the makers who may be fortunate enough to appear in the prize list. On Friday the trial of swing general purpose ploughs commenced at nine o'clock, and the following were the competitors:—Messrs. J. Cooke and Co., Lincoln; Vickers, Snowden, and Co., Doncaster; R. Boby, Bury St. Edmunds; R. Hornsby and Son, Grantham; J. and F. Howard, Bedford; W. Ball and Son, Rothwell; and Ransomes and Sims, Ipswich. The Messrs. Howard did some level and sound work. Mr. Cooke's was level and good; indeed, the whole, with one exception, in this class, was so well done that it is scarcely fair to mention other names, unless we give the whole their due praise.

The deep land wheel ploughs did some extraordinary work, and if the performance be looked at from a general agricultural point of view, this is all we can say of it. On peaty soil, with a bit of clay or marl at the bottom, this style of cultivation may be serviceable, and when planting trees or shrubs is to be done it may be good; but for growing corn or roots on heavy lands, this turning up the dead soil to the depth of a foot, and burying the surface, in which is a collection of inexhaustible manure and decaying roots, is to fly in the face of all practical experience. The probability is, the spot of the field in which this took place will be injured for many years to come, unless great care be taken in turning the "dead" soil back to its original position before much wet falls. The manufacturers who competed were:—Messrs. J. Cooke and Co., Lincoln; E. Page and Co., Bedford; R. Hornsby and Son, Grantham; James and Frederick Howard, Bedford; W. Ball and Son, Rothwell; and Ransomes and Sims, Ipswich. The work done by Messrs. Ransomes and Sims' plough was straight and clearly cut; that by Messrs. Howard's plough was extraordinary for soundness and accuracy to the eye; while that done by Messrs. Cooke's plough was well-turned and good. These ploughs, however, are only for exceptional work, and the expenditure of horse-power required must either resolve itself into a fancy outlay, or if any profit on their use be required, they must be used for market-gardening purposes, when the surface is so full of town manure that fresh soil uppermost will be beneficial.

There were some other classes in which ploughs were tried, but as the whole work was done under the conditions described, and the implements were made by the well-known makers we have mentioned, we leave any further expression of opinion in this place to the judges, as they may record them in the prize list, or at some future and uncertain period in the pages of the *Society's Journal.*

CULTIVATORS AND BROADSHARES.—Next in order of importance to ploughs follows this class of implements. The trial of these took place in a field hanging from the Knighton-road towards the railway arches. The baked state of the field made the test a severe one. The competitors were Messrs. Coleman, Clay, Hunt and Pickering, Bentall, Underhill, and Millard. After the first round four articles had come to grief; or, in the language of the Stock Exchange, they were so crippled as to be lame ducks. The race then lay between Mr. Bentall's broadshare and Mr. Clay's lever cultivator. Under the conditions as regards stubbornness of the soil, nothing could touch Bentall's broadshare. The power of this implement is intelligible enough, for it is fitted, in a case of this kind, with a narrow sharp point, while nearly the whole of the cutting is done at the hind parts of the arms and shoes (so to term them), of the implement. If the principle of this machine were applied to such implements as Mr. Smith's Woolston cultivators, the tossing of the steersman would not be so violent, and the work would therefore, it is clear, be more regularly and evenly done. In this field Comstock's rotary spade was started on a trial, and as its principle of action is the same as a wood-planing machine if it would go, its disintegration of the soil would be more perfect than any other method, for the soil behind would be left in a finer state than the dust from a planing and rabbiting machine. But as it will not go through soil unless it is first broken up and sifted to take out the stones, why there is an end of the article. The only wonder is that anyone can be found who could possibly become so infatuated as to spend time and money in producing such an instrument.

CLODCRUSHERS AND ROLLERS.—On Friday the trial of the first class of these machines came off in the field adjoining the Knighton-road, on that part of the land which had been previously heaved out and washed up into a layer of clods, of the size of Dutch, Wilts, and double Gloucester. A finer opportunity could not have been offered for testing the merits and demerits of these implements. The lower corner of the field had been under water some time during the spring, and it was consequently very bad; further on the soil was more friable, and there was a mixture of finer moulds and more tender clods. It was here that the real test was executed, for here the judges very properly had their stakes and numbers placed against each piece of work. The competitors were Cambridge, of Bristol; Woods and Cocksedge, of Stowmarket; Amies and Barford, of Peterbrough; Hunt and Pickering, of Leicester; the Reading Ironworks Company, the BeverleyIron and Waggon Company, Croskill and Son, Ashby and Jeffery, of Stamford; Lewis of Shrewsbury; Coleman and Morton, of Chelmsford; Boby, of Bury St. Edmunds; J. Coultas, of Grantham; J. James, of Cheltenham, and other makers, were in competition. On such a surface as this the lighter and smoother faced implements rode over the clods, and made about as much impression as they would have done had the irregular obstructions been bricks and mortar instead of baked arable soil. On Monday there was a selection of four implements for the final trial, and distribution of prizes. These were the serrated self-cleaning clodcrushers of the Beverley Company, the clodcrusher of Croskill and Sons, Cambridge's notched wheel and press wheel roller, and Amies' and Barford's Cambridge roller, with scrapers and solid wrought iron steerage frame, instead of shafts. It is, of course, a foregone conclusion that the former article of the Beverley Company would hold its own against all comers, and this opinion was affirmed by the judges, for they awarded it the first honour. The next was an extraordinary roller, made by Messrs. Amies and Barford, of Peterborough. The work done by this implement was certainly greatly effective, and nothing but the regular serrations in the Beverley Company's implements could have made sufficient difference for the judges to have put the Peterborough roller in the second place. Messrs Crossfield and Sons were awarded the third prize. In this class there was an implement which may be termed a cross or hybrid, as its crossing parts are composed of alternate rings of Cambridge's serrated crusher, and the thin edge cutting rings of his combined clod crusher and press wheel roller. This implement pleased many spectators, but in such work it is a bit of a flat catcher, for while it breaks some of the clods with its notched rings it smooths more down to a level surface with its more regular rings.

A trial of rollers is, of course, a very simple affair. The points are simply weight, circumference, and facilities for turning without driving up the sod, and price according to size, weight, and durability. Both the heavy and light rollers were tried on Saturday, when the competitors were the following manufacturers:—The Beverley Company, Hunt and Pickering, Croskill and Sons, Lewis, Boby, Page, Holmes, Amies and Barford, and Woods and Cocksedge. The first prize has been awarded to Amies and Barford, the second prize to the Beverley Company, and a high commendation also was given to Amies and Barford.

A small travelling crane by Messrs. Aveling and Porter, exhibited in action, appeared to be an exceedingly handy little thing, being managed easily by a boy. The traction engines of the above firm are now too well-known to require comment. The principal novelty in the show was Mr. Norton's tube well, which obtained a silver medal. The different sizes of apparatus for sinking it were shown, including the largest of all, in which an arrangement is made for counteracting the rebound of the pipe after the blow of the monkey by means of a cross-bar over the head of the triangle, held down at each side by a series of continually extended india-rubber tubes, which maintain a powerful and constant downward thrust on the tube. On one side of the tube well Mr. Norton's screw ventilator, which also obtained one of the silver medals, and consists in the employment of a well-balanced cowl with radiating veins, below which, in what we may call the up-cast, and on the same spindle as the cowl, are two turn of an archimedean screw in light ironwork completely filling up the aperture. The use of the screw lies in its playing the part of a stop valve against downward currents; the heated air ascending keeps the cowl in revolution, and though it does not thereby actually facilitate its own exit, or make power, it effectually prevents downward draft. On one side of Messrs. Norton's stand was Bailey's well-known oil tester, with which many interesting experiments were made; and near at hand was a very neat modification of the differential policy block of Jonathan Pickering, of Stockton-on-Tees.

Messrs. Amies and Barford received two silver medals—one for a very simple arrangement of a straw elevator, by which, when the thrashing engine is working, it can be driven in the ordinary manner, or by lifting the lower end of the elevator it becomes supported on a post, which forms the upright for a one-horse pole, the horse moving under the elevator to drive it for stacking purposes. The receiving end is then at such a level as is convenient for pitching hay or straw from a waggon, and the delivering end high enough for any ordinary stack. Their other medal is for a clod-crusher, with revolving shafts to allow the horses to turn without turning the implement. For their water land roller they also obtained a prize, water ballast being placed inside a wrought iron roller.

The Reading Ironworks Company had an excellent stand, and amongst the machinery thus exhibited was a beautifully finished condensing engine, with Cornish boiler. Messrs. Clayton and Shuttleworth obtained one of the silver medals for Mr. Gillyatt's revolving liquid manure and seed-drill, which consists of a barrel supported on wheels, behind which is the ordinary feed motion for the seed delivering through two drops. The barrel is divided into two compartments by a perforated diaphragm. Into one of these compartments the manure is pumped. In the other is an endless chain of buckets, which keeps the liquid in continual agitation, as it percolates through the holes in the partition, and at the same time lifts it to a trough, from which it flows down by pipes at each side to the two drops, where it enters the drill simultaneously with the seed. Messrs. Williamson Brothers, of Kendal, exhibited their turbines, centrifugal pumps, and blowing fans at work. Near them were some of Bastier's pumps, exhibited by Warner and Sons, who had also a well constructed windmill with narrow vanes, the feather of which was regulated in a somewhat similar manner to the Belgian mill which appeared at the French Exhibition. Messrs. Hill and Smith, of Brierley Hill, had an immense collection of implements and wrought ironwork. Messrs. Owen and Co. had one of Bernay's pumps, in full operation, and they had also a nice-looking donkey engine. Messrs. Allchin and Son had a portable engine, with springs to the bind axle, a steel boiler, steel crank shaft, and a superheater in the smoke-box. The latter consisted of nine short lengths of 1½in. tubing, united by malleable iron bends.

Messrs. Powis, James, & Co., had a very large set of machinery in motion. Their spoke machine is a great improvement in detail on most of those already in use. The revolving cutters have two blades, so that at the same speed of the machine twice the number of cuts are taken, and the work is consequently much smoother. Their saw sharpener is also well arranged, and is completely self-contained. Of the three motions necessary for giving any desired form to the tooth one is obtained by angling the set in which the saw is fixed, and the other two by vertical and horizontal adjustment of the bearers of the sharpening blade. In addition to these tools—which have been but recently perfected—the firm had large planing and moulding, joinering, and other tools at work. Messrs. Charles Powis & Co., also exhibited some machinery of very good quality. Messrs. Turner, of Ipswich, had a horizontal engine, with expansion valve, regulated from the governor.

Messrs. Tangye, Brothers, and Holman exhibited a great variety of ingenious machinery, amongst which is their steam pump, which seemed to work very efficiently. Messrs. Appleby Brothers have a novelty in the shape of a diamond rock-boring machine. This machine consists of a tubular boring bar fitted at the end with eight semi opaque diamonds, which cuts an annular hole. Mr. R. H. Marsden, of Leeds, shows one of Blake's patent stone breakers, also a new form of machine for breaking coprolites and similar material.

A great quantity of miscellaneous machinery well worth noticing must be left for want of space to our next number.

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## ROYAL INSTITUTION OF GREAT BRITAIN.

### ON SOME EFFECTS OF THE HEAT OF THE OXY-HYDROGEN FLAME.

By William Odling, M.B., F.R.S.

Chemical changes, whether of combination or decomposition, result in the production of new bodies which, under the conditions of the change, have for the most part a greater stability than the original bodies.

One evidence of this greater stability is afforded by the development of a quantity of heat—the heat of chemical action—from the produced bodies having a smaller potential heat than the original ones.

It results, both from reason and experiment, that in order to undo or reverse any definite chemical action, just so much heat must be directly or indirectly expended as was evolved by the original action.

For the same quantity of heat evolved, the resulting temperature varies with the mass and kind of matter heated, and with the rapid or gradual evolution of the heat.

When the evolution of heat is instantaneous, the resulting temperature may be calculated from the quantity of heat evolved, and the mass and specific heat, &c., of the matter heated.

By a unit of heat is meant the quantity of heat necessary to raise the temperature of one kilogramme of water one degree centigrade, or more accurately from 0° to 1°.

Every 18 grammes of water is a combination of two 1-gramme proportions of hydrogen H, with one 16-gramme proportion of oxygen O; and by the combination of two grammes of hydrogen with sixteen grammes of oxygen, there are developed 68 units of heat.

Of these 68 units of heat, however, little more than 57 units are really due to the chemical action,—nearly 11 units of heat being evolved by the contraction of the original mixed gas into two thirds its volume of steam, and by the further condensation of the resulting steam into 18 cubic centimètres of water.

While the quantity of heat evolved by the combination of a given quantity of oxygen and hydrogen is invariable, the intensity of the heat may vary from a scarcely recognisable rise of temperature up to the highest temperature of the oxy- hydrogen blowpipe flame, capable of fusing platinum and silica.

A most remarkable effect of the intense temperature resulting from the combination of oxygen and hydrogen into water, is the partial decomposition of water into oxygen and hydrogen, discovered by Mr. Grove in 1846.

At this high temperature, hydrochloric acid and carbonic anhydride gases also undergo partial decomposition, into hydrogen and chlorine, and into carbonous oxide and oxygen respectively.

Upon what do these singular decompositions by heat, of bodies formed with great evolution of heat, depend; or with what class of chemical phenomena may they be associated?

Under certain familiar conditions, chemical action seemingly takes place to its utmost possible extent in a single direction only, with production of a maximum amount of the substance that is formed with maximum evolution of heat.

For example, taking atomic proportions in grammes, the heat of formation of chloride of zinc, $ZnCl_2$, is 101 units, and the heat of formation of chloride of copper, $CuCl_2$, is 60·5 units. Hence, with chlorine in solution and excess of both copper and zinc, there is finally produced the maximum possible amount of chloride of zinc and no chloride of copper.

Again, by an addition of sufficient zinc to solution of chloride of copper, there is complete combination of chlorine with zinc and complete separation of chlorine from copper, *i.e.* complete burning of the one metal and complete unburning of the other.

But under simpler though less familar conditions, chemical action habitually takes place in more than one direction simultaneously, with production of correlative products in varying proportions.

Thus, with hydrogen and excess of both chlorine and oxygen, although the heat of formation of oxide of hydrogen $H_2O$ is 57 units, and the heat of formation of chloride of hydrogen $H_2Cl$, is only 47·5 units, yet, in this case, the hydrogen does not combine with the oxygen to the exclusion of the chlorine but divides itself between the oxygen and the chlorine in proportions which vary with the conditions of the experiment.

In accordance with this result it is found that, at the same red heat, excess of chlorine will effect the partial decomposition of water with extrusion of oxygen; and conversely, that excess of oxygen will effect the partial decomposition of hydrochloric acid with extrusion of chlorine.

So that, beginning with two chemical substances, water and chlorine, or beginning with the two chemical substances, hydrochloric acid and oxygen, or beginning with the three chemical substances, hydrogen, chlorine, and oxygen, there exist, at a full red heat, the four chemical substances, water hydrochloric acid, chlorine, and oxygen; the proportions of the four substances depending certainly upon the relative quantities present of the elements concerned, and most probably also upon the temperature of the experiment.

Similarly, beginning with the one chemical substance, water (Grove), or beginning with the two chemical substances, oxygen and hydrogen (Bunsen), there always exist, at a sufficiently high temperature, the three chemical substances, water, oxygen, and hydrogen.

Although, by exposure to a red heat, the electrolytic mixture of oxygen and hydrogen gases becomes completely combined, or transformed into water, yet, as recently shown by Bunsen, at the high temperature of 2024 degrees, only one-half, and at the still higher temperature of 2844 degrees, only one-third of the mixture undergoes combination, the other one-half or two-thirds remaining in the state of mixed gas.

Chemists are acquainted with many reciprocal actions comparable with those of chlorine upon water, and of oxygen upon hydrochloric acid, the most familiar instance being probably the decomposition of ignited oxide of iron by hydrogen with extrusion of iron, and the converse decomposition of oxide of hydrogen by ignited iron with extrusion of hydrogen.

Similarly, sodium will decompose the oxides of carbon, while carbon will decompose oxide of sodium; and just as a sufficient excess of chlorine may be made to effect the almost complete decomposition of a given quantity of water, so may a sufficient excess of carbon (or carbonous oxide) be made to effect the almost complete decomposition of a given quantity of sodium oxide or zinc-oxide, as in the ordinary processes for obtaining the two metals; notwithstanding that, for an equal consumption of oxygen, the respective combination heats of sodium and zinc exceed by far the combination heat of carbon or carbonous oxide.

Again, although the combination heat of oxygen and carbonous oxide is 68 units, while that of oxygen and hydrogen is only 57 units, yet, as was shown by Bunsen many years ago, upon exploding a mixture of oxygen with a joint excess of carbonous oxide and hydrogen, the oxygen does not attach itself exclusively to the carbonous oxide, but divides itself between the carbonous oxide and hydrogen in a ratio determined by their relative proportions.

## INSTITUTION OF CIVIL ENGINEERS OF IRELAND.

### ABSTRACT OF ADDRESS

By W. Anderson, President.

An industry in which Ireland has very successfully engaged is paper-making. Within the last few years considerable progress has been made, not only in the treatment of well-known raw materials, but in the introduction of new ones. Paper may be regarded as a "felt" of pure woody fibre, obtainable from a great variety of plants, which may be classed as follows:—

1. Forest timber, from which the fibre is obtained by grinding.
2. Plants, such as cotton, in which the fibre is developed pure.
3. Plants, such as hemp, flax, palmite, &c., from which the fibre may be obtained by maceration.
4. Plants, such as the cereals, esparto, halfa, &c., from which the fibre is obtained by boiling in solutions of caustic soda.

I am not aware that the manufacture of wood-pulp has yet been introduced into Ireland; yet, I think, there are many situations where it could be applied with advantage. The process merely consists in pressing short blocks of wood against a rapidly revolving coarse grindstone, a stream of water, flowing over the stone, carries away the finer particles, while the chips and splinters are replaced upon the stone. The pulp is next strained through revolving cylindrical wire sieves, which separate the fibre ground sufficiently fine from the coarser stuff, which is re-ground between stones, arranged much as in flour mills. The resinous and other soluble impurities of the timber are washed away by the large quantity of water used, and pure fibre remains without the aid of any chemical treatment. The white woods, such as willow, aspen, poplar, lime, and deal, yield a pure white pulp that does not require bleaching to make white paper. Wood-pulp cannot be used by itself, but must be associated in the ratio of from 50 to 80 per cent. with stronger materials.

Mills for the production of wood-pulp have been established with great success in Sweden, Germany, and other parts of the Continent; and in many situations, by no means rare in Ireland, where water-power and timber are abundant, and labour cheap, but where cost of carriage makes coals and chemicals dear, wood-pulp will be found a profitable manufacture and find a ready market among our numerous rag paper mills.

Cotton, and the produce of the hemp and flax plants, present themselves to the paper-maker chiefly in the form of rags, sailcloth, cordage, tow, and waste. These materials are already partially prepared and require very slight boiling in alkali to get rid of grease and other impurities before they are fit for converting into pulp. Their manipulation is well understood. I would merely remark that in dealing with new plants it is well not to overlook the fact that simple retting or maceration, with subsequent scutching, will set free the fibre quite as well as the more costly process of boiling in caustic soda.

The straw of the cereals and esparto contains from 40 to 50 per cent. of available woody fibre, which can only be set free by boiling in a solution of caustic soda. This operation for all cereal straws is best performed under a pressure of about 80lb. per square inch, and in steam derived from the solution itself, so that during the 8 or 9 hours the boiling continues, the strength of the liquor should not vary. Paper made from straw so treated looses the harsh and glossy appearance that straw papers generally possess.

Esparto and the allied grasses are best, boiled for about four hours in open caldrons and by injected steam. With either material the proportion of soda ash used is very large, from 16 to 25 per cent. by weight, and there results a dense black liquor which requires to be carefully washed out; and which, if discharged into rivers, is apt to destroy animal life, and be lashed into thick foam by every weir or water-wheel, emitting in summer a very unpleasant smell. Within the last few years many attempts have been made to get rid of the "black liquor." Some by chemical re-agents have tried to destroy its colour and noxious properties, but without any success. Others have simply evaporated the greater part of the liquor, and by incinerating the dry residue have recovered a considerable proportion of the soda, in the form of impure carbonate, which, however, is again available for use after being rendered caustic by the addition of lime. This process, however, is very costly, as one ton of straw requires about 12,000 gallons of water to wash it thoroughly, and such a volume cannot be evaporated by less than 5 tons of coals, worth about £4; about 3cwt. of soda would be recovered, which would thus cost 27s. per cwt. for fuel alone, the price of fresh soda being 10s.

The importance of this subject was forcibly brought under my notice through the stoppage of the Stowmarket Paper-making Co.'s Mill, in Suffolk, by an injunction of the Court of Chancery, for pollution of the small stream on which it stands. It became indispensable to purify the refuse; the firm with which I am connected was intrusted with the task, and after visiting several mills, both in Great Britain and the Continent, where apparatus was in use for the evaporation of "black liquor," it occurred to us that while a great deal of ingenuity had been expended in reducing the cost of evaporation, no attempts had been made to diminish the quantity of liquor to be operated on. We therefore instituted some experiments on straw pulp, and abandoning in succession exhaustion, steam, and hydraulic pressure, at last perfected a machine in which the pulp was passed in a continuous sheet between 3 pairs of rollers, and succeeded in expressing all but about ½ per cent. of the soda-bearing liquor, and so far cleansing the pulp that further washing became unnecessary. By this means only 2,000 gallons of "black liquor" was produced to each ton of straw, and the cost of the recovered soda ash reduced to about £6 per ton, fully 80 per cent. of the soda used being recovered. It does not appear that the soda thus used over and over again deteriorates in quality, although patents have been taken out to remedy this theoretical evil, which, after considerable experience, I have not found to exist.

Esparto, and the allied grasses, are very much easier to treat, as the boiled grass simply pressed in mass yields up most of its black liquor, so much so that it may be bleached without previous washing; but still, I think, a more regular and satisfactory result will be obtained by breaking the grass in an ordinary washing machine, and then passing it through the roller machine.

By adopting the process above described, and by constructing settling ponds to catch the solid refuse of the machine, the Stowmarket Mill was enabled to resume work, with the agreeable result that the injunction which had appeared certain ruin was the cause of enhanced profits. At the present moment there are paper-makers in Ireland who cannot use straw on account of polluting the rivers on which their mills stand. I trust that it may be useful to them to know that a moderate outlay will not only enable them to use a cheap and excellent material of native growth, but will add considerably to the economy of the process,

There is one other substance from which paper, or rather parchment, can be made, and that is the fibrous portions of the hides of animals, under the patent process of Captain Brown, R.N. This gentleman, possessed of rare inventive faculties, first came into public notice many years ago, as the inventor of the beautiful process of manufacturing seamless cartridge papers now in operation at the Royal Arsenal, Woolwich. That process consists in sucking a layer of paper pulp on to flannel moulds, drawn over perforated pipes in which a partial vacuum is created. By means of the same system, but with animal pulp, Captain Brown has succeeded in making jointless cartridge-boxes, bayonet and sword sheaths, and many other similar articles. The method of preparing animal pulp is briefly thus: Clippings of hides and skins from the tan-yards—the raw materials of the process—after soaking in water and preliminary cleansing, are steeped in a warm solution of alkali, then cleansed mechanically, after which the alkali is neutralized by acid, the substance crushed between fluted rollers, and finally placed in an ordinary beating engine, where it rapidly assumes the form of common vegetable pulp, and may be made into sheets of paper either by hand or on a machine. Of course each step of the manufacture requires its special apparatus and dexterity of management, even the arrangements of the paper machine are peculiar for pulp so much more dense than ordinary vegetable fibre, and incapable of enduring the heat of steam-drying cylinders, as it is ordinarily applied. Captain Brown's process has for several years been in abeyance on account of a ruling of the courts of law, which defined it to be paper, subject to duty, and not parchment, hence it could not be used for legal documents, or sold as anything but paper. The duty, however, on the latter article has been taken off, and the manufacture is now being re-established on a large scale at Romsey, in Hampshire, the artificial parchment commanding a high price, compared with its cost, for book-binding, and many other purposes for which skins have been used. I believe that this is the first time in which this elegant process has been publicly explained, and I have mentioned it because from my intimate knowledge of the process I have reason for considering it a manufacture well adapted to the resources of this country.

Closely allied to paper-making is a manufacture, which within the last three or four years has assumed great commercial importance, and which possesses special interests to our profession—I allude to gun-cotton. From the time of its first discovery till a year or two ago this substance was little better than a scientific toy; but the researches of Mr. Abel of the Royal Laboratory, Woolwich, and, above all, the persevering skill of Messrs. Thomas Prentice and Co., of Stowmarket, have given to gun-cotton an importance, the ultimate magnitude of which it would be rash to predict. The preparation of pure gun-cotton is very simple. Raw Cotton-wool is steeped in a mixture of sulphuric and nitric acid and thoroughly washed and dried. In this state it is so violently explosive as to be practically valueless. The problem has been how to mitigate with certainty and precision the rate of combustion. It has been found impracticable to prepare the gun-cotton of varying strength, so that the only remaining means is to dilute to various degrees the one strong quality that can be obtained. At first it was sought to effect this by spinning the prepared cotton into yarn, and then twisting it into rope, or weaving into cloth, with similar unprepared material; but although this process yielded very excellent results, the requisite amount of uniformity in quality was not obtained. It was then suggested by Mr. Abel that the prepared cotton might be converted into pulp as for paper making, and in that state most intimately mixed with unprepared pulp in an ordinary beating engine, and then made into sheets of explosive paper for small arm cartridges, or into cakes of any form and weight for cannon and blasting charges. This system appears to have met with complete success, every shade of intensity can be obtained with certainty, and the Messrs. Prentice appear likely, in a rapidly increasing business, to reap the reward of years of persevering and most intelligent application to this important manufacture. The peculiar advantages of gun-cotton are mainly these:—The manufacture being carried on in the wet state up to the final drying is absolutely devoid of danger. Gun-cotton when loosely packed is not violently explosive; it rather burns fiercely. It makes no smoke, and consequently does not foul firearms, and is peculiarly valuable for blasting in mines. Its report when fired is not so sharp and piercing as that of gunpowder; and a charge of given intensity occupies only one-sixth its space, in consequence of which the blasting holes may be made much smaller and more economically.

An exceedingly convenient as well as novel arrangement of pumping machinery for the drainage of reclamations has been devised and brought into operation by Mr. A. Harmens, of Amsterdam. This gentleman has exhibited a great deal of skill and enterprise in reclaiming the "polders" or lakes in Holland, and having experienced the great cost of fixing powerful pumping engines on the marshy borders of the reclamations, it occurred to him to construct a pontoon into which the engines and pumps should be placed and floated into the lakes which would thus be pumped out in succession by the one set of machinery, with very slight expense in removal from one side to another. As the pontoon sinks the delivery pipe of the pump is lengthened, and finally when the water is all out, the machinery is either taken to pieces and the boat pulled out, or a dam is constructed round it, and the whole apparatus is floated out into the canal receiving the drainage. When large sums of money have been expended in forming embankments, it is, of course, of great commercial importance to get the water out as quickly as possible so that the land may be placed in the hands of the farmer. The permanent machinery necessary to keep the land drained where once it has been reclaimed is comparatively small and easily fixed, whereas the pumps necessary to clear out the water that has for ages formed a sea over the land must be very large. Hence Mr. Harmen's system, which completely dispenses with the cost of transport and fixing, is likely to prove very valuable, and induce the reclamation of lands which would not repay the heavy outlay upon the old method. The first of these pumps, constructed by the firm with which I am connected, consists of an Appold centrifugal pump capable of raising 50 tons of water per minute, driven by a pair of horizontal engines fixed on the top of a Cornish multitubular boiler. The engines work at 120lb. pressure cutting off by means of double-slide valves at one-fourth the stroke, the whole of the machinery fitting into a pontoon 22feet long, 10feet broad, and 4feet deep, drawing 3feet 3inches of water. The floating pump was towed over to Rotterdam without difficulty, and by means of rivers and canals brought close to a lake near Amsterdam, which was being drained. It was hauled over the bank, launched, and set to work in a very short time, and at small cost, its performance comparing very favourably with that of condensing engines, which were already at work on the shore. There are many places where floating pumps would prove very useful not only as temporary but as permanent machines, and save the large sums of money that must frequently be expended on foundations.

In the construction of steam engines little or no progress has recently been made, which is more remarkable when we consider the wide field which exists for improvement. It is popularly held that the steam engine is a model of perfection, the beau ideal of mechanical skill. In reality, however, it is still very far from utilizing even a fair proportion of the mechanical power known to be derivable from the combustion of fuel.

The terms "high" and "low" pressure engine now no longer convey the meaning they formerly did; indeed, in many cases, the terms might with correctness be reversed. They used to signify "non-condensing" and "condensing" engines; these now frequently work at the same boiler pressure, in which case the condensing engine is really under the higher pressure of the two. There is a growing tendency to reduce the size of engines and to increase their speed to obtain the requisite power. For permanent engines I think this tendency is mischievous, because high speeds mean frequent repairs. To obtain smooth running there must be a certain relation between the weight of the reciprocating parts—the pressure of steam—grade of expansion—and velocity. If you will refer to a most interesting paper by Mr. Strype in the seventh volume of our Transactions, you will see the influence of the inertia of the reciprocating parts of steam engines on their motions demonstrated mathematically as well as practically; and if engines were constructed with this consideration in view there is no reason why considerable speed should not be compatible with smoothness of motion. I fear, however, that few engineers trouble themselves about such niceties. The grade of expansion of engines is varied without regard to the proportions of the engine, the ready cure for rough running being a little more or less lead; a contrivance, in fact, to correct in a wasteful way the evil consequences Mr. Strype has shown must arise from improper relations between the mass of moving parts and the energy of steam. Wide differences of opinion exist as to the most advantageous pressure to use. I do not think there is much gained beyond 60lb. above the atmosphere, because the advantages of increased expansion are counteracted by the increased loss by radiation from the more highly heated parts, by the increased temperature of the smoke leaving the boiler, and by the practical difficulties of lubrication and the wear of parts. Much misconception exists about "superheated steam." There is no advantage in using really dry steam at a higher temperature than that due to its pressure. But steam never issues from a boiler dry; it carries up with it mechanically more or less water, and is itself partially condensed by radiation and conduction. Extra heat applied to vaporize this water is a direct gain, but any heat beyond that is much better applied to the water in the boiler.

I now approach a subject of peculiarly national importance, but which I fear will find little favour in your eyes. I mean, the artificial drying and consolidation of Peat. I dare say, many will exclaim that there have been quite failures enough of attempts to give our bogs a high commercial value to justify the conclusion that so desirable an end is beyond our reach, and that it is mere waste to devote time and money to it. To such objections I would reply that repeated failures by no means prove that an enterprise is impracticable, that on the contrary they should be made stepping-stones by which men of talent and perseverance can rise to the goal they have determined to attain; that in difficult undertakings the failures that have arisen are like buoys laid down by our predecessors to warn us of the rocks on which they have made shipwreck, and that consequently the course of each succeeding adventure is the more clear and secure. Those who care to take the trouble to study the history of peat-fuel manufacture, and who will patiently ascertain the cause of each failure, will, I think, agree with me that the following points have at least been determined:—

1. That the climate of Ireland is very ill adapted to natural drying; that the number of fine days does not, on an average, exceed 100 in the year, and that it is very rare to have many fine days in succession. It is therefore imperative in air drying to expose the greatest possible surface and to accomplish the process in the least possible time.

2. That every ton of peat in an average bog is associated with 9 tons of water; that this water can only partially be separated by mechanical means, and cannot be evaporated naturally when the peat is in the form of sods, in less time than an average fine summer; that not unfrequently the seasons are so wet that dry turf cannot be procured at all, and that consequently any manufacture depending on it could not be prosecuted.

3. That the cost of cutting and saving turf by the ordinary process increases rapidly with the yield required from a given area, because of the immense surface necessary for spreading out the sods to dry. To cut a moderate quantity of turf from a bank and throw it up to be spread by an assistant is, no doubt, a cheap process, but when a certain width is covered the assistant has to be supplemented by two others with barrows, who at once double the cost, which, after a time, must be increased in a still higher ratio if further width of spreading is required.

4. That peat cannot be compressed in the wet state and dried afterwards, and still form a compact and durable fuel, because a cake of wet peat is in the worst possible condition for drying, and when dry, it becomes porous and friable in proportion to the quantity of water removed.

What then is wanted to hold out a reasonable prospect of success is a process by which a crop of peat could be collected and partially dried in the course of a single fine day, or even a portion of one; an economical means of completing the drying, and a machine competent to compress the dried peat into a compact form.

If you will refer to Vol. VII. of our Transactions, and to the Record of the Proceedings of the Mechanical Engineers of Birmingham in August, 1865, at their meeting in Dublin, you will find a minute description of a process of manufacture which complies with the conditions I have just named, which has been in actual operation for some years, and by which over 7,000 tons of excellent fuel has been produced at a very moderate cost, but which, unfortunately, and for reasons which I will presently explain, is not at this moment in operation.

I will first, however, give the salient points of Mr. Charles Hodgson's beautiful and simple process, pausing for a moment to pay a tribute to the ingenuity and perseverance of our Associate, who for more than ten years devoted the best part of his time, his fortune, and his talents, to the question before us, and whose name will one day be recorded among the benefactors of his country.

The first dawn of success became apparent in the invention of the continuous tube-pressing machine. Mr. Hodgson found that to make a permanent cake of fuel out of dry peat required not only very heavy pressure, but that the pressure should be kept on not less than one minute. No sort of moulding machine could turn out any quantity under these conditions until the happy idea occurred to obtain the necessary resistance to pressure in the friction of a tube, and he embodied this principle in his Patent Pressing Machine, which consists of a tube 4inches in diam. and 5feet long, in one end of which a ram reciprocates, and at each stroke produces a cake about 1inch thick, pushing the full of the whole tube of pressed fuel forward to the same amount; and as each cake takes about one minute to traverse the length of the tube, it remains one minute under pressure, and yet the machine produces 60 cakes in that time. This press leaves nothing to be desired, is extremely simple and durable, and has proved itself capable of compressing regularly at the rate of 100 tons per week.

No sooner was the Pressing Machine perfected than it became apparent that no known process could supply dry turf enough to keep it in operation. The raw material was wanted in the state of powder; Mr. Hodgson set himself to ascertain if the bog could not be made to yield it in that state more abundantly than in any other. He soon noticed that in a well-drained piece of bog each ton of the upper surface for an inch or two deep was associated only with three tons of water, and if harrowed up and exposed for a few hours on a fine day this was reduced to 1½ tons, and the peat or "mull" so dried, if put into heaps, did not again absorb moisture, and if raked slowly over iron plates heated only by the waste steam of the compressing machine, most of the remaining water was drived off, and in fact that by the combustion of 25 tons of compressed fuel, power and heat enough could be obtained to dry and compress 75 tons for the market.

The question of supply thus resolved itself into area of bog brought under treatment, and it has been found from experience that eight Irish acres are sufficient to provide, during the fine weather of the summer months only, sufficient material for the production of 5,000 tons of compressed fuel per annum.

In the year 1865 Mr. Cotton and I were requested to examine and report as to the cost of manufacture upon the process I have just described, the experimental works were placed at our disposal for a month, and the conclusion we arrived at was, that the actual production, at the rate of 84 tons per week, cost 6s. 4d. per ton, and the probable cost, at the rate of 400 tons a week, would not exceed 3s. 11½d. per ton—cost of management in both cases excluded. I have taken considerable pains to ascertain from the actual experience of more extended manufacture how far these anticipations have been realized, and I find that the cost will probably be 4s. 2d. per ton on the large production, while the expenses of management and depreciation will amount to 1s. 8d.; or 5s. 10d. in all. And the price realized for the compressed peat has actually been 9s. per ton at the works, and 11s. 6d. on the canal side in Dublin, leaving in each case a profit of 3s. per ton, with apparently an unlimited demand.

It will naturally be asked why, if these statements are correct, did the undertaking collapse like so many of its predecessors? The causes are chiefly the following:—

1. The company started with insufficient capital.

2. The time necessary to prepare the bog for collecting the "mull" was not sufficiently considered.

3. Under mistaken ideas of economy the manufacture of the several portions of the plant was confided to various contractors, the company itself making a good deal of the coarser machinery; the consequence was want of undivided responsibility and a great deal of very bad workmanship.

In one great branch of our national industry—the cultivation and manufacture of flax—I cannot find that any very marked improvement has recently been introduced. There has been a steady advancement in perfecting details, and notably a great increase in the use of the power loom for linen fabrics. I cannot, however, resist alluding to the very honourable position Mr. James Comb, of the Falls Foundry, Belfast, has achieved as a maker of flax machinery; not only does he successfully compete in the Home Market, but is able to find work for his 1,200 men in England, Scotland, the Continent of Europe, and in fact wherever linen machinery is required.

Iron shipbuilding also appears to have taken firm root in Ireland; the yards of Belfast, Drogheda, Dublin, Waterford, and Cork, have shown themselves quite equal to the largest and best class of work, and Dublin has quite recently added the construction of marine engines to its industries. The honour of this introduction belongs to Mr. Bailey, one of our members, and my successor in the old house of Courtney, Stephens and Co., and I see no reason why, as the port accommodation of Dublin is improved, its ironworks should not assume a very prominent position in the kingdom.

The dredging of the port is being carried on with very great vigour, and I am informed that the introduction of hopper barges capable of containing from 800 to 1,000 tons of dredged material, and being towed by steam power some eight miles out to sea to be emptied, has effected a saving of about £20,000 a year, besides enabling the work to be carried on with much greater rapidity. Our Honorary Secretary, too, has further contributed to his own reputation and to the laurels of this Institution by the publication of a very valuable work "On Strains." We have all known his predilection for that branch of analysis, and from time to time have had specimens of the investigations he has carried on, but we now have a complete work, which, I am sure, will find a place in every Engineer's library.

The conditions of the streets of Dublin has somewhat unpleasantly reminded me of the recent introduction of steam road rollers for consolidating macadamized and other roads. Several experiments have lately been made by the Government in Hyde Park, London, and there can no longer be any doubt of the vast improvement it is, to subject newly laid-down roads to the action of heavy pressure before any traffic is permitted to go over them.

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## MANCHESTER ASSOCIATION FOR THE PREVENTION OF STEAM BOILER EXPLOSIONS.

The last ordinary monthly meeting of the Executive Committee of this Association was held at the offices, 41, Corporation-street, Manchester, on Tuesday, June 30th, 1868, William Fairbairn, Esq., C.E., F.R.S., LL.D., &c., &c., president, in the chair, when Mr. L. E. Fletcher, chief engineer, presented his report, of which the following is an abstract:—

During the past month 318 visits of inspection have been made, and 677 boilers examined, 397 externally, 15 internally, 6 in the flues, and 259 entirely, while in addition 4 have been tested by hydraulic pressure. In these boilers 84 defects have been discovered, but none of them proved dangerous. Furnaces out of shape, 5; fractures, 19; blistered plates, 6; internal corrosion, 9; external ditto, 12; internal grooving, 15; external ditto, 3; water guages out of order, 1; safety valves ditto, 1; pressure guages ditto, 7; without feed back pressure valves, 5; cases of deficiency of water, 1.

During the past month advantage was taken of the stoppage during Whitweek for making as many internal and flue examinations as possible. The whole of the staff were in active operation, the office assistants turning out to do duty as inspectors. The results of this is shown in the very high number of "entire" examinations given above. Notwithstanding this, however, it is satisfying to be able to report that no dangerous defects were discovered.

### Explosions.

Four explosions have occurred during the past month, from which five persons have been killed and six others injured. The scene of the catastrophe has been visited in each case by an officer of this Association, and full particulars obtained. Before entering, however, on the consideration of these, I may refer to two others entered in last month's table, but not then reported on fully, by which three persons were killed and three injured. Not one of the boilers in question was under the inspection of this association.

No. 16 explosion, by which one man was killed, occurred on Monday, May 11th, at twelve o'clock mid-day, to a boiler on board a small screw steamer, employed for towing purposes in a floating basin. The steamer was a wooden one, 50ft. in length, 10ft. in width, and propelled by a screw 2ft. 6in. in diameter, driven by a single direct acting inverted high-pressure engine, which exhausted into the funnel of the boiler. The steamer was engaged to move a vessel of 800 tons burthen, and the steam, as is usual in such cases, was well up in order to make a fair start. It appears that soon after setting to work the tow rope parted, and that the engine stood while a new rope was attached, when, just after the engine had set to work again, and had run for a minute or two the explosion occurred.

The boiler was cylindrical and of multitubular construction, having a single flue tube running into a combustion chamber at the back, from which a number of small flue tubes returned to the smoke box at the firing end. The shell was 7ft. 9in. in length by 5ft. 4in. in diameter, while the thickness of the plates was three-eighths of an inch in the cylindrical portion, and seven-sixteenths of an inch in the flat ends, the furnace tube being 6ft. long by 2ft. 7¼in. in diameter, and made of four plates laid longitudinally, which had been originally a quarter of an inch in thickness. There are two safety valves, one of dead weight construction, and the other loaded with a spring balance, both of which were defective as hereafter explained, while in addition there was no pressure guage.

The boiler gave way in the furnace tube, which collapsed at the crown, rending transversely about midway in its length, and also from one end of the tube to the other at one of the longitudinal seams of rivets. The rush of steam and hot water that took place consequent on these rents, carried away the furnace mountings and fire bars, knocked down the engine, tore up the after part of the deck, and swept away a portion of the boat's stern, while the engineer, who was standing on the step ladder, died a few hours after his extrication by drags. Added to this, the vessel in tow was set on fire by a quantity of live coals thrown into the forecastle, but fortunately the tug-boat was not sunk, and the man at the wheel escaped unhurt.

The cause of the collapse is complex. The furnace tube was not strengthened as it should have been with encircling hoops or other suitable provision, while the plates, which had been only a quarter of an inch thick originally, had suffered from wear and tear, being cracked at several of the rivet holes over the fire, and reduced at the crown by internal corrosion to the thickness of three-sixteenths of an inch from one end of the tube to the other, so that it was seriously weakened and unfit to stand the pressure of 62lb. on the square inch, to which the dead weight valve was loaded. In addition to the weakness of the furnace tube, both the safety-valves were so defective that there was great liability to excessive pressure. The dead-weight valve was most contracted in area, being barely one inch and five-sixteenths in diameter, while the lift was only three-sixteenth of an inch, and the steam way so choked by the central spindle which carried the dead weight that the effective area for allowing the escape of the steam was little more than half of a square inch. The other valve, which was loaded by a spring balance, was altogether false in its indications, the proportions of the lever to the diameter of the valve being such that for every pound indicated on the index there was upwards of one and a half pounds on the valve, and with the pointer at 60lb., which was the ultimate range of the index, the actual pressure was 98lb. Added to this, there was no stop ferrule to prevent the springs being overscrewed, and thus the valve jammed fast. It is reported that the engineman was seen to screw down the valve but a few minutes before the explosion took place, but as the parts were altogether dismantled by the explosion, it was impossible at the time of examination to determine to what point the valve may have been loaded.

Thus it appears that the furnace tube was weak from its dilapidated condition, and both safety-valves defective, so that the boiler laboured under a complication of disorders. It may be difficult correctly to adjudicate to each one of these its precise share in the cause of the explosion, but it is clear that the catastrophe arose from the generally defective state of the boiler, and that it would not have occurred had the safety-valves been efficient and the furnace tube well constructed and maintained in good condition.

At the inquest, though the coroner instructed the jury that it was their duty to consider whether there had been anything radically wrong either with regard to the boiler or its condition, yet he recommended the jury, notwithstanding the facts just alluded to, to return a verdict of 'Accidental death,' with which they complied. No attention appears to have been drawn to the condition of the boiler or the unsatisfactory state of the safety-valves. Such verdicts afford complete immunity to steam users to work on defectively equipped and worn out boilers, and it may here appropriately be stated that in the port in question five explosions have occurred on board tug-boats of a very similar class to the one under consideration. In one of these explosions, which took place eighteen years since, as many as fifteen persons were killed, while in another, which happened nearly two years ago, two boilers exploded simultaneously, killing five persons. As I am in possession of the particulars of this latter explosion, which are of interest, and were not given at the time in the Association's Monthly Reports, they may briefly be referred to on the present occasion. The explosion was included in the table of 1866 as No. 50. The particulars are briefly as follows:—

No. 50 Explosion, 1866, by which five lives were lost, occurred at half-past one o'clock on the afternoon of Thursday, November 1st, on board a steam-tug when its two boilers exploded simultaneously, just as she was towing a vessel out of port.

The tug-boat was a wooden one propelled by paddles, while both its boilers were of peculiar construction. They were neither truly cylindrical nor truly oval, and measured 8feet 4inches horizontally by 7feet 5inches vertically at the front, and tapered down at the back to 7feet 3inches by 7feet, their length being 16feet 4inches, and the ends nearly hemispherical at the back, and flat at the front. They had two oval furnace tubes running to the back of the boiler and returning to the funnel at the front by means of a flattened flue of very questionable shape, while the load on the safety-valve was 18lb.

Both boilers gave way at the bottom, rending longitudinally from one end to the other, when the shells opened out and were blown upwards to a considerable distance. At the same time the sides of the vessel were blown out, and the whole sunk with all hands on board. Added to this, the debris was shot in every direction, and dwelling-houses in the neighbourhood invaded by a shower of missiles, a fire shovel being thrown into the window of one, a piece of plate on to the roof of another, fragments of the deck and spars on to a third, and so on.

The cause of the explosion was simple in the extreme. The boilers had been so neglected that the plates at the bottom had been allowed to become wasted away by external corrosion till nearly eaten through, probably by the wash of the bilge water. In consequence of this they burst from simple weakness, the most decayed boiler going off first, and by its shock leading to the rupture and consequent explosion of the other.

The evidence at the inquest was of the most unsatisfactory character, though given by witnesses professedly scientific. Although a piece of plate, measuring 5feet long, and reduced to the thickness of a knife-edge, which had been blown into a gentleman's garden, was called attention to, yet the hacknied opinion was given that the explosion was due to shortness of water and red-hot plates, while the boiler was declared to have been a very good one, indeed, that the force of the explosion proved it to have been strong throughout, in addition to which, a Government officer, though his attention was specially called to the thin plates in the boiler, stated that such, though requiring to be treated with great care, would not cause an explosion, though they might a leak, and propounded the theory that explosions were generally due to superheated steam and the introduction of cold water. Palpable as were the evidences of corroded plates, the jury came to no decision whatever as to the cause of the explosion, but merely returned as their verdict that 'the deaths were caused by the explosion of a boiler on board a steam tug.' Such a verdict, affording no suggestions for the prevention of similar catastrophes in the future, could scarcely have been satisfactory to those whose houses had been invaded by the fragments of the exploded boiler. It must be clear that such inquiries must be perfectly useless as far as the prevention of steam-boiler explosions is concerned. Coroners' inquests, however, might be of the utmost value if a competent investigation were made, and the truth plainly spoken, and if the juries, instead of confining themselves to the stereotyped verdict of "Accidental Death," would, whenever the circumstances call for it, return for their verdict "Six men blown to pieces by the explosion of an old worn-out boiler, totally unfit for use."

It may be added that another boiler explosion had occurred on board this same steam tug some time before when in another port, on which occasion three men were killed, and the captain lost one of his eyes.

No 17 Explosion, by which two persons were killed and three others injured, occurred at a quarter-past one o'clock on the afternoon of Tuesday, May 12th, at a building yard.

Disastrous as were the results of this explosion, yet the boiler was a very small one, being only 4feet 10inches long, 2feet 2inches in diameter, and made of plates originally one-eighth or three-sixteenths of an inch in thickness. It was cylindrical in construction, with cambered ends, and had no furnace tube, but was fired externally. Though the age of the boiler could not be exactly ascertained, it appears that it was an old one, and had been purchased secondhand a few days before the explosion, at a sale, for £11 15s., including the brickwork, engine, and piping. It had been described on the auction bills as a "capital" boiler, but the boiler-maker, who repaired it shortly after purchase, spoke of it at the inquest as inferior, very thin, and much worn, and that there did not seem to be any nature left in the iron; this view was corroborated by other witnesses. On setting the boiler to work it was not found to be satisfactory, and the owner stated "it was all leaks, and would not drive the saws sufficiently to cut anything." The day of the explosion was the first time of getting the boiler at all into work, and it appears that after running the engine a short time with the safety-valve screwed down to 15lb, and finding there was not sufficient power to drive the saws satisfactorily, the valve was further screwed down to 25lb. or 30lb. Shortly after this the explosion occurred, when the boiler was severed into four fragments, all of which were thrown from their original seat, one of them to a distance of 30 yards, in addition to which the chimney was levelled to the ground, while the son of the owner, and a plumber who had been called in to set the boiler and engine to rights, were both killed. Three of the rents started from the man-hole, which measured 14½inches by 12½inches, and was not strengthened as it should have been by a substantial mouthpiece. The estimates of pressure just given were only taken from the index on the spring balance with which the safety-valve lever was loaded, and depended for their accuracy on the correctness of the spring, and the proportions of the lever. These could not be verified after the explosion, as the parts were completely destroyed; while in addition, as there was no stop-ferrule to the safety-valve, if the range of the spring balance was a limited one, the valve may have been locked down on to the solid, as frequently explained in reporting on previous explosions, but it is now impossible to say what the pressure of steam was at the time of the explosion.

Though this boiler was no doubt considerably weakened by thinning of the plates from wear and tear, yet the explosion is attributed mainly to the manholes being unguarded, while at the same time it may be pointed out that it was not safe to render the boiler entirely dependent on a single safety valve loaded with a spring balance, especially since it was not fitted with a stop ferrule, so that this explosion must rank among those due to defective boiler equipment.

TABULAR STATEMENT OF EXPLOSIONS, FROM MAY 23RD, 1868, TO JUNE 26TH, 1868, INCLUSIVE.

| Progressive Number for 1868. | Date. | General Description of Boiler. | Persons Killed. | Persons Injured. | Total. |
|---|---|---|---|---|---|
| 18 | May 28 | Multi-flued marine Internally-fired …… | 2 | 0 | 2 |
| 19 | June 8 | Plain Cylindrical, egg-ended. Externally-fired …… | 2 | 0 | 2 |
| 20 | June 20 | Single-flue, or Cornish, Internally-fired …… | 1 | 6 | 7 |
| 21 | June 22 | Two-flue Lancashire, Internally-fired …… | 0 | 0 | 0 |
| | | Total……………… | 5 | 6 | 11 |

No. 18 Explosion, by which two men lost their lives, occurred at a quarter-past one o'clock on Thursday, May 38th, on board a tug-boat propelled by paddles, and driven by a pair of grasshopper engines and a couple of boilers. The boilers were about three years old, and the boat had just been undergoing repairs, and was on its trial trip to test their completeness when the explosion occurred.

The boilers were cylindrical in the shell, with two internal furnaces, and measured 13ft. 5in. in length, by 7ft. 2in. in diameter, while the furnaces were of almost triangular shape, the outer sides being a portion of a flat circle struck from the centre of the boiler, so as to accord with the sweep of the shell, and thus forming portions of a circle of about 6ft. in diameter. The height of these furnaces was 2ft. 10in., and the width on the top 2ft. 11in., the length 10ft. 10½in., and the thickness of the plates barely $\frac{5}{16}$in., while the load on the safety-valve was 22lbs. per square inch.

The boiler that exploded was the one on the port side of the vessel, the left hand furnace of which collapsed, the curved side bulging inwards and rending at a transverse seam of rivets. The boiler was not moved from its place, but the contents of the boiler rushed out into the engine-room, killing the two firemen. One of them was standing just in front of the boiler and managed to creep into the starboard coal bunker, but his lungs were so injured from inhaling the hot steam that he died shortly after. The other fireman was thrown down and rolled underneath the side lever of one of the engines, which continued to work on for a short time after the explosion, each revolution driving the end of one of the rods into the poor fellow's back, while his legs were smashed by the motion of the air pump.

The cause of the explosion is clear. The curved side of the furnace-tube, though of so flat a circle as 6ft. in diameter, and made of plates barely $\frac{5}{16}$in. in thickness, was not strengthened by any stays, as it should have been, though these might easily have been applied by passing short screwed bolts through the water space to connect it to the shell. A plate derives no strength from forming a segment of a circle unless the ends are firmly secured, otherwise it becomes an arch without an abutment. Such was the case with the sides of these furnaces. Had this boiler been tested with water, and carefully gauged while under pressure, the movement of the sides would at once have displayed the weakness to any competent observer. This explosion was clearly due to the malconstruction of the boiler, but the jury brought in the usual verdict of "Accidental Death."

No. 19 Explosion, by which two persons were killed, occurred at half-past seven o'clock, on the evening of Monday, June 8th, at a colliery, and affords a further illustration of the treachery of plain cylindrical externally fired boilers, which has been so frequently pointed out in previous reports.

The boiler was one of a series of eight, set side by side, all of them of the plain cylindrical egg-ended externally-fired class; the exploded one being No. 3, reckoning from the left hand. The boiler was twenty-seven years old; it had worked three years at one colliery, and was then re-set at another but not worked; after which it was removed to the pit at which it exploded, where it had worked eleven years. It had had an interval of thirteen years, during which it laid idle, and had only worked fourteen years out of the twenty-seven. It was 30ft. in length, 6ft. in diameter, and made of plates fully $\frac{5}{16}$in. thick, and laid longitudinally from one end of the boiler to the other, while the pressure to which the safety-valves were loaded was 35lbs. per square inch. Boilers 1 to 4, which included the exploded one, were fired by Jucke's self-acting furnaces, which had been applied about two years since; the remainder, 5 to 8, being fired by hand in the ordinary way.

The boiler was severed into four pieces, one of the rents, which in all probability was the primary one, running along the bottom longitudinally through the line of rivets for a length of about 15ft. These fragments were scattered right and left. The main portion of the shell was thrown to a distance of about

50yds., crushing down the crab gear in its flight; while another was thrown to a distance of 70yds.; and a third, 130yds., carrying away the coping of a chimney about 30ft. high in its course. A fourth fragment was thrown to a distance of 77yds., while a portion of one of the steam pipes was thrown 180yds. to the west, and a safety-valve the same distance to the east, so that some of the parts flew as much as a fifth of a mile asunder. Two boilers to the left of the exploded one, and another to the right were torn from their seats, while boilers 5 and 6 were bulged in at the sides and had to be re-plated. The stoker, who was in the firing space at the time, was killed on the spot, and a pitman, happening unfortunately to enter at the moment of explosion to request the fireman to wake him early in the morning, was so severely scalded and otherwise injured that he died in a few hours afterwards.

At the coroner's inquest the foreman smith, who had recently repaired the boiler, but at a part not in any way affecting the explosion, stated he considered the boiler was quite safe to work at a pressure of 70lbs. per square inch. He had examined it from one end to the other, and found the plates all right, and had detected nothing to account for the explosion. Another witness, an engineer, who had been inside the boiler ten weeks ago, and had seen nothing amiss, produced a plate through which the longitudinal rent already referred to had run, which presented the appearance of an old crack that had gone partially through the metal. The government inspector of mines considered there was plenty of water in the boiler at the time, and that the plates had not been overheated, but that the explosion arose from the flaw in the plate already referred to, and that being the case, as it had been shown that the defective plate could not be detected by inspection, no one was in any to blame for the manner in which the deceased came by their deaths.

This evidence must be considered as eminently unsatisfactory, and as long as explosions are considered unaccountable and accidental, it is quite clear they will continue to recur from time to time with their fatal consequences. No notice was taken at the inquest of the injudicious way in which the feed was introduced. It was carried down by a vertical open-mouthed pipe to within a few inches of the bottom of the boiler, and thus impinged severely on the plates, the consequence of which would be to distress them through severe straining from local contraction, and it was in the neighbourhood of this feed inlet that the primary rent occurred. It would have been well had this been called attention to at the inquest, while it is thought that the fact of these boilers being liable to such treacherous and hidden flaws as the one discovered in this instance afforded an argument rather for discarding these boilers as destructive of human life, than for condoning their explosion as unaccountable and accidental.

No, 20 Explosion, by which one person was killed and six others were injured, occurred at about half-past nine o'clock on the morning of Saturday, June 20th, at a fire-clay works.

The boiler was of the ordinary Cornish type, being internally fired, and having a single flue tube running through it from end to end. Its length was 23ft. 10in., its diameter in the shell 6ft., and in the furnace tube 3ft. 4in., while the thickness of the plates was three-eighths of an inch in the shell, and seven-sixteenths in the tube; and the load on the safety valve 40lbs, per square inch.

The boiler gave way in the external shell, which was completely opened out, torn away from the flue tube, and rent into two pieces, one of the fragments being thrown on to a bank at a height of about 20ft. above the level of the original seat of the boiler, and at a distance of about 30ft. On the occurrence of the explosion, the fireman, who had just gone into the stokehole, was killed on the spot, some adjoining buildings to the right of the boiler were reduced to a heap of ruins, and six persons who were in various parts of the works injured. Added to this, the engine-house was thrown down, the engine buried, and a good deal of other property destroyed.

An examination of the fragments of the boiler left no doubt as to the cause of the explosion. The plates at the right-hand side of the boiler, and at the back end above the level of the external side flue, were reduced to a thickness of about one-sixteenth of an inch, and at this part the primary rent occurred, which assumed a horizontal direction, and ran through the solid metal for a length of 7ft. The thinning of the plates was external corrosion, and although there was some difficulty, after the explosion, in arriving precisely at what the arrangements had been, yet it appeared that the boiler had been injudiciously set, and the corroded plates inaccessible to examination. It is thought that this part of the boiler had been concealed by flags, which is a most undesirable mode of covering. Competent inspection could not have failed to detect the wasted condition of the plates in time to have prevented the explosion.

No. 21 Explosion occurred to a boiler closely adjoining a public street, and although fortunately no one was either killed or injured, yet it shows the jeopardy in which the lives of persons living near to improperly constructed and equipped boilers are placed, and the absolute necessity of competent periodical inspection for public safety.

The explosion took place at half-past eight o'clock on the evening of Monday, June 22nd, at a mill let out in tenements to cotton spinners, machine makers, and others, who were supplied with power by the owner.

The boiler was of the ordinary Lancashire mill type, being internally-fired, and having a couple of furnace tubes running right through it from one end to the other. Its length was 27ft., its diameter in the shell 7ft. 6in., and in the furnace tubes 3ft., the thickness of the plates being seven-sixteenths of an inch in the shell, and three-eighths in the tubes, while the safety-valve, which had a diameter of 2⅛in., was loaded to a pressure of 70lbs. per square inch.

The boiler gave way in the left hand furnace tube, which was the only portion of it that failed, the tube collapsing from one end to the other, with the exception of a few feet over the furnace, and crumpling up as if made of cardboard, the crown coming down vertically and rending in six places. The boiler was scarcely moved from its seat, being only slightly canted over a little to one side, but in consequence of the rents, the steam and hot water rushed out at both ends of the tube, blowing up the brickwork at the back, and effecting a breach in the base of the chimney, while at the front end of the boiler, the fire bridge, fire door, and grate bars were shot out at the furnace mouth like grape shot from a cannon, and, flying across the road, completely demolished a small tobacco pipe manufactory at the opposite side, as well as bringing down the corner of a dwelling-house on its right, and damaging the doors and windows of another factory on its left, while in addition a great quantity of glass was broken in the windows all round. Fortunately the explosion occurred after working hours, otherwise the workpeople in the tobacco pipe factory must have been involved in the ruin of the premises.

With regard to the cause of the explosion:—The boiler was totally unfit for the pressure at which it was worked, since the furnace tube was not strengthened as it should have been, with any encircling rings or other suitable appliances, so that a pressure of 70lbs. for the flue tube of 3ft. diameter was highly dangerous. The equipment of the boiler was very second-rate and defective. Every boiler, more especially a single one, should have duplicate safety-valve, whereas this had but one of the small size of 2⅛in. in diameter, and of such rough construction that the eye through which the lever passed, prevented its keeping the valve down to its seat, so that a loose nut had been put in as a make-shift, and it is reported that this nut immediately after the explosion was found to have slipped a little to one side, so that the lever bore unfairly on the safety-valve, and prevented its free action. It is difficult now to determine whether this nut slipped out of place before the explosion or from the shock at the time, but it must be evident to all that such a make-shift arrangement to so vital a fitting as a safety-valve, on which the safety of the boiler and the lives of all those around it depended, was perfectly inadmissible, and more especially in so public a situation, and this explosion is attributed simply to the improper treatment of the boiler, the fittings being defective and the pressure much too high for the furnace tubes unguarded by any suitable provision.

It is impossible to conclude the notice of this explosion without calling attention to the reckless disregard shown for the lives of those persons in the immediate neighbourhood, and the consequent necessity of all persons in the vicinity of boilers urging the general adoption of independent periodical inspec- for their own protection.

## INSTITUTION OF CIVIL ENGINEERS.

The Council of the Institution of Civil Engineers have just awarded the following premiums for original communications submitted to the Institution, and read at the ordinary meetings during the session of 1867-68:—

1. A Telford Medal, and a Telford Premium, in books, to George Higgin M. Inst. C.E,, for his paper "Irrigation in Spain, chiefly in reference to the construction of the Henares and Esla Canals in that country."

2. A Telford Medal, and a Telford Premium, in books, to Christer Peter Sandberg, Assoc. Inst. C.E., for his paper "On the Manufacture and Wear of Rails."

3. A Telford Medal, and a Telford Premium, in books, to Lieut.-Colonel Peter Pierce Lyons O'Connell, R.E., Assoc. Inst. C.E., for his paper "On the relation of the fresh water floods of rivers to the areas and physical features of their basins."

4. A Telford Medal, and a Telford Premium, in books, to William Wilson, M. Inst. C.E., for his "Description of the Victoria Bridge, on the line of the Victoria Bridge and Pimlico Railway."

5. A Telford Medal, and a Telford Premium, in books, to Charles Douglas Fox, M. Inst. C.E., for his paper "On New Railways at Battersea; with the widening of the Victoria Bridge and approaches to the Victoria Station."

6. A Telford Medal, and a Telford Premium, in books, to John Wolfe Barry, M. Inst. C.E., for his paper "On the City Terminus Extension of the Charing-cross Railway."

7. A Watt Medal to Edwin Clark, M. Inst. C.E., for his paper "On Engineering Philosophy; the durability of materials."

8. A Telford Medal to William Jarvis McAlpine, M. Inst. C.E., for his paper "On the supporting power of piles; and on the pneumatic process for sinking iron columns, as practised in America."

9. A Telford Premium, in books, to Thomas Logan, M. Inst. C.E., for his paper "On the benefits of irrigation in India; and on the proper construction of irrigating canals."

10. A Telford Premium, in books, to Allan Wilson Assoc. Inst. C.E., for his paper "On irrigation in India."

11. A Telford Premium, in books, to Wilfred Airy, Assoc. Inst. C.E., for his paper "On the Experimental Determination of the Strains on the Suspension Ties of a Bowstring Girder."

12. The Manby Premium, in books, to Andrew Cassels Howden, Assoc. Inst. C.E., for his paper "On floods in the Nerbudda Valley; with remarks on monsoon floods in India generally."

## UNITED SERVICE INSTITUTION.

### COAST DEFENCES AND THE APPLICATION OF IRON TO FORTIFICATION.

By Colonel Jervois, R.E., C.B., &c, &c.

To provide against naval attack on a port during the absence of the fleet, big guns, with all the numerous accessories for their service, are necessary; and these must be placed in positions so protected and arranged as to give to them a decided superiority over the artillery of assailing ships.

The question then arises whether they shall be placed afloat in strongly-protected vessels, *i. e.*, in floating batteries; or at fixed points either on land or on shoals, *i. e.*, in forts.

The proposal to defend our forts against naval attack by floating batteries alone implies, however, that we must maintain at each of our chief ports a naval squadron sufficiently powerful to resist, during the absence of our sea-going fleet, the attack of a superior force of the enemy. Then arise the questions, what is a sufficiently powerful force to maintain at each point for this object? what would be its first cost? in how many years will it be necessary to repeat the outlay for it? what will be the expense of its annual maintenance?

It is impossible to examine these questions without arriving at the conclusion that, even if our resources in money and in seamen rendered it practicable to maintain such a force, in addition to our sea-going navy, the defence of our ports can be effected much more efficiently and economically with the aid of other means. As on land, fortification enables us to economise in troops; so on the sea coast we can, by the same means, economise in ships in providing for the protection of our harbours against naval attack.

Irrespective, however, of the question of the expense of providing for coast defence by floating batteries alone, very little consideration is requisite to understand that if there be positions on land from whence an effective fire can be brought to bear on the channel, anchorage, or shore to be defended, there is no object in placing the guns in vessels afloat.

In positions such as I have referred to there cannot be any object in substituting an unsteady platform on which the amount of protection that can be afforded is limited by considerations inherent to floating structures, and which is liable to be taken away or to be sunk, for a fixed and perfectly steady platform on shore, which can be fully protected, either against its fire being silenced, or from capture by an enemy.

In cases, however, where the distance between the forts is so great that the intervening space cannot be properly commanded by their fire, or where it may be necessary to have advanced batteries of artillery at a distance from the shore, and where foundations for fixed works cannot be obtained without expense and difficulty disproportioned to the object, it becomes necessary to employ floating defences. In short, we must in each case consider—first, whether we can provide for the defence by forts without floating batteries; second, if not, to what extent floating defences should be applied in conjunction with forts; and, third, whether the circumstances are such as to render it advisable to employ floating batteries in substitution of forts.

The question is not one, as it is often put, of "floating batteries *versus* forts. There is no "versus" in the matter. Both are required in their proper places.

Whether, however, the batteries for the defence of our harbours are fixed or floating, submarine mines, of which I will presently speak more particularly, should be employed in conjunction with them.

The question of the kind of floating battery to be employed for harbour defence has from time to time been much discussed.

Ten years ago, at my suggestion, a committee was appointed by General Peel to consider the subject. Admiral Cooper Key, Colonel Wilmot, R.A. and myself were the members of this committee. We then recommended the employment for harbour defence of small vessels, each carrying a fixed iron tower for four guns, and provided with eight ports. It is curious how nearly this vessel approached the "Monitor" type first used in the momorable fight at the mouth of the James River, in America, in 1862. I believe it is generally admitted that the Monitor class of vessel is the best kind of armour-clad floating battery for coast defence, but amidst the many projects for floating structures for defence now advocated it would be presumption for me to give any decided opinion on this subject. In some cases iron-clad Monitors, supplemented by a mosquito squadron of gun-boats, might be employed, and to oppose unarmed cruisers or privateers (to the attacks of which alone the less important harbours would be liable) small gun-boats of light draught, in conjunction with submarine mines, would alone suffice. This is a model of a small gun-boat for one gun, proposed by Mr. Rendel, of the Elswick Ordnance Company, which appears admirably well-adapted for the small class of vessels for harbour defence.

Another and a scarcely less important element of coast defence than either forts or batteries, is that of obstructions, which are now in most cases essential to keep an enemy's ships under the fire of the guns of forts. Obstructions are of two kinds, passive and active.

Passive obstructions may consist of rafts or barges, booms of timber, chains, nets, wire, or rope, sometimes (in places which it is unnecessary to keep open) of piles, stones, dams, or sunken vessels. The attention that has been given during the last few years to the application of submarine mines has, however, rendered it improbable that we shall find it necessary to use passive obstructions.

Active obstructions, or submarine mines, have become of especial importance since iron armour has been applied to the sides of ships of war, those vessels being most vulnerable at their bottom. Submarine mines should, as I have just stated, be placed between the forts or batteries on either side of the channel which they are intended to defend. They may also be employed in connection with either fixed or floating batteries, to prevent an enemy occupying any particular position within range of the guns from which it is desired to exclude him. Attempts had been made by the English so early as the seventeenth century to apply floating and submerged charges of gunpowder for purposes of offence and defence. The Russians, in 1852, however, were the first to apply explosive machines of this kind with any approach to success; and, although the mechanical self-acting torpedoes which they laid down in the Baltic were somewhat defective of construction, there is little doubt that they might have produced disastrous effects upon our ships had the charges of gunpowder employed in them been sufficiently large. The Russians were also the first to attempt the employment of electricity for the explosion of torpedoes, though their arrangements for this purpose never appear to have been placed in position for actual use.

The successful results attending the employment of torpedoes as engines, both of attack and defence, by the Americans, and more especially by the Confederates in the recent war, has attracted considerable attention to these engines of destruction. Though the means at command were limited, and the arrangements generally of very crude description, there are official records of the destruction of no less than twenty-four ships of the Federal States, and of the injury of nine others, by means of torpedoes. The progress made in the application of these mines during the civil war in America is shown by the fact that whilst in the year 1862 only one Federal vessel was destroyed, in the first four months of the year 1865 eleven were destroyed or sunk, and four injured.

If it is considered that the area of water or passage to be defended may be perfectly closed against friendly vessels without disadvantage, the employment of torpedoes which are exploded by self-acting mechanical contrivances present advantages over torpedoes which are exploded by electricity, as being less costly, and more expeditiously placed in position.

This class of explosive machine would be of a size to contain about 150lbs. of powder, and would be so moored as to be within range of the bottoms of vessels of small size. They can be fitted up and placed in position with great expedition, and their cost being comparatively small, their number could be so large that even the most careful search after them by the enemy would fail to render a water safe to their ships.

These mechanical torpedoes are, however, altogether inapplicable in positions where it is desired to keep the water open to friendly vessels, and to close it effectually against an enemy.

In such instances it is indispensable that submarine mines should be arranged to be exploded by electric currents.

Electric torpedoes or mines may either be self-acting, *i. e.*, their explosion may be accomplished by the collision of a ship with them, or with a mechanical arrangement floating near the surface, and connected by an electric cable with the mine beneath; they may also be exploded at will by operators on shore, when a ship is observed to be over them or in their immediate vicinity; or they may be so arranged that the collision of a ship with the self-acting mechanism with which they are provided will instantly give a signal at the station on shore, whereupon the mine may be at once exploded by the operator at the station. Lastly, the torpedoes may, by simple means, be so arranged that they may be either exploded spontaneously by a passing ship, or at the will of the operator on shore, in the possible event of the ship not coming into contact with the self-acting trap.

The torpedoes would be placed some fathoms below the surface, and at such distances apart that the explosion of one would not seriously affect those in its vicinity. Their charges would be sufficiently large to ensure the destruction of a ship by their explosion, not merely when immediately over one of them, but even if any portion of her were within 40ft. or 50ft. of that position. It is obvious that by arranging the torpedoes in two or more chequered lines a vessel, even if passing harmlessly between two torpedoes in one line, must come within destructive range of a torpedo in the second or the third line. The placing of torpedoes at considerable depths, and their arrangement for optional explosion from on shore, must render it extremely difficult for an enemy to interfere with such a defensive arrangement, and such interference is impossible if the area of water defended is guarded by artillery. It is often stated that the torpedoes may be removed by night, but this objection is effectually met by lighting up the channel by the electric lights or other lights which may be employed for that purpose. The Federals used to bombard Charleston, I was going to say, by candle-light. The knowledge and experience acquired within the last few years regarding the application and effects of explosive agents more destructive in their action than gunpowder have demonstrated that some of them, and especially gun-cotton, may be advantageously employed in submarine mines. The Austrians used gun-cotton as the explosive agent in torpedoes, which were applied by them to the defence of Venice, and the results which they obtained in experiments with these indicated that a submerged charge of 40lbs. of gun-cotton produced destructive effects at least equal to those obtained with 1,000lbs. of powder. Improvements recently made by Mr. Abel, the chemist of the War Department, in the preparation of gun-cotton have led to a very considerable reduction in the space occupied by a charge of the material, and experiments with the new form of gun-cotton have demonstrated that very important advantages, both as regards destructive effect and reduction in weight and dimensions of a charge, are secured by the substitution of gun-cotton for gunpowder as the explosive agent in torpedoes.

The submarine mines I have referred to are all stationary, and strictly defensive in character. Torpedoes may, however, also be used offensively by means of small vessels specially constructed for the purpose, to which these mines may be fixed at the end of a long pole, and an enemy's ship thus sunk by ramming.

In order to ensure the ready application of these means at a time of impending attack, the necessary arrangements for their construction should in each case be well considered and matured beforehand, and, as is now being done, officers and men of the Royal Engineers, as well as in the navy, should be specially trained to ensure their proper application.

Submarine mines would not only be of immense advantage for the defence of our harbours in time of war, they would also, in conjunction with small gun-boats, be most valuable for the protection of places on the coast, like St. Leonards or Brighton, against privateers who might, perhaps, in the absence of other defence (which in these cases cannot be applied on shore) levy contributions upon the inhabitants of these and other watering places.

We now come to consider the construction of forts and batteries to resist naval attacks.

Before considering batteries for guns I must refer to the advantage, in some cases, of vertical fire where it is desired to prevent an enemy occupying a certain anchorage. The deck of the ship, like the bottom, is completely vulnerable, and judiciously placed batteries, if armed with a sufficient number of mortars throwing bouquets of shells into the air, would be so excessively disagreeable that an enemy would, no doubt, hesitate to take up a position where he was liable to such treatment.

The Royal Artillery, I believe, have under consideration a rifled howitzer which will afford vertical fire with accuracy, whereas mortar fire is somewhat wild and dependent on quantity for its effectiveness.

The simplest form of battery for guns is one to fire *en barbette*. In this case there is no difficulty about the construction of embrasures, the requisite protection for the guns and gunners against horizontal fire being obtained by an unbroken parapet. The exposure to which the artillery would be subjected in batteries on a comparatively low level, if the guns are always seen above the parapet, renders it undesirable, however, to construct batteries *en barbette*, except at a considerable elevation, say about 100ft. above the sea, in which case the guns and men working them are scarcely seen from seaward.

It is, however, undesirable in any case to construct batteries *en barbette* where they should stand out in strong relief against the sky line.

The advantage of a barbette battery is the great extent of lateral range of the guns which can be obtained, and it is a question on which differences of opinion have always arisen, according to the taste of the individual, whether it is better to obtain this at the probable expense of gunners' lives, or to have a limited amount of lateral range coupled with greater security. I believe that about the limit of the application of ordinary barbette batteries is the elevation above the sea to which I have just referred.

For the better protection of artillery in batteries at low elevations the guns themselves, instead of being arranged so as always to show above the rampart, are placed behind the parapet, in which cuts or embrasures are made to fire through.

Here the throats of the embrasures are nearly in the middle of the parapet, so that the merlons between the guns act the part of short traverses, separating gun from gun, though not separating the rear parts of the platforms.

The plan of forming the parapet in this manner, moreover, admits of the guns being covered over by "blindages" of timber and earth, for protection against shells exploding over the guns and gun detachment.

The cover between the shields, however, if composed of earth alone, must necessarily be comparatively weak, more especially at the junction with the shield, and in order to afford the requisite resistance, should be also be strengthened by introducing masonry, brickwork, concrete, or other suitable material.

Indeed, in all cases in which the space will not admit of the requisite degree of strength being obtained by the additional thickness of earth necessary to resist modern projectiles, the plan of inserting Portland cement concrete, a wall, or perhaps a thin iron plate in the interior of the parapet, should be adopted.

Even where there is no limit with respect to space, if earth is not procurable at reasonable cost, or if the breadth of the work cannot conveniently be made sufficient for an earthen parapet, as, for instance, on a narrow headland, or on a foundation constructed in the water, it may be necessary to employ other material.

In these cases masonry or brickwork alone was formerly applied to the construction of batteries.

Masonry alone is, however, no longer admissible at the embrasures of works; as in the case of earthen batteries iron must be substituted at those parts of the work which must necessarily be thin, in order to allow of sufficient lateral range and space for the efficient working of the guns.

The subject of structures, with the exterior wholly of iron, will be referred to subsequently in dealing with the question of casemated structures.

Specimens of open batteries, with the guns *en barbette*, may be seen at the Needles, Hatherwood, and Warden Point. These are all high above the sea, and the guns sweep the whole Channel, from the Needles' Point upwards.

A specimen of open batteries prepared for iron shields may be seen on either side of Southsea Castle.

The lateral range obtainable in the barbette system, combined with the protection afforded by the embrasure and iron shield plan, can be obtained by the employment of turrets, which may be employed without reference to the elevation of the battery above the water. The origin of the invention of the turret by Captain Cowper Coles, to whom we are so much indebted for the proposal, was the protection of deck or pivot guns on board ship, by means of shields. To effect this, and at the same time obtain the greatest lateral sweep of the gun, it was necessary to place both the gun and the men working them on a turntable, and to attach the shield to the turntable, so that the guns, the gunners, and the protection should revolve together.

The objection to turrets is that they are very expensive. The cost of a turret for two great guns, by the most economical arrangement of the system is, however, not less than £15,000, and this irrespective of the basement of masonry and iron on which it must be mounted, and which must contain magazine accommodation for powder and shells, and space for the men. This basement will not cost less than from £5,000 to £10,000, according to whether the turret is alone or forms part of a work, so that the cost of a turret complete for two guns is not less than from £20,000 to £25,000. The question then arises whether that amount of money can be applied to any other kind of work, so as to afford a more powerful fire upon the space to be commanded than can be obtained from two guns in a turret. In many cases it will be found that is so; in other cases, however, like the Spithead forts, where the works are entirely surrounded by water, it will be found that in order to employ the most powerful guns with the greatest effect it is better to employ turrets.

Another plan for mounting guns on turntables, and at the same time protecting them by iron shields, is shown in this diagram.

The shield is a segment of a circle, in which are two or more ports, according to the extent of lateral range required. The turntable affords the means of turning with facility from port to port, and when fixed with the gun opposite one of the ports, the arrangement for traversing is the same as in an ordinary battery with iron shields. By means of the turntable the gun may also be rapidly turned round with its muzzle to the rear, and this affords great facility for loading.

In cases where great guns are mounted *en barbette* it will probably be found advantageous to place them on small turntables, without any shield.

I must now notice a very important invention with regard to gun-carriages, which, probably, will very greatly affect the construction of the parapets of open batteries, and which, though not a substitute for turrets in all cases, will afford the advantage of lateral range obtainable from turrets and guns on turntables or *en barbette*, without exposure of the gun to direct fire, except at the time when it is being laid and discharged.

The principle I refer to is that which has lately been so successfully dealt with by Captain Moncrieff, of the Edinburgh Militia Artillery.

Very ingenious suggestions, with a view of attaining the same object, have also lately been made by two officers of engineers, Lieutenant Hogg and Lieutenant Lloyd. These two last-named officers proposed to effect the object by different plans, but both by means of two guns, one counterbalancing the other, and to fire alternately.

Captain Moncrieff in his plan mounts the gun on a carriage with curved sides, which rock on a level platform; attached to the carriage is a counterpoise weight, rather in excess of the weight of the gun, thus enabling it to get up like a man, to fire over the parapet, whilst it stores up the recoil, and when fired, the gun makes, as it were, a low curtsey, and retires behind the parapet.

There would not be time for me now to enter into the details of the construction of this carriage, and it is unnecessary for me to do so, as Captain Moncrieff has himself fully explained them in a lecture he delivered on the subject in this place. The nature of the action will be understood from the model you see here.

The great point of this invention is that it enables us to protect guns in open batteries by a parapet unweakened by openings, and thus to have the advantage of the great lateral range of barbette batteries even at a low level above the water, without exposure, except at the moment of firing; it enables us at the same time to avoid the expense of iron shields for embrasures for open batteries.

Some extra expense may probably be necessary for this gun-carriage as compared with one of the late service-pattern carriages, but I doubt the Moncrieff carriage being dearer than a muzzle-pivoting carriage (which is necessary to afford the smallest opening for an embrasure), and it is with this that its cost should be compared.

But however this may be, the extra cost of the Moncrieff carriage, when applied in any number, cannot, I conceive, be anything like the cost of an iron shield, and it is from this point that the question should be regarded. Fortunately we advisedly deferred the provision of iron shields for our works in this country; we are, therefore, in a position, supposing the Moncrieff carriage to be adopted by the artillery authorities, after the full trials which it must necessarily undergo at Shoeburyness, to apply it in all the open batteries in which it has hitherto been proposed to provide iron shields, and that without any expense in the works, except the alteration to the parapets and to the traversing arrangement for the guns.

After witnessing the late experiments with this carriage I did not hesitate at once to submit proposals for the application of the invention to several of our new works of fortification. Works constructed for carriages of this description will not afford protection against vertical fire, nor are they applicable in cases in which casemated structures are necessary.

A work for sea defence must be casemated when it is necessary to provide by tiers of guns an amount of fire which cannot be obtained by a lateral extension of the work. A sea battery should be casemated; when otherwise it would be liable to be plunged into by fire from ships. Casemates are also applied in some cases when it is necessary to secure the battery against the fire of infantry from the rear; and when this cannot be effected by traverses, or when the work is on the side of a hill, or is in front of another battery, it must be secured from splinters of rock or shells.

## ROYAL GEOGRAPHICAL SOCIETY.

At the meeting of this society on June 22nd (the last of the present session), the President, Sir Roderick Murchison, in the chair, a paper, by Mr. J. G. Taylor, was read, giving an account of a journey he had performed between Erzeroum and Diarbekr, at which latter place he holds the position of British consul. During this journey he traced the course of the Kara Su (river Lycus of the ancients), ascertained the site of Pompey's Nicopolis, at the modern town of Purk, and discovered a practicable road over the high mountain range of the Deyrsim Dagh, well known to the Kizzilbash inhabitants, but not travelled over in modern times by a European. A paper was also read by the Bishop of Honolulu on "The Geography of Hawaii and the Recent Volcanic Eruptions." After giving a general sketch of the Hawaiian archipelago, he described the present condition of the native inhabitants, The whaling trade, he said, happily for the social and moral improvement of the Hawaiians, had fallen off. The total number of vessels entered at Honolulu in 1867, other than whalers, was 118. The last census in 1867 showed a decrease of the native population of 8,300 in seven years, while there was an increase of white foreigners of 400 in the same period, the total population being 58,765 natives, and 4,194 foreigners. The Hawaiian Government were seeking to encourage everywhere the formation of industrial girls' boarding schools, in order to check the evil of depopulation at its source, and train the future wives and mothers of the race to a higher appreciation of the dignity of their sex. Honolulu is under the isothermal line of 77°, and the annual range of temperature is only 12°, but the climate is much cooler on the table-lands of the larger islands. There is no tropical wet season, the heaviest rains falling at the winter and not at the summer solstice, as in India and Africa. The islands have now an abundance of rich pasture supplied by a very nutritious kind of grass, which spreads along the ground, striking its roots over a large space. In 1867 nearly 1,000,000lbs. of rice and 17,127,187lbs. of sugar were exported; the increase of sugar cultivation and manufacture had been very rapid. The whole archipelago had been lifted to its present great elevation by volcanic agency, and it was remarkable that the subterranean forces had slowly marched from the north-western to the south-eastern extremity of the archipelago, the western islands being the oldest, and the recent volcanic vents being in the south-east. In some of the islands coral beds are found at an elevation of 4,000ft. above the sea level. The central islands have no longer any active volcanoes, although slight earthquakes are felt. The same direction of the volcanic forces is exhibited in the island of Hawaii itself, the old craters of the northern part (one of them, Mauna Kea, being 13,000ft. high, and covered with perpetual snow) having long since become extinct. The author described his visit to the pit crater of Kilanea, on Mauna Loa, the seat of the recent great eruption, and exhibited specimens of vitreous and vesicular lavas which he had collected. The pit is nine miles in circumference, and its area and depth have generally sufficed to keep the lava from overflowing the surrounding country, which was fertile, and dotted with villages and plantations. The last great eruption commenced on March 27th of the present year; between this date and the 2nd of April 300 shocks of earthquake were counted; mud eruptions burst through the soil, and buried villages and cattle ranchos. On the 7th of April a new crater opened on the southern flank of Mauna Loa, and vomited forth a stream of lava which flowed towards the sea. A great tract of the most fertile portion of the island was thus in a few hours rendered desolate. The column of vapour which issued from Kilanea was visible at a distance of 120 miles, and was computed to be eight miles in height.

## COMMERCE AND MANUFACTURE OF ITALY.

The third of a series of bluebooks, containing reports by Her Majesty's Secretaries of Embassy and Legation, has just appeared, and comprises a large amount of interesting matter with reference to the Kingdom of Italy, forwarded to Lord Stanley by Sir A. Paget. From particulars recorded with reference to the silk trade it appears that the number of looms now at work in Italy is about 20,000, Genoa and Como being the great centres of manufacture, and that the annual produce of the throwing mills is a about 2,721,759 kilogrammes, the value of which is computed at 196,500,000f. The production of wool is small, as it is estimated that there are in the country less than nine millions of sheep, yielding on an average not more than one kilogramme of wool per head, The total quantity of woollen and worsted yarn made annually is reckoned at 8,950,000 kilogrammes, and about 240,000 persons are employed in the woollen manufacture. Italy contains 200 cotton spinning mills, producing annually 143,767 metrical quintals of yarn, valued at 34,900,000f. The annual produce of flax amounts to 135,000 metrical quintals, and of hemp to 500,000 quintals. A great quantity of lace is made at Genoa, in parts of Lombardy, at Venice, and in the Southern Provinces. The manufacture of trimmings or "passementerie" is very large, and the value of ecclesiastical ornaments alone amounts to aboute 800,000f. There are 34 iron mines now worked in Italy, producing an annual average of about 1½ millions metrical quintals of ore; 22 copper mines, from which are extracted yearly about 32,010 tons of ore; 15 lead and silver mines, producing about 160,447 metrical quintals of ore, four mercury mines, and one zinc mine. About 15 varieties of marble are quarried in Italy, and the annual value of that exported from Carrara amounts to upwards of a million of francs. There are now 536 paper mills in the kingdom, the annual consumption of rags being 367,034 quintals, and the value of the paper manufactured 28.040,000f., while the value of the paper exported may be set down at 4,385,000f., and that of the importations at 2,117,000f. The coral fishery employs between 300 and 400 boats, and upwards of 2,500 men and boys, and most of that obtained is wrought at Naples, Leghorn, and Genoa, from 8,000f. to 9,000ft. being realized yearly by the trade. The total produce of wine in Italy is estimated at 28,879,000 hectolitres, the countries to which these wines are exported being England, Austria, Switzerland, and America. The agricultural statistics show that the superficial extent of the productive soil of Italy is 23,017,096 hectolitres, more than 11,000,000 of which consist of arable land. The average crops are insufficient for the supply of the country and the average annual importation of grain amounts to about 6½ millions of hectolitres. There were registered in the ports of Italy in 1865 17,048 vessels, having an aggregate burden of 124,391 tons, 341 of which were employed in distant navigation, and the rest in the coasting trade. The institution of savings-banks in this country dates from 1822, and at the present time the propertion of depositors to population is 1 in 61, the average amount to the credit of each person being 521f. Such are some of the commercial statistics of the kingdom of Italy.

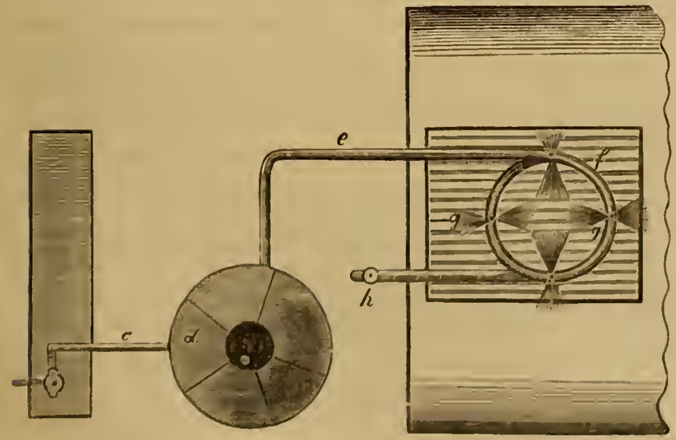
## LIQUID FUEL COMBUSTION.

Responding to an invitation from Messrs. Dorsett and Blythe, of the Patent Fuel Company's Works at Deptford, we witnessed, a few days since, the trials of Dorsett's patented arrangements for burning liquid fuel, as applied to the furnaces of four boilers used for tar boiling in the patent fuel process. The application differs from others having a similar object, in the principle of feeding, which this patent accomplishes under pressure.

The creosote, or liquid fuel, is pumped from a reservoir by a small force pump, into an upright or any other form of boiler (similar to the feed of an ordinary boiler), where the pressure is raised to about 25lbs. on the square inch, which enables it to be injected with considerable force into the furnace of the boiler where steam has been generated. The combustion appeared so perfect that little or no smoke was emitted from the chimney. The feed from the boiler, when the pressure is raised, takes place through a small wrought iron gas-pipe having one coil near the surface of the grate, from which the creosote escapes at a temperature of about 670° to 700° Faht., through four apertures, each about one-sixteenth of an inch in diameter We are informed that the productive power of 36 gallons, costing 3s., was equivalent to about 8 cwt. to 10 cwt. of coal, while the relative volume would be only two-fifths of that of the coal.

In the absence of more detailed experiments, it would be premature to pronounce any decided opinion upon the merits of the application, but the impression made, judging from the appearance of the furnace, was decidedly favourable.

The accompanying engraving illustrates this method, where it will be seen that a force-pump is fitted to a tank containing creosote, and shown on the left-hand side of the engraving. By means of this force-pump the small boiler *d* is fed through the pipe *c*, where the creosote is brought to the requisite heat. From this boiler a pipe *e* is led into the steam boiler, and made into a coil *f* over the furnace bars. The small holes or jets are shown at *g*, and at *h* is a cock to draw off materials from condensation in the coiled pipe.



## AERONAUTICAL EXHIBITION.

The following is a list of the various models and designs exhibited at the Crystal Palace, and which will no doubt be regarded with curiosity. It is perhaps unfortunate that the very first that claims attention should come from Hanwell:—

### Class I.—*Light engines and machinery.*

1. Rotary engine made of steel, 1-horse power; dimensions, 2ft. by 18in. and 1ft. high; weight, about 60lb. Motive power, gun cotton.—R. C. Jay, 4, St. Leonard's-villas, Hanwell.

2. A 1-horse power turbine injector steam engine weighing less than 12lb., with inclined vanes showing its adaptation for aerial purposes, with rudder and gear for working. Designed and manufactured by the exhibitor, R. E. Shill, engineer, 1, Schrier's-terrace, Bridge-street East, Mile End.

3. A 200-horse power (nominal) double-cylinder horizontal colliery winding engine, with patent spiral drum, link-reversing motion, and steam brake (¾in. scale).—Wm. Henry Pilditch, of Frome.

4. Light engine and machinery for aerial purposes, about half-horse power. Cylinder, 2in. diameter, 3in. stroke; generating surface of boiler, 3½ft.; starts at 100lb. pressure in three minutes, works two propellers of 3ft. diameter, about three hundred revolutions per minute. With three and a-half pints of water and eighteen ounces of liquid fuel, works about ten minutes. Weight of engine, boiler, water, and fuel, 16¼lb.—J. Stringfellow, Chard, Somerset.

5. A 1-horse power copper boiler and fireplace. Weight, about 43lb., capable of sustaining a pressure of 500lb. to the square inch. Price, £20.—J. Stringfellow, Chard, Somerset.

6. Aluminium steam engine.—Viscount de Ponton d'Amecourt, 30, Rue de Lille, Paris.

7. Working model of the Brighton oil engine (Dr. Money's patent). In this engine power is derived from explosion within the cylinder of inflammable gas or vapour mixed with atmospheric air. The vapour is produced by volatilisation of certain liquid hydrycarbons, the heat resulting from the explosion being made available for this purpose. The exhibited arrangement is employed where coal gas is not procurable, as in country places, or not adaptable, as when power is required for locomotive purposes. But the engine is equally suited to the combustion of that substance, or a powerfully explosive gas may be cheaply and easily prepared for the purpose by a simple apparatus.—Fredk. J. Money, M.D., Brighton.

8. Light engine.—Shand and Mason, Upper Ground-street, Blackfriars-road.

### Class II.—*Complete working aerial apparatus.*

1. Flying machine, which, being attached to the body, enables a person to take short flights. The exhibitor of this machine has, with less perfect apparatus, accomplished flight to the extent of 160ft., rising from the ground by a preparatory running action. Owing to the delay and difficulty of adapting a perfect apparatus to a novel experiment, and the possibility that when complete it may not prove upon trial to be the best form of construction which could have been devised, it is necessary to say that some delay might occur.—Charles Spencer, 35, Old-street, E.C.

2. Complete working aerial apparatus by muscular power.—Wm. Gibson, 1, Outram-street, West Hartlepool.

### Class III.—*Models.*

1. Model of a balloon, with a ring or belt attached which, in ascent or descent, is placed in an inclined position. relative to the axis of the balloon, the current of air rushing through the open side of the bell, urging the whole in that direction.—John Heath, 17, Shakespere-road, South Hornsey.

2. Model of the framework of a car, adapted to receive the machinery described in a drawing (class 5), the object of which is, by a system of levers. to raise the car two or three or more inches, according to the force required, which, suddenly dropped on to its supports, produces a rapid succession of jerks, thereby effecting descent without loss of gas.—John Heath, 17, Shakespeare-road, South Hornsey.

3. Model of an improved balloon. By this model it will be seen that the car is done away with, and that a structure of bamboo or wicker-work is to be built round the balloon, which is used as an ascending agent only. The steering apparatus has only to be seen to be understood, proper care being given to the adjusting of ballast.—W. Prichard, 22, Thornhill-place, Caledonian-road.

4. Model of an aerial machine to go to any direction.—John Venus, 29, Lower Thorn-street, Reading.

5. Model of the aeromotive, constructed for rising in and steering through the air by the rapid rotation of a screw (one on each side of the machine), which, by creating a reaction in the air, overcomes gravitation, and thus rises. Fixed to the top is a parachute for gradual descent in case of accident. The aeromotive is propelled by a screw and guided like an ordinary vessel. The principle of the screw is the same as Rennie's conoidal.—S. M. Gregory, 11, Prior Park-place, Bath.

6. Model of an aerial steamship, propelled by four wings, giving alternate stroke, and two screw fans. one of which is placed vertically for assisting in ascension, the other placed horizontally for propelling ahead, with internal space for gas.—Duncan McPhail, 2, St. Ann's-lane, Westminster.

6. Model of aerial boat to be propelled by hot air or steam engine, or possibly by treadles acting upon two double screws.—Moreton H. Phillips, 1, High-row, Kensington.

7. Small model of a steam or hot air engine, chiefly constructed of vulcanised india-rubber for aerial purposes.—Moreton H. Phillips, 1, High-row, Kensington.

8. Experimental model of a balloon, dispensing with gas and ballast.—A. Clestadoro, Ph.D., Free Library, Manchester. Will attend and explain.

9. Model in demonstration of a proposition to omit ballast in balloon ascents. By this proposition gas would be withdrawn from the balloon by an air-pump, which would compress the gas into a chamber carried in the car when a descent becomes necessary. An ascent will be obtained by opening a tap, and thus allowing the compressed gas to escape from the chamber by a tube into the balloon. The advantages of this would be that the natural balance used by fishes would be applied to balloons, gas being reserved for use instead of escaping as now obtains.—George F. Ansell, Royal Mint.

11. Model of an aerostat with various propellers.—J. Luntley, 13, North-buildings, Finsbury-circus. Will attend and explain.

12. Model of an aerostat or aerial float, 8in. long, 20in. broad, and 2in. deep, rendered rigid by inflation. When the two shorter ends are doubled together it assumes the form of an open boat or canoe, and will then balance itself in the

air, and can be used as a parachute, for it will always descend with its convex side downwards, and in doing so may be propelled and steered in any direction. It is expected, however, that when made on a large scale, inflated with gas and propelled horizontally, it will support itself, The engine intended to be employed is an ammoniacal one.—D. S. Brown, Braywick-house, Green-lanes, Stoke Newington.

13. Model showing the action of a bird's wings, and how form imparts strength to them.—D. S. Brown, Braywick-house, Green-lanes, Stoke Newington.

14. Model of an aeromotive engine.—J. M. Kaufmann, 33, Abbotsford-place, Glasgow.

15. Model of Cocking's parachute, made by himself.—Lent for the Exhibition by Robert Holland.

16. Model of fish-shaped balloon, showing the possibility of obtaining descent without loss of gas or ballast.—François Herou, Crystal Palace, Sydenham.

### Class IV.—*Working Models.*

1. Working model to illustrate a mode of flying vertically by direct action on the air, without any screw motion in the wing. This machine will ascend in a vertical line.—Thomas Moy, 1, Clifford's Inn.

2. Working model to illustrate natural flying, the wings being used to propel and sustain, the tail to sustain only. This model will fly horizontally for a short distance.—Thomas Moy, 1, Clifford's Inn. N.B.—These two models will occasionally be removed to illustrate Mr. Moy's lectures on flying (see programme), at which lectures other models will be used not included in the catalogue.

3. Small brass model of a rotary engine, to be worked by gun cotton.—R. C Jay, 4, St. Leonard's-villas, Hanwell.

4. "The Chrysalis," a working model of a gaseous engine, designed to prove, as far as possible, the practicability of air navigation, and by such means to establish communication between distant objects and places with certainty.—W. Quartermaine, Little Harcourt-street, Bryanstone-square.

5. Working model of an air ship, lifting itself by motive power, and capable of being governed in every direction, based upon a system supposed to be not hitherto known, which enables it to work against any lesser currents of air; therefore a certain horizontal direction can be pursued, inasmuch as the cubic contents of the apparatus are comparatively little in proportion to its carrying powers. Each cubic foot of the space occupied by the apparatus is capable of carrying half a pound (Vienna weight).—Joseph Liwcscath, Vienna, who will explain his invention.

6. Orthoptere.—Viscount de Ponton d'Amecourt, 36, Rue de Lille, Paris.

7. Working model, showing progressive motion by flapping action of the wings.—The Duke of Argyll, K.P.

8. Working model of cigar-shaped balloon, showing progressive motion by mechanical action.—François Heron, Crystal Palace.

9. Working model, illustrative of wing structures and wing movements, as observed in the bird, insect, and bat.—J. B. Pettigrew, M.D., Somerton House, Wexford, Ireland.

10. Working model of aerial machine.—E. Egelhaaf, 87, Port-street, Anderston, Glasgow.

### Class IV.—*Outside the Main Building.*

1. A working model of an aerial machine, raising and sustaining itself in the air for several minutes, being worked by a power evolved from the combustion of materials similar to those used in the original fire anihilator, steam and gaseous products of combustion being intermixed within the boiler, and forced at high pressure into a rotary engine, turning, lifting, or driving fans. The model machine weighs only a few pounds, and by raising and sustaining itself in the air is to demonstrate the practicability of raising heavier weights, and effecting aerial transit at a high speed in any direction for a lengthened time.—W. H. Phillips, Nunhead, Surrey.

2. Working model of an aerial machine, with steam engine.—Camille Vert, 9, Rue Morel, Paris.

3. Working model of an aerial steam carriage, the whole, including engine, boiler, water, and fuel, weighing about 12lb.; cylinder, 1 and 3-16th inches diameter, 2in. stroke; works, two propellers, 21in. diameter, about 600 revolutions per minute; gets up steam to 100lb. pressure in five minutes. On account of steam the manager of the Crystal Palace Company will not allow this or similar models to show flight in the main building, and it will be necessary, for want of space, to attach it to a line by a travelling pulley. If the distance will allow of the attainment of such a speed as the engine is capable of imparting, it will be seen that this model will sustain itself in flight.—J. Stringfellow, Chard, Somerset.

4. Working model of complete aeromotive engine.—J. M. Kaufmann, 33, Abbotsford-place, Glasgow.

### Class V.—*Plans and Illustrative Drawings.*

1. A drawing of a system of levers by which the car of a balloon is raised two or three or more inches, according to the force required, and suddenly dropped on its supports, producing a rapid succession of jerks by which descent is effected without loss of gas. N.B.—A model of the framework of a car adapted to receive the machinery is exhibited in Class III.—John Heath, 17, Shakespere-road, South Hornsey.

2. Drawing of "aeronautic explorer," fitted with wings flapped by machine worked by hand, and with tail fitted to act as rudder; the person or two to be inside the "explorer.—Robert Quintavalle, 6, Paxton-place, Swansea.

3. Plan and illustrative drawing of complete aerial apparatus, showing the application of the extraordinary power employed by the inventor to work in any description of steam engine by which horizontal and vertical fans can be driven or other mechanical appliance, such as artificial wings, the main feature being the generating a power many times greater than that of steam, taken relatively as to weight of furnace, fuel, boiler, and water.—W. H. Phillips, Nunhead.

4. Drawing of a spheroidal balloon, furnished at each end with a four-armed propeller, one being designed to draw and to despel the air in front of the balloon, also to prevent its rotation; the other to propel. Also a section of the above with aft propeller only, to be worked by steam power generated by gaseous fuel. The steam to be condensed within the balloon.—John Luntley, 13, South-buildings, Finsbury-circus.

5. Diagrams or plans for a complete aerial machine, calculated to convey passengers from country to country.—Richard Shewald, 21, Royal Mint.

6. Drawing of a machine for aerial locomotion, accompanied by an exposition of the principle upon which it is constructed.—Charles Lean, jun., Lama Villa, Birkenhead.

7. Drawing and plan of an aeronautic machine.—This machine consists of an oblong frame of light wood, which supports a platform and tent for the aeronaut. To this frame are attached two spherical balloons, fastened at their centre to the frame in the usual way. A light shaft supported on the lower side of the frame gives motion to the steering apparatus, which is worked by hand, and by which the aeronaut can change the position of the machine at will. There are sails attached at the forward end of the machine by which it is expected an oblique course can be given to it.—James Moncrieff, Mount Pottinger, Belfast.

8. Drawing of an aerial apparatus for establishing a communication from a wreck on shore, or between two vessels at sea. It is a ship's sail or flag, according to the strength of wind, made in the following proportions:—Top, 8ft.; bottom, 6ft.; sides, 6ft.; two extenders made of wood 5ft. 6in., attached to each side, and the holding line, which should be marked every fathom, that the paying-out should be equal. At the end of the communication lines a small lamp or weight should be fixed, and slung over the lower part of the holding line. The persons paying out should stand in the middle of the vessel, one rope to go out at the head and the other at the stern of the vessel. When it is paid out the distance required the communication lines should be fastened and the apparatus still payed out, which will drag the lamp over, and the line will drop accordingly. The advantages of this plan are as follows:—First, three sailors could make it in less than five minutes; secondly, two lines could be forwarded at once; thirdly, it could be hauled in a gale of wind when a kite could not.—R. W. Cooper, 19, Colegate-terrace, Chatham.

9. Design for an improved method of generating steam, also improvements in the construction of light engines for aeronautical and other purposes.—William Rayner, engineer, Radcliffe, near Manchester.

10. Photograph of an ascent in Austria in a balloon invented by the exhibitor.—Mayerhofer, 5. Circumgasse, Vienna.

11. Diagram showing the law and resolution of forces as affecting the motion of an inclined surface in a current of air.—H. Reda St. Martin, 55, Bolsover-street.

12. Diagram showing the progress of an aerial machine based upon the principles which govern the movements of the kite.—H. Reda St. Martin, 55 Bolsover-street.

13. Diagram showing a view of the above apparatus.—H. Reda St. Martin, 55, Bolsover-street.

14. Diagram showing (Fig. 1), a mid-section of the plane of the apparatus. (The longitudinal section of the plane is somewhat of the same shape, *i.e.*, tapering towards the bow and stern). Also (Fig 2), a reticulated screw made of basket work; and filled with down or feathers.—H. Reda St. Martin, 55, Bolsover-street.

15. Design for an aerial machine.—J. K. Chappell, 13 and 14, Union-street, Clarendon-square, St. Pancras.

16. *Un memoire descriptif concernant la navigation aerienne.*—J. Billet, Rue du Begucie, 28, a Lyon Guellotiere, France.

17. Drawing of Hammaut's patented machine for aerial navigation. A small and very imperfect model (accidentally destroyed), worked with the hands by means of depending cords was able to rise and move in the air in any required direction, and assistance is required to bring out this invention.—W. Hammaut, 20, Colchester-street, Pimlico.

18. Four illustrative photographs.—J. M. Kaufmann, 33, Abbotsford-place, Glasgow.

19. Plans for light steam engine.—Frederick J. Money, M.D., Brighton.

20. Balloon over the clouds, on its voyage to Nassau, painted by E. W. Cocks, lent for the Exhibition by Robert Holland.

21. Plans and designs.—Mons. Soleillet, Rue Régale Nismes, France.

### Class VI.—*Separate Articles connected with Aeronautics.*

1. Varnishes for balloons.—Mons. Bertaux, Rue de la Verrerie, Paris.

### Class VII.—*Kites or other similar Apparatus proposed to be used in cases of Shipwreck, Traction, or in the attainment of other Useful Ends.*

#### Inside.

*Vita sic liberata, Deo dedicetur eandem postulanti.*

1. A rough kite made of materials most likely to be found on board ship, suggested to the unprovided mariner in peril of being driven upon a lee shore, a ready way of making a kite to be flown with "two strings." When about one-third out, attach a small wooden weight to the second line; pay out again until the kite reach the distance required; then cut and let go the second line, which will swing to the shore, and communication is accomplished. On an uninhabited coast, attach the second line to the man swimming thereto. The inventor, a working man, freely gives this very simple, rough, and common invention of "two strings to the kite" for the benefit of the maritime populations of all nations, humbly requesting of all persons interested therein to extend

translate, and further advance the knowledge of the same.—John Neale, 2, Queen-street, Troy Town, Rochester.

2. A kite for conveying a line from a vessel in distress to the shore, or to another vessel at sea.—George Howatt, 141, High-street, Renfrew.

3. Model apparatus for throwing a line of communication to persons in danger, either from fire or water.—George Howatt, 141, High-street, Renfrew.

4. A form of kite with means to communicate between vessels or other objects.—David Mayer, Six Ways, Balsall Heath, Birmingham.

5. An apparatus to enable bathers or people getting into the water by shipwreck or otherwise to swim for a short distance.—John Goucher, Church Walk Ironworks, Worksop.

OUTSIDE.

6. Rogers' patent projectile anchor and block, for launching lifeboats, &c., in rough weather, and for other life saving and useful purposes. Working model, scale 1-16th, with diagrams, to effect direct communication with a wreck on shore, or between a ship and the shore, or between two vessels at sea, or for assisting boats to leave the ship's tide (when at anchor) or in a rough sea, or for use in club-hauling a vessel off a lee shore; also as a means of aid in case of fire occurring in high buildings.—John Banting Rogers, 70, St. Andrew's-road, Hastings.

7. An arrangement of kites showing Cordner's application to the saving of life, &c., from shipwreck, and to other purposes. This consists in applying to the saving of life and property from shipwreck, &c., a set or succession of kites, or several combined sets, so arranged that the power exerted by the several kites of a set shall be at one point or upon a single line, the line of the first or uppermost kite being attached to the adjacent kite, and the line of this to the next adjacent, and so on through all their series.—J. E. Cordner, 4, Belvedere-place, Mountjoy-street, Dublin.

8. A mariner's kite.—Thomas Moy, 1, Clifford's Inn.

9. A patent kite and apparatus showing, by experiment upon a smaller object, how it is possible for a man to ascend the line of a kite by the draught power of another kite attached to a car. The exhibitor has himself ascended by these means to the height of several hundred feet.

## ON THE MANUFACTURE OF SUGAR FROM CANE JUICE.

By Mr. W. E. Gill.

It is strange, that in these days of scientific research, and mechanical and chemical progress, we find our planters perpetuating, in the main, the process of bygone ages, and continue to lose £40 worth of sugar, when securing £20 worth for the market. It would be assuming too much if we supposed that the planters were content to suffer this extravagant loss.[*] They have often tried to extricate themselves from the ugly dilemma, as their limited knowledge or experience suggested; but the failure of one has been a caution to most of them. Science did something towards improvement, and a small portion of the patent was sold for thousands of pounds; so high was a remedy prized. But the men, commonly employed at such work, are not skilful manipulators as Dr. Scoffern is admitted to be, and fear was engendered lest some portion of the deadly poison—acetate of lead—might remain in the sugar.[†] Rejection of that panacea was the only practical result, and the process fell back again into its old groove.

An increase of product of first class Muscovado sugars has since been accomplished, without any poisonous or deleterious ingredient whatever. A sugar has been made directly from cane, which is in every way suitable for the grocer; thus throwing the refiners' expenses and profits together into the lap of the planter. Such a fact deserves to be made known to the planter, from a commercial point of view, which he can better appreciate.

Of course, this increase of sugar having been legitimately obtained by known laws, the process can be repeated under like conditions. That an increased sugar-product is as possible as desirable, may be familiarly demonstrated, without troubling ourselves now with the elaborate details of organic chemistry.

It is a well known fact, that the juice of the sugar-cane contains on the average 21 per cent. of sugar.[‡] It is equally well known, that 7 per cent. of sugar rewards the planter for his outlay and leaves a margin of profit. If, by any means, this per centage of sugar realised becomes 14, it is clear that his common product has been doubled, and he loses only one-third of the contained sugar. At present we see he loses two-thirds, and if he lost none, of course his product would be three times as much as at present. But this proximate loss of two-thirds before he can sell the remaining one-third, is unfortunately augmented by an ultimate loss on the voyage to England, when 12 to 20 per cent. of the cargo is pumped overboard as drainings.

These unpleasant, yet well-known facts, accumulate at the expense of the planter, to reduce his profits, and of the consumer, who bears treble the burthen of that which might be his share.

It must be satisfactory to turn from this loss, to a prospect of relief and benefit to the planter and the consumer. An outline of the facts may suffice for the present. A challenge had been accepted to "do with sugar what others had not done, in relation to quantity and quality;" 25 per cent increase of first-class sugar was obtained, more than had been got by the old process, from the best canes of same field, and in their own boiling-house.

It may better elucidate our position, if we trace this 25 per cent. of increased sugar-product to its consequences. To this end, we may assume the annual produce of an estate to be 2,000 tons of sugar, and the clear profit to be 10s, per ton. With these elements we have an annual revenue of £1,000.

Again, if instead of these 2,000 tons, we get 2,500 by an increase of 25 per cent., and if we take the selling price of sugar at only £20 per ton, we have

| | | £ |
|---|---|---|
| The original 2,000 tons, paying the expenses as before, and giving a clear profit of 10s. per ton ........................... | | 1,000 |
| We have to add 500 tons of sugar at £20 per ton ... | £10,000 | |
| From which we will deduct, *extravagantly*, for new expense ........................................................ | 1,000 ... | 9,000 |
| And the revenue now rises, by an increased product of 25 per cent., to the respectable figure of ................................ | | 10,000 |

This result must astonish many, yet what has been adduced does not go beyond sufficiently corroborated facts, which appeal with confidence for the confirmation of business men in the application of those facts.

This result was not an elegant laboratory experiment, but was obtained in a boiling-house, with hundreds of gallons of cane-juice, slowly obtained by an antique stone-mill, and other ordinary appliances.

The canes used, were mainly, gnawed canes which a colony of rats had thrown down from day to day, and also other refuse canes which had been as carefully avoided by the collectors, for the field had been finished the week before. These canes would have spoiled any sugar made by the old process, and reduced it to the state of molasses. There must have been no opportunity for deception when surrounded by practical Indians, who were the adverse witnesses, and the assistants at the whole process. At the conclusion, each of them solicited, and bore away a portion of this sugar-product of superior quality, as if it were a trophy.

The owner of that plantation, and also the Padre Curé of that parish, voluntarily and separately recorded the unanimous verdict.

We have been contemplating no accident, but the result of a plan based on known laws, that can be carried out into practice, in all its completeness by the sugar-planter, to his immense profit.

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[*] The Planters of Cuba, being aware of this loss, proffered their thousands to Don Alvaro Reinoso, to cover his expenses, immediately that native chemist announced his ability to overcome the difficulty. He failed in practice, and their anxieties remain unsatisfied.

[†] "Thousands of tons of sugar have been manufactured by this process at home and abroad. * * * No accident ever can arise *if the directions be complied with*. Instead of merely getting out 7 per cent. of the 18 to 23 found in cane-juice, as now accomplished in the West Indies, he has seen 20 *per cent. extracted from Spanish cane-juice*. In the very first year of this patent he sold a fortieth part for £2,000, and the sale was considered a favour. A London refiner, moreover, paid him £1 per ton royalty on his produce, about £150 per week."—History of Sugar," by William Reed. Longmans, Green, & Co., pp. 95-96.

[‡] "If a portion of moderately rich sugar-cane were handed to the chemist for laboratory experiment, the chemist would rarely extract less than 17 per cent. of pure white sugar. Supposing the cane to be very rich, then the quantity of pure white sugar extracted might amount to no less than 23 per cent. In commercial practice rarely is more than 7 per cent. extracted, and that not in the condition of pure white sugar, but of a yellow or yellowish brown product, commonly called "muscovado." *It would be in vain to scan the records of chemical manufactures to discover a sacrifice so great*, and, what is still more to the purpose, there seems very little hope of amelioration." *Idem*, p. 83.

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## ON THE RESOLUTION OF THE SOUNDING FLAME.

By Professor Francis H. Smith.

By those who have no mirrors, lenses, or revolving apparatus, and who find a difficulty in properly moving the eyes to and fro before the flame, the intermittent character of the latter, when sounding, may be exhibited by simply shaking a chalk crayon near it, and noting the marked change assumed in the appearance when the flame passes from silence to song.

With a revolving apparatus, however, the following form of experiment will be found satisfactory:—"To the margin of a blackened disc of cardboard was cemented a silvered glass bead. This was set into rapid rotation in a dark room, and in close proximity to the flame in the glass tube. While the flame was silent, there was presented to the eye fixed upon the revolving bead a complete luminous circle, which, when the flame began its song, was broken up into detached beads of light. By increasing the velocity of the disc, these brilliant points, or lumps, were reduced in number, and stretched into separate luminous arcs. The tube used was 3ft. long, and it was found possible to secure such a speed as to have only five luminous arcs. If the revolving mechanism be furnished with a counter or register, like the syren, we have here a simple and ready method of determining the number of vibrations per second of a sounding flame. For this purpose the bead should be light and the disc small. For lecture-room illustration the silvered ball should be large, so as to give a larger image of the flame and a more voluminous bright circle.

To illustrate the use of the method suggested above, let me cite the following measurement:—Employing a glass tube 3⅛ft. long, with an average diameter of nearly $1\frac{11}{16}$in., and keeping the bead whirling so as to present five stationary luminous arcs, the first and second observations gave each 1576·8 rotations of the disc in 43 seconds. The third and last gave 2014·8 rotations in 56 seconds. Giving to each observation the same weight we have 182·2 vibrations of the sonorous flame per second.

The syren, applied to the same problem, gave 177·7 vibrations per second; but it must be added that I found it impracticable to keep my syren exactly in unison with the flame at so low a note. Beats were heard during almost the entire period (90 seconds) of the experiment.

The note in question, compared with those of a set of excellent tuning forks made by Richie, of Boston, was nearly F.

Again, the luminous arcs were, as nearly as I could judge, about 48° each in extent. This being so, the light of the sounding flame endured conspicuously at each pulsation 0·00366, or $\frac{1}{273}$ of a second.

It was noticed, too, that each are varied in brightness, the point of maximum illumination being, not at the centre of the arc, but beyond it; so that it would appear that in each luminous interval, the flame lost its light more rapidly than it acquired it.

I have spoken of the luminous arcs as though they were absolutely detached from each other. So they appear to a careless observer. A close scrutiny, however, revealed an extremely faint and fading thread of bluish light uniting them. Hence, in this case at least, we cannot accept Dr. Tyndall's conjecture that there is an absolute extinction, periodically, of the singing flame.

I have applied the revolving silvered ball to the solution of the following problems:—

1. To adjust two sounding flames to exact unison, or to test the perfection of accord between two apparently unisonant flames.

The revolving ball presented to the two flames, gives two intersecting circles of images, which, in case of exact unison, are equal in number, and present identically the same retrogradations, stations, and advances, during the variable motion of the ball.

2. To determine the exact, or the approximate value of the musical interval between two sounding flames. Adjusting the velocity of the ball so that each flame gives a circle of stationary images (luminous arcs), the relative number of these images will express the interval required. Thus, for one pair of flames, I found the interval to be 2 : 1; for another pair, 4 : 3.

If, when one set of images is stationary, the other set has a slow motion, the relative number of the images will give an approximate value of the interval, the direction of the motion with respect to that of the ball determining whether the value is too large or too small.

For these applications it is obviously unnecessary for the rotating mechanism to be furnished with a register. Indeed a kaleidophone might be used for the same purpose, though with some inconvenience. The silvered balls I have employed vary from half-inch to 2in. in diameter.

In the progress of these experiments, it was often noticed that the luminous arcs, or stretched images, of the sonorous flame, were placed in echelon. The reason is manifest, when the silvered ball is revolved slowly and close to the flame. The separate images are then found to be inclined in the direction of revolution, their inclination augmenting with the velocity of the convex mirror, and the slope of the after image being steeper than that of the front edge. The same tilting of the images occurs, as is well known, in resolving the flame either by Wheatstone's or Tyndall's processes, when the mirrors, plane or concave, is rapidly turned. I am not aware that the significance of this fact has attracted attention. Does it not indicate that the flame both recovers and loses its light progressively from base to summit, the loss being more rapid than the recovery, and that at no single instant of its history is the sounding flame such in size and form, as it appears to be when steadily viewed? Moreover, if the flame, in any case, be rekindled from above, as it must be, if it is ever absolutely extinguished while sounding, it would seem that its image on its first edge at least should be tilted in a direction opposite to the motion of the mirror.

I shall conclude these notices by stating a fact bearing upon the theory of these flames. I have found no difficulty in causing the flame to sing when inserted quietly into a horizontal tube carefully levelled. Tubes of various lengths and diameters were used. In narrow horizontal tubes, the vibrations are soon arrested by the accumulating products of combustion. In a tube 1¾in. in diameter and 3ft. long, the flame sang for an indefinite time. While it was sounding, no drifting of smoke previously introduced into the tube, or of a column of smoke rising past its distant end, could be detected. It is easy to pass from the ordinary erect position of the tube and gas jet, through all grades of inclination to the inverted position of both, without cessation of the sound, and without disturbing the axial position of the flame.

If by maladroit handling the flame is silenced at the critical attitude, it will be observed that the latter is below the horizontal position.

## ON NITROGLUCOSE.

By M. Carey Lee.

As nitroglucose has been much less studied than its congeneric nitro-substitution compounds, pyroxylin, xyloidin, and nitroglycerine, a few words on its preparation and properties may not be uninteresting.

The substitution does not take place in sugar with quite the same facility as with cellulose; the acids need to be stronger, and the temperature lower. The sugar, moreover, appears at first to dissolve, and then to separate out again in the form of a greyish paste, which, when thrown into water and freed from the adhering acid, becomes nearly white.

An attempt to prepare nitroglucose by the use of nitre and sulphuric acid, which succeeds so well and so easily in the case of cellulose, failed almost wholly with sugar. Not more than two or three per cent. of the weight of the sugar was obtained.

With sulphuric and strong nitric acids, allowed to cool thoroughly after mixing, the reaction takes place easily, and a considerable quantity of nitroglucose is obtained. The nitric acid should be as strong as possible, and as the acid of the requisite strength is not easily obtained commercially, I found an advantage in using in part the fuming sulphuric acid. Two fluid ounces of fuming sulphuric acid, two of common sulphuric, two of strong nitric acid, as near to 1·5 sp. gr. as can be obtained, give good results. The sugar is stirred up in the form of powder, to a thin paste. The stirring is kept up, and as fast as the nitroglucose separates in doughy masses, it is removed with a spatula and thrown into cold water. A further addition of sugar will give more nitroglucose, but considerably less in proportion than the first edition. As soon as possible, the nitroglucose is to be kneeded up with cold water to get the acid out. In one case, when this was neglected for ten or fifteen minutes, the nitroglucose passed to a greenish colour, and apparently was undergoing a commencing decomposition.

The removing of the adhering acid is much more difficult than in the case of pyroxylin, and is an extremely disagreeable operation. The acid pervades the whole of the doughy mass so fully that the fingers are stained and burned by it, nor can the whole of the acid be removed satisfactorily in this way. The best means I found was to dissolve the crude nitroglucose in a mixture of alcohol and ether, and then to pour this into a large quantity of cold water with constant stirring, and violent agitation afterward. The method is not altogether satisfactory, and seems to be attended with some loss of material, though why, it is not easy to see.

Prepared in this way, nitroglucose is a white lustrous body which may either assume the doughy amorphous condition or the crystalline, and passes from one to the other with extreme ease. When first formed by the mixed acids, it always has the doughy form. That which I obtained by the use of nitric and sulphuric acid, was crystalline from the first. When precipitated by water from its solution in alcohol and ether, it is doughy and almost liquid, and remains so for a long time, if there is any considerable quantity of it.

The best mode of preserving it appears to be under water. By standing thus it gradually hardens, and passes sometimes to a somewhat hard amorphous mass, and sometimes to a granular crystalline state. It appears to be wholly insoluble in water. A few minute grains of the crystalline form diffused through 15 or 20 ounces of water, did not dissolve after many hours standing. In a mixture of alcohol and ether it dissolves as easily as sugar in water, and in such quantity as to make the liquid syrupy.

Its detonating properties are but slight. If it be well dried and a match be applied, it deflagrates with a feeble flash.

It has been stated by Dr. V. Monckhoven that when dissolved in alcohol and kept some time in a warm place, it undergoes decomposition, as evidenced by the fact that the solution then gives an abundant precipitate with nitrate of silver, which at first it did not do. An experiment made in this direction did not give the result thus indicated. A solution of nitroglucose in alcohol, containing about 40 grains to the ounce, was placed in a stoppered vial, and was kept in the sand bath at a temperature of about blood heat for nearly a month. But neither it nor a fresh solution gave a precipitate with alcoholic solution of nitrate of silver. It would seem from this that certain conditions of temperature or otherwise are necessary, in order that this decomposition should take place.

## REVIEWS AND NOTICES OF NEW BOOKS.

*A Record of the progress of Modern Engineering*, 1866, *comprising Civil, Mechanical, Marine, Hydraulic, Railway, Bridge, and other Engineering Works, with Essays and Reviews.* Edited by William Humber, A.I.C.E.; M.I.M.E., London, Lockwood and Co., 7, Stationers' Hall Court, 1868.

We gladly welcome another year's issue of this valuable publication from the able pen of Mr. Humber. The accuracy and general excellence of this work is well known, while its usefulness in giving the measurements and details of some of the latest examples of engineering, as carried out by the most eminent men in the profession, cannot be too highly prized. In this year's issue a greater variety of subjects have been treated upon, and, we think, with advantage, as it makes the work of more general interest than when exclusively devoted to one branch of engineering. The subjects that were treated upon in the last volume, viz., The Main Drainage and Thames Embankment are here made still more complete by some excellent illustrations of the Abbey Miles Pumping Station of the former, and some useful extracts from the specifications of the latter. The article on Harbours, Ports and Breakwaters, that was treated upon in a former volume, has been concluded by some very useful plates upon this subject, those illustrating the Barrow and the Millwall Docks, are particularly serviceable, giving besides, general plans of both docks, full details of every part of each of them. In Roofs and Bridges, Mr. Humber is a well known authority. Of the former, there are several examples, some of which, as for instance, the Cannon-street Station Roof, and various station roofs on the Metropolitan Railway, are excellent modern examples of this branch of engineering. The examples of bridges and viaducts are also very good, including a lofty viaduct on the Santiago and Valparaiso Railway, and a very pretty bridge of 100ft. span, for Mauritius. The descriptions of these and the various other plates is lucid and concise, while to make the work as useful as possible to practical men, they are accompanied in several cases with their specifications. On the whole we think that this is the best volume of the Record of the Progress of Modern Engineering that Mr. Humber has yet edited.

*On Iron Shipbuilding, with practical examples and details in forty plates, together with text containing descriptions, explanations and general remarks, for the use of ship owners and shipbuilders.* By John Grantham, M.I.C.E., and N.A., Fifth Edition, Lockwood and Co., 7, Stationers' Hall-Court, London, 1868.

The fact that this work has reached the fifth edition is sufficient, without any praise from us, to testify its excellence. As it has before been noticed in The Artizan, it will be sufficient to mention that this edition has been considerably enlarged and brought down to modern times by a supplement; this supplement increasing its size to nearly half as much again. This addition contains several large illustrations of our latest armour plated ships, such as the Bellerophon, Hercules, &c., as well as some fine examples from the mercantile marine. In it, also, Mr, Grantham investigates the question of steel *versus* iron, upon which, however, he does not venture to express a decided opinion, although evidently inclining somewhat in favour of steel. We notice that the alterations in Lloyds' Rules are given so that shipbuilders may construct their vessels in conformity with them, and also that to this edition is added several examples of the latest improvements in tools employed in iron shipbuilding.

## CORRESPONDENCE.

***We cannot hold ourselves responsible for the opinions of our Correspondents.***

### WATER SUPPLY OF THE METROPOLIS.

*To the Editor of* The Artizan.

Sir,—We have read with great interest your report of Professor Frankland's lecture at the Royal Institution, on the Water Supply of the Metropolis, and as there are in it some observations bearing upon filtration, a few remarks from us may not be out of place.

Dr. Frankland, in speaking of the various impurities of an organic nature contained in drinking-water, refers to the spores or germs of organic life, which are supposed, under favourable circumstances, to produce disease—"each one containing within itself the power of indefinite multiplication and mischief." He also mentions the extreme difficulty of getting rid of these spores when once they have been introduced into water. "Filtration," says the Doctor, will not do it; neither will boiling for several hours."

Now, on reference to The Artizan of July 1, 1867, p. 167, we find that you then called attention to the existence of these spores in the water contained in cisterns, and you were good enough to recommend the Silicated Carbon Filter as the only one which had the power of arresting them and preventing their passing through with the water.

We take leave to say, that although the ordinary modes of filtration through coarse animal charcoal, or through charcoal and sand, are inadequate to the removal of these germs, the principle upon which our filters are constructed renders the passage of even microscopic objects physically impossible, and that the most rigorous chymical and microscopic examination of the filtered water fails to detect the slightest trace of organic matter. Your obedient servants,

The Silicated Carbon Filter Company.

### LIQUID FUEL.

*To the Editor of* The Artizan.

Sir,—Our attention has just been drawn to a notice of the Aydon system of burning liquid fuels, contained in The Artizan for July, in which you speak of Mr. Aydon as a member of "*the firm of* Wise, Field, and Aydon."

This is an error, which, if not corrected, may lead to serious misapprehension. We therefore beg to state that there is no such firm, Messrs. Wise, Field, and Aydon being merely joint patentees of the invention in question; and that no partnership whatever does exist, or ever has existed, between *any* of those gentlemen, nor is either Mr. Field or Mr. Aydon in *any* way connected with our firm. We simply act as agents for the patentees.

The insertion of this short explanation in your next issue will oblige, Sir,

Yours very obediently,
Francis Wise & Co.

## Obituary.

### DEATH OF MR ALEXANDER MITCHELL.

The Belfast *Northern Whig* announces the death of Mr. Alexander Mitchell, a gentleman who, though blind from an early age, led an active, working, and successful life. He was possessed of mechanical genius of a very high order; and he conceived many an invention which under more favourable circumstances he might have successfully carried out. He is, however, well and widely known for one—that of the screw-pile, used in the building of lighthouses and the mooring of ships in harbour. He was born in Dublin on the 13th April 1780, and was consequently in the eighty-ninth year of his age when he died.

It is said that the idea of the screw-pile occurred to him at a social reunion, the members of which had been disturbed by a cow that had pulled up her tether-stake, and rushed about the fields in such a way as to alarm some of the friends then assembled. He was told that all sorts of fasteners, wood and iron, thick and thin, had been tried upon the animal, but in vain; nothing would hold her in except the trunk of a tree round which her halter had to be entwined. He said at once that a stake with a screw at the point, would prevent her from breaking loose. The idea recurred to him when he was meditating another invention. He had an idea that a floating graving-dock for the repairing of ships might be made of wood, which might be moored in the bay or roadstead. But here he was met with the difficulty—how could such a huge structure be secured in its place, notwithstanding the action of the winds above, and the tides below? He easily perceived that no anchors or moorings (which are permanent anchors), then in use, would be sufficient for his purpose, and his mind recurred to the experiment which had been tried upon the refractory cow years ago. He proposed, therefore, to lay down moorings, which, having broad flanges in the form of a screw, might be forced into the mud, shingle, or sand at the bottom of the bay, to such a depth that the superincumbent mass would oppose a resistance which no power of the tide or wind would be able to overcome. And it further struck him that a mooring thus buried deeply in the bed of the harbour would exhibit no shank such as would foul the ground and expose vessels to danger. The graving-dock was never carried into effect; but the screw-mooring, after standing a long warfare of ridicule and prejudice, has been adopted in every tidal harbour in Europe, and has everywhere been found a most important and useful invention. Of many hundreds that are now in use, and have been in use for the last twenty years, not one has ever yet given way by "coming home;" and it is impossible that any accident could occur by their fouling the ground.

### DEATH OF CAPTAIN BLAKELY.

We regret to learn of the death, in the prime of life, of Captain Blakely, late of the Royal Artillery, and whose name has been prominently before the public for the last few years in connection with the improvements in ordnance introduced by him, unfavoured and unaided by Government patronage. We believe that a considerably greater number of Blakely guns than of any other ordnance have been sent abroad and have found favour in every part of the world where they have been introduced.

Captain Blakely's death took place at Chorillos, Peru, early in May, from an attack of yellow fever; the deceased Theophilus Alexander Blakely was the only surviving son of the late Very Rev. Theophilus Blakely, Dean of Down, and was in his forty-first year. Naturally of a delicate constitution his health had already been severely taxed by the years of hard study which he had devoted to the important subject of improvements in ordnance.

## NOTES AND NOVELTIES.

### MISCELLANEOUS.

Ramie.—An American paper states that the Ramie plant, which was introduced into the States from Java, to the soil of which it is indigeneous, is attracting much attention in the south. It is claimed, that if properly cultivated and worked, it will take the place of cotton and supply any deficiency in that great staple production. Its fibres are said to be much finer and stronger than the best flax; that they are as fine as Sea Island cotton; and that after cleaning they become very soft and white, and take colours as readily as the finest wool or silk. Several articles of clothing made from this fabric were lately exhibited at an agricultural fair in Alabama, and attracted much attention by the strength and beauty of the material. The cultivation of the Ramie plant is said to have succeeded on a number of plantations in Alabama.

Kohn, an engineer in Berlin, gives the following as a method of effectually stopping up a porous cylinder cast for a hydraulic press. The cylinder is heated over a charcoal fire to about 170° Fahr. It is then filled up with resin and suspended by a crane over the fire until the liquified resin is seen sweating through on the outside. The excess of resin is then poured out and the cylinder allowed to cool, when the pores will be found completely stopped, so that no water can possibly pass.

The following trials have been made with the ships composing the Channel Fleet under the command of Rear Admirals Warden and Ryder. The fleet left Portland Roads under steam on the 4th June, and during the cruise made had fine weather, with the exception of fogs and summer mists, and, consequently, no opportunity occurred for trying the seaworthiness of the ships or what their behaviour would be in a gale or heavy seaway. On 20th June a trial of sailing was made with the following conditions and results:—Wind, N.W., force, 4 to 6; signal made at 11 a.m.; "Chase to windward" at 1.25 p.m. The fleet tacked to signal from the flagship, and at 2.50 p.m., discontinued the chase. From 11 a.m. to 2.50 p.m. the *Warrior* gained on the *Minotaur* 6,139yds., *Bellerophon* 11,432yds., *Royal Oak* 5,641yds., *Defence* 3,800yds., *Achilles* 4,695yds., *Prince Consort* 5,737yds., *Pallas* 4,464yds. On the 29th a second trial of sailing was made, lasting from 10 a.m. to 5.15 p.m.; wind east, force 5 to 6; signal, "Chase, E.S.E." In this trial the *Warrior*, still retaining her unconquerable character, gained on *Minotaur* 15,649yds., *Bellerophon* 19,004yds., *Royal Oak* 10 647yds., *Defence* 7,159yds., *Achilles*, 7,043yds., *Prince Consort* 17,023yds., *Pallas* 9,928yds.

Italy.—According to statistics, which the recently imposed mill tax has rendered it necessary to collect, in the 8,562 communes or parishes of this kingdom, inhabited by 24,265,428 persons, there are 52,568 mills, having 78,813 grinding apparatus. There are also 2,465 machines for rice. The quantity of wheat annually ground is estimated at 24,520,372 quintals. The quantity of rice is 2,885,467 quintals. The other articles ground amount altogether to 15,092,801 quintals. The total of alimentary substances annually ground is, therefore, 43,198,640 quintals and 1·78 quintal per head. The consumption per head is 1·01 of wheat, 0·11 of rice, and 0·65 of other substances.

Postal communication is maintained by the Royal Mail Company under Government contracts by means of eight distinct routes. The first and chief of these routes is from Southampton to St. Thomas, a distance of 3,622 miles, which is performed in 14 days nine hours twice a month. There are three routes from St. Thomas, two being performed twice, and one once a month. The first includes Jacmel (Hayti), Jamaica, and Colon, a total distance of 1,275 miles; the second, Porto Rico, Havannah, Vera Cruz, and Tampico, 2.083 miles: and the third, St. Kitt's, Antigua, Guadaloupe, Dominica, Martinique, St. Lucia, Barbadoes, and Demerara, 935 miles. There are two routes from Colon performed severally once a month; the first includes Carthagena and Santa Martha, 415 miles; and the second Greytown, 248 miles. One service is worked from St. Lucia twice a month, which includes St. Vincent, Grenada, Trinidad, and Tobago, a total distance of 318 miles. The eighth route (from Southampton) is performed once a month, and includes Lisbon, St. Vincent (Cape Verd), Pernambuco, Bahia, Rio Janeiro, and thence to Montevideo and Buenos Ayres, a distance of 6,326 miles which is completed in 36 days four hours.

Newport Steel Works.—The steel works recently erected by Messrs. B. Samuelson and Co., near Middlesborough, for the purpose of manufacturing steel by Martin's process have been got into successful operation, several casts having been already made.

Rattening.—Messrs. Bunnett and Co., of New Cross, have received a threatening letter from the "General Secret Committee," to the following effect:—"We have to inform you that a resolution has been passed condemning the system of piecework, as most obnoxious to trades' unions, and after the ensuing month should you attempt to deviate from the tenour of this intimation you must bear the consequences." Several other firms have been similarly threatened.

Destruction of a Shipbuilding Yard by Fire at Montrose.—One of the most destructive fires that has occurred in Montrose for many years took place on the night of the 1st of June. On that evening, the harbour-master, Captain Reid, observed smoke issuing from the boiler-house of the shipbuilding yard occupied by Mr. Petrie, and gave the alarm. In a short time the brigade was on the spot, under the command of Captain D. Mitchell, and four hose were soon at work on the burning yard. The Militia were also called out, under command of several of the officers. The fire by this time had made considerable progress. From the boiler-house it went into the office, and to some outhouses; then it seized upon a large ship of about 500 tons, which was all planked, and upon another, the ribs of which were nearly all up. The yard being full of inflammable material, there was a great blaze, which was seen for miles round. Between one and two o'clock the large ship fell in pieces, and it was not till three o'clock that all danger was past. The only thing saved in the yard was the smithy.

Steam Floating Fire-Engine at Calcutta.—A floating steam fire-engine which was tried on the river Thames, and noticed in The Artizan of last year, has been tried at Calcutta. The boat and engines, with pump, were taken to pieces in segments and shipped to Calcutta, where it has since been put together under the supervision of the chief engineer of her Majesty's Dockyard. A very satisfactory report has been forwarded to the makers, Messrs, Shand, Mason, and Co., of London, and we have no doubt that the present successful result of their skill will further establish their reputation for that class of machinery.

Steam Fire-Engines for Singapore.—Two new steam fire-engines of a medium size have just been shipped from the works of Messrs. Merryweather and Son, of London, for the service of the fire-brigade of Singapore. The authorities were induced to adopt steam fire-engines in consequence of the feeble effects produced by manual-power engines on large fires, especially in tropical countries, and of the great benefits that have been found to accrue from their now extended use. The engines in question are of the pattern "L'Imperatrice," one of the engines for which this firm were awarded the first prize and only gold medal at the late Paris Exhibition. We fear, however, that from the nature of many of the buildings in Singapore, especially those occupied by the Chinese, even steam fire-engines will scarcely suffice to prevent the recurrence of large fires which periodically occur.

Extraordinary specimens of wheat and oats, grown on sewage farms, were exhibited at the meeting of the Metropolitan Board of Works.

### SHIPBUILDING.

Shipbuilding on the Clyde.—Messrs. Randolph, Elder, and Co., have launched the *City of Rio de Janeiro*, an iron steamer, of 1,420 tons burden, builders' measurement, and 300 horse-power nominal. The *City of Rio de Janeiro*, which will be engined by her builders, is of the following dimensions:—Length between perpendiculars, 265ft.; breadth, 33ft.; and depth (moulded), 27ft. 8in. She has been built to the order of Messrs. P. Tait and Co., of London, and is intended for the London, Belgian, Brazil, and River Plate Steamship Company. Messrs. Aitken and Mansel, of Whiteinch, have launched a screw of 860 tons, builders' measurement, named the *Headquarters*. This vessel has been built to the order of Mr. W. Lang, of Leith, and will be fitted with compound high and low pressure engines of 110 horse-power, by Messrs. J. Aitken and Co., of Cranston Hill. Messrs. Caird and Co., of Greenock, have contracted to build two additional steamers, to ply between Bremen and Baltimore, for the North German Lloyd. The steamers are to be ready for sea within ten months. The *Samaria*, built by Messrs. J. and G. Thomson, for the Atlantic service of Messrs. Burns and McIver, has just been launched. Her dimensions are as follow:—Length, 325ft.; breadth, 39ft. 6in. depth, 28ft.; and gross burden, 2,600 tons. The *Samaria* will be fitted with engines of 400 horse-power. The *De Buffel*, armour-clad twin screw turret ram, built by Messrs. R. Napier and Sons for the Dutch Government, has made a trial trip, in which she attained a mean speed of 12·82 knots per hour, while with her screws alone, one going ahead, and the other backing, she made a complete revolution in about four and a-half minutes. The *De Buffel*, being a twin screw, has two distinct pairs of engines, of the collective force of 400 horse-power nominal. She is fitted with two 300-pounders 11½ton Armstrong guns. Her principal dimensions are as follow:—Length, 205ft.; breadth, 40ft.; depth, 24ft. Her sides are plated with armour 6in. thick, with a backing of teak, 10in. thick, and this again over an inner skin of iron 1in. thick, supported by strong iron frames. She has one revolving turret on Capt. Coles's principle, plated with 8in. armour with a backing of 12in. teak.

### STEAM SHIPPING.

It appears that while in 1853, 1,385 steamers of an aggregate burden of 250,112 tons, were registered as belonging to the United Kingdom, the total had risen in 1867 to 2,931 of an aggregate burden of 901,062 tons, or very nearly one-sixth of the whole tonnage registered, while the corresponding proportion in 1863 was only one-sixteenth. The number of steam vessels built and registered in the United Kingdom in 1853 was 153, in 1854 174, in 1855 233, in 1856 229, in 1857 228, in 1858 153, in 1859 150, in 1860 198, in 1861 201, in 1862 221, in 1863 279, in 1864 374, in 1865 385, in 1866 354, and in 1867 315. The building of steamers appears to have fallen off within the past two years, a result attributable to the depression which has occurred since the monetary crisis of May, 1866 in commercial affairs.

### LAUNCHES.

Messrs. Andrew Leslie and Co., launched at Hepburn, the third of three small screw steamers, named the *Echo*, built for Messrs. Gaudet Freres, of London and Paris. Her size is 120ft. long by 20ft. beam by 10ft. deep, and she is fitted with high pressure expansive engines of 50-horse power. These steamers are built for running a daily service between England and France, and will attain a speed of 11 knots per hour. They are constructed with lowering masts and funnels, for passing under the bridges on the Seine, and can so go direct up to Paris.

Messrs. Cairn and Co., of Greenock, have launched a magnificent screw steamer, of 2,800 tons, named the *Westphalia*. She is a sister to the *Holsatia*, and is in every respect the same, and is for the same company, viz., the Hamburg and American Steam Packet Company.

Messrs Scott and Co. launched from their yard on the Clyde a handsome screw named *Hispania*, of 400 ton. She is the property of Messrs. Moris, Munro, and Co., Glasgow, and will be employed in the Mediterranean trade. The engines, which are compound high and low pressure, will be put on board by the Greenock Foundry Company.

There was lately launched from the yard of Wm. Denny and Brothers, on the Clyde, a iron screw steamer, 1,700 tons of the following dimensions:—274½ft. and 34 by 26. She will be fitted up in handsome style for passenger accommodation, and supplied with engines of 400 horse-power nominal, by Denny and Co.

### TELEGRAPHIC ENGINEERING.

Indian Telegraphs.—From 1857 to 1866 the length of telegraphs in British India increaseed from 4,162 to 13,390 miles. In the latter year the total expenditure for telegraphs amounted to £253,791. £48,067 of which was the cost of construction, £163,392 on account of working and maintenance, and £41,732 spent in England for stores, freight, &c. The total receipts for the same year amounted to £112,944, £101,307 of which were derived from private messages and other sources, and £11,638 from service messages of all kinds. There has been a large progressive increase of receipts year by year since 1857, except in 1860, and there are now 172 offices open throughout the country for the use of the public.

Telegraph Extension.—We understand that a surveying vessel has been despatched from Malta, by direction of the Government, for the purpose of sounding the direct route between Malta and Alexandria, preparatory to the submersion of the cable now being manufactured for the Anglo-Mediterranean Telegraph Company by the Telegraph Construction and Maintenance Company, at their works at Greenwich.—The *Narva*, with the Cuba cable, has arrived at Key West, and it is daily expected that the news of the wire having been successfully laid will be received in England.—A cable about 11 miles in length is being made for the Isle of Man Company for the purpose of restoring the communication between Whitehaven and the island. The cable will be composed of some of the old Hague cables purchased from the Electric and International Company. These are served with hemp, and strengthened with galvanised iron wire of No. 3 guage. The core of the proposed cable had been sunk in the North Sea for several years. It was then picked up and laid across the Irish Channel to Howth, and was then again brought up from the depth of the sea. Its future uses we have indicated.—It is contemplated to lay a cable between Peterhead, in Scotland, and Norway. The length of the cable will be about 300 miles.

### RAILWAYS.

The traffic receipts on the Mount Cenis railway for the week ending the 21st of June, amounted, for the conveyance of 300 passengers and for luggage, parcels, and mails, to £313.

**East Indian Railways.**—At the end of the year 1866, 3,452 miles of railways were open for traffic in India. During the year these railways conveyed a total of 10,120,910 passengers, the receipts for which amounted to £1,278,586. The receipts for goods traffic were £3,328,656, and the total receipts amounted to £4,607,236; £2,056,411 being derived from those in Bengal and the north-western provinces, £476,667 from the presidency of Madras, £1,930,723 from that of Bombay, £53,166 from Scinde, and £90,269 from railways in the Punjab. The total working expenses during the year amounted to £2,225,995, so that the nett receipts amounted to £2,381,241. Receipts for goods traffic include telegraphs and sundries, and the charges of maintenance are included under the head of working expenses. The total capital paid up to the end of the same year amounted to £64,483,834, and the total interest to £18,929,576 sterling.

**Mr. Brunlees**, C.E., who has been employed by the contractors of the Honduras Railway loan to report on the value of the State domains pledged for its security, after a complete investigation said.—"I am quite satisfied from the careful way in which the information has been obtained as to the produce of the mines and the forests, that the interest in the present loan of £1,000,000 will be secure from these sources, independent of the earnings of the railway, which, however, will be considerable, more especially when the settlement of emigrants shall have extended, as it is certain to do so immediately the line is known to be commenced; and I am further of opinion that the produce from the mines, the mahogany, and the dyewood can be so much extended as to secure the interest on a further loan for the completion of the whole railway." The contract for the construction of the railway has been undertaken at £8,000 per mile by Messrs. Waring Brothers and M'Candlish, who will commence operations at once, the loan applicable to the first section having been subscribed.

## ACCIDENTS.

**Another** of those terrible disasters so common on American waters occurred on Lake Erie, on the night of Saturday, the 20th June. The steamer *Morning Star*, going from Cleveland to Detroit, came in collision with the bark *Cortland*, when thirty miles out, and both vessels sank in a few minutes. The steamer carried 40 passengers, and had a crew of 30 men. The bark's crew numbered 13, making a total of 83 persons on both vessels. A passing steamer picked up 63 persons, leaving 20, who are missing and probably all lost.

**Advices** from Jamaica mention that Her Majesty's ship *Royalist*, while being hove down for the purpose of repair, righted suddenly through the failure of the heaving down gear, and carried away her masts. This had increased the interest in the proposals for the construction of graving-docks, and subscriptions had been already sent in for an amount beyond that reserved for the island.

**Bursting of the Boiler of a Steam Fire Engine in New York.**—The *New York Times*, of the 19th June says:—At nine o'clock last evening a fire was discovered on the fifth and top floor of No. 3 Bowery, which is almost immediately opposite the old Bowery Theatre. The engines of the district hurried at once to the scene, and first among them was No. 9 Company, lying in East Broadway, near Catherine Street, and in charge of Stuart Carson, fireman, and Patrick W. Hand, engineer. This engine took position close to the side walk immediately in front of the pit door of the Bowery Theatre, and began working. The fire was confined to the floor on which it originated inflicting only slight damage to the occupants and injury to the building. The engine of No. 9 Company continued to work steadily and without an accident for thirty minutes, when an order was issued to take up preparatory to going home. At the moment the order was given an act of the performance at the Bowery Theatre had just concluded, and men and boys poured out of the pit door upon the side-walk, and, as it were, upon the engine itself. The engineer—Patrick W. Hand—in compliance with the orders given made the necessary alterations, and turned on the cold water. Instantaneously came an explosion. The huge machine was lifted clear from the street, poised an instant in mid-air, and then fell with terrible force, crushing and crushed upon the side-walk. Masses of iron, grate bars, and pieces of rods were torn from the framework and hurled through the crowd of human beings, being thrown in some instances the length of one hundred feet. The steam from the rent boiler seethed the scalded its way through the dense mass of humanity at the same moment; and with both the scalding steam and the mangling iron came the terrible noise of the explosion as it shook the neighbouring houses, and with, it the shrieks of human agony. For some moments there were confusion and wailing. There were crushed, mangled, bleeding, writhing men and boys upon the side-walk; there was the huge machine, riven and hissing, upon its side. When order was obtained, the bodies of three men and one boy were found who had been killed outright, and the severely injured, 22 in number were sent in carriages at once to the New York Hospital. Of those sent to the hospital one died soon after admission, and several others are not expected to survive.

## DOCKS, HARBOURS, BRIDGES.

**The** third portion of the Thames embankment on the Middlesex side of the river is commenced. The work extends from the Temple to Blackfriars Bridge, and the undertaking must be completed in a year, according to the terms of the contract.

**Hopes** are entertained that the work of clearing the harbour of Sebastopol will be completed by the end of 1869. On May 20th the hull of the *Sviatoslaw* was raised so that on the second line there only remain the *Tchesma*, the *Maria*, and the *Ratislaw*. Afterwards the operations will be commenced on the first line, which, however, causes no obstruction to navigation.

**Another Submarine Tunnel.**—It is now proposed to make a tunnel to connect Scotland with Ireland. The points where the tunnel is to have its mouths are Leak's Point, in the Mull of Cantyre, and the coast of Antrim respectively. The length would be about 14½ miles, and the cost is estimated at only £3,150,000.

**The** dry dock at Martinique was opened last June. This a stone dock, and intended chiefly for the French navy, steamers, and traders.

## APPLIED CHEMISTRY.

**Oxyhydrogen Light.**—The magnesia cylinders having been found to corrode and waste away too rapidly for the purposes of a continuous light, M. Caron, after experimenting with a variety of substances, has adopted zircon, a substance which Berzelius pointed out as infusible, and giving forth a very brilliant light under the blowpipe. It is said that M. Caron has had a cylinder of this substance in use with the oxyhydrogen light for a month without the slightest trace of volatilisation. The luminous power of zircon, under the oxyhydrogen jet, is about one-fifth more than that of magnesia. The zircon employed is an oxide of zirconium; it is found principally near Miask, at the foot of the Ural Mountains. M. Caron economises the zircon by mounting a point of it on a small stick of magnesia or fire-clay, the zircon being made to adhere by compression and afterwards baking.

## LATEST PRICES IN THE LONDON METAL MARKET.

| | From | | | To | | |
|---|---|---|---|---|---|---|
| COPPER. | £ | s. | d. | £ | s. | d. |
| Best selected, per ton | 79 | 0 | 0 | 80 | 0 | 0 |
| Tough cake and tile do. | 77 | 0 | 0 | 78 | 0 | 0 |
| Sheathing and sheets do. | 78 | 0 | 0 | 79 | 0 | 0 |
| Bolts do. | 83 | 0 | 0 | ,, | ,, | ,, |
| Bottoms do. | 87 | 0 | 0 | 88 | 0 | 0 |
| Old (exchange) do. | 68 | 0 | 0 | 70 | 0 | 0 |
| Burra Burra do. | 81 | 0 | 0 | ,, | ,, | ,, |
| Wire, per lb. | 0 | 1 | 0 | ,, | 1 | 0½ |
| Tubes do. | 0 | 0 | 11½ | 0 | 1 | 0 |
| BRASS. | | | | | | |
| Sheets, per lb. | 0 | 0 | 9 | 0 | 0 | 10 |
| Wire do. | 0 | 0 | 8½ | 0 | 0 | 9½ |
| Tubes do. | 0 | 0 | 10½ | 0 | 0 | 11 |
| Yellow metal sheath do. | 0 | 0 | 6¾ | 0 | 0 | 7½ |
| Sheets do. | 0 | 0 | 6¾ | 0 | 0 | 7 |
| SPELTER. | | | | | | |
| Foreign on the spot, per ton | 19 | 15 | 0 | 20 | 0 | 0 |
| Do. to arrive | 19 | 15 | 0 | 20 | 0 | 0 |
| ZINC. | | | | | | |
| In sheets, per ton | 25 | 10 | 0 | ,, | ,, | ,, |
| TIN. | | | | | | |
| English blocks, per ton | 96 | 0 | 0 | ,, | ,, | ,, |
| Do. bars (in barrels) do. | 97 | 0 | 0 | ,, | ,, | ,, |
| Do. refined do. | 98 | 0 | 0 | ,, | ,, | ,, |
| Banca do. | 94 | 0 | 0 | ,, | ,, | ,, |
| Straits do. | 93 | 0 | 0 | ,, | ,, | ,, |
| TIN PLATES.* | | | | | | |
| IC. charcoal, 1st quality, per box | 1 | 5 | 6 | 1 | 8 | 6 |
| IX. do. 1st quality do. | 1 | 11 | 6 | 1 | 14 | 6 |
| IC. do. 2nd quality do. | 1 | 4 | 6 | 1 | 5 | 6 |
| IX. do. 2nd quality do. | 1 | 10 | 6 | 1 | 11 | 6 |
| IC. Coke do. | 1 | 2 | 6 | 1 | 3 | 0 |
| IX. do. do | 1 | 8 | 6 | 1 | 9 | 0 |
| Canada plates, per ton | 13 | 10 | 0 | ,, | ,, | ,, |
| Do. at works do. | 12 | 10 | 0 | ,, | ,, | ,, |
| IRON. | | | | | | |
| Bars, Welsh, in London, per ton | 6 | 5 | 0 | ,, | ,, | ,, |
| Do. to arrive do. | 6 | 5 | 0 | ,, | ,, | ,, |
| Nail rods do. | 6 | 15 | 0 | 7 | 0 | 0 |
| Stafford in London do. | 7 | 7 | 6 | 8 | 10 | 0 |
| Bars do. do. | 7 | 5 | 0 | 9 | 10 | 0 |
| Hoops do. do. | 8 | 2 | 6 | 9 | 15 | 0 |
| Sheets, single, do. | 9 | 0 | 0 | 11 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. mrch. Tyne or Tees do. | 6 | 10 | 0 | ,, | ,, | ,, |
| Do. railway, in Wales, do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. Swedish in London do. | 9 | 17 | 6 | 10 | 2 | 6 |
| To arrive do. | 10 | 2 | 6 | ,, | ,, | ,, |
| Pig No. 1 in Clyde do. | 2 | 13 | 0 | 2 | 16 | 0 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | ,, | ,, | ,, |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 7 | 0 | 0 | 7 | 10 | 0 |
| STEEL. | | | | | | |
| Swedish in kegs (rolled), per ton | 14 | 5 | 0 | ,, | ,, | ,, |
| Do. (hammered) do. | 14 | 15 | 0 | 15 | 0 | 0 |
| Do. in faggots do. | 16 | 0 | 0 | ,, | ,, | ,, |
| English spring do. | 17 | 0 | 0 | 23 | 0 | 0 |
| QUICKSILVER, per bottle | 6 | 17 | 0 | ,, | ,, | ,, |
| LEAD. | | | | | | |
| English pig, common, per ton | 19 | 0 | 0 | ,, | ,, | ,, |
| Ditto. L.B. do. | 19 | 0 | 0 | ,, | ,, | ,, |
| Do. W.B. do. | 21 | 5 | 0 | ,, | ,, | ,, |
| Do. sheet, do. | 19 | 17 | 6 | 20 | 5 | 0 |
| Do. red lead do. | 20 | 10 | 0 | ,, | ,, | ,, |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 10 | 0 | ,, | ,, | ,, |
| Spanish do. | 18 | 10 | 0 | 18 | 15 | 0 |

* At the works 1s. to 1s. 6d. per box less.

## 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 June 23rd, 1868.

2018 C. M. H. Downing—Improvements in fire-arms, &c.
2019 H. A. Bonneville—Carding wool
2020 J. and A. Douglas—Reaping machines
2021 C. Johnson—Improvements in boilers
2022 A. V. Newton—Folding chair
2023 A. V. Newton—Brick machine
2024 P. and B. Brown—Staff to ascertain the irregularities in the surfaces of millstones
2025 C. T. Burgess—Reaping machines
2026 W. Sowerby—Rails to be used on common roads

### Dated June 24th, 1868.

2027 D. M Giacometti—Apparatus for economising motive power
2028 C. T. Sutton—Apparatus to be used for educational purposes, &c.
2029 B. T. Moore—Protecting water pipes
2030 W. Carr—Carriages, &c.
2031 J. Gregory—Charring animal charcoal
2032 N. C. Underwood—Carding engines
2033 W. H. Crocker—Cartridges
2034 J. Mitchell—Furnaces
2035 S. Owens and T. Patterson—Raising or moving heavy bodies
2036 J. Lambert—Ornamenting lace, &c.
2037 M. and J. Mackie—Apparatus applicable to
2038 T. Restell—Military and sporting guns, &c.
2039 G. Smith—Ventilating boots, &c.
2040 E. B. Wilson—Furnaces
2041 R. Elsdon—Burning lime, &c.

### Dated June 25th, 1868.

2042 E. Mucklow—Utilising refuse tanning matters
2043 J. Briggs—Ingot moulds
2044 J. Jack—Applying auxiliary screw propellers to sailing ships
2045 E. Lever—Preparation or coating of woven fabrics which are to be subsequently rendered liquid proof or non-inflammable
2046 A. D. Aulton—Giving motion to sewing machines
2047 J. G. Garrard—Rick cloths
2048 Rev. H. Highton—Artificial stone, &c.
2049 G. T. Bousfield—Improvements in firearms and cartridges

### Dated June 26th, 1868.

2050 J. Hine—Apparatus for cutting or dressing millstones
2051 C. Hastings, J. Briggs, and J. Law—Finishing yarns
2052 C. D. Abel—Cleansing bottles
2053 T. Dodd—Apparatus for covering and uncovering railway trucks
2054 M. Burke—Folding chairs
2055 T. Winder—Marine chain stoppers
2056 R. Clough—Improvements in looms for weaving
2057 S. S. Maurice—Fastenings for neckties, &c.
2058 J. Taylor—Opening, cleaning, and preparing cotton
2059 A. Thomson—Waterclosets
2060 F. H. Holmes—Electro-magnetic machines
2061 L. Thomas—Distillation of pure water from salt water
2062 A. H. Brandon—Metallic cartridge shells
2063 T. C. Blanchflower—Packing and preserving meats, &c.
2064 A. H. Brandon—Spinning hemp and other textile fabrics

### Dated June 27th, 1868.

2065 P. R. Hodge—Application of the use of hydro-carbonacious fluids, &c.
2066 R. Warry—Breech-loading firearms
2067 I. Baggs and F. Braby—Extrication and condensation of ammonia
e068 C. Mather—Excavating soil
2069 J. Bowker and J. Ivers—Slip for raising, &c., on the lines of rails, engines, &c.
2070 J. Tyson—Bobbins
2071 G. McCulloch—Thread-polishing machines
2072 W. F. Deane—Obtaining oxide of manganese
2073 H. Large—Bricks
2074 G. H. Wilson—Cases for holding winding tape measures
2075 J. Morris—Steam boilers
2976 R. Smith—Preventing the fouling of ships' bottoms
2077 W. C. Stiff—Breech loading firearms
2078 W. R. Lake—Dyeing textile fabrics

### Dated June 29th, 1868.

2079 S. Hannah—Fluid meters
2080 J. Wardman, and J. and F. Baldwin—Steam boilers
2081 W. Baxter, D. Waring, and J. S. Wooller—Drying textile fabrics, &c.
2082 R. Shaw and J. Clayton—Looms
2083 H. Jewitt—Needle gun
2084 A. V. Newton—Liquid meters
2085 C. E. Brooman—Bleaching fabrics
2086 G. H. Wilson—Watches
2087 C. E Brooman—Shawls
2088 W. R. Lake—Generating and burning the vapour of naphtha

### Dated June 30th, 1868.

2089 F. J. Drechsler—Boilers and furnaces
2090 G. Glover—Combustion of naphtha, &c.
2091 G Bower—Boilers for heating purposes
2092 J. Randall and W. R. Crabb—Self-propelling carriages
2093 J. Blomfield—Tables applicable for sewing machines
2094 M. Bebro, O. Hopwood, and W. Elam—Mechanism for numbering and printing tickets consecutively
2095 J. H. Banks—Constructing buildings
2096 A. M. Clark—Breech-loading firearms
2097 W. Daglish—Kilns for burning bricks, &c.
2098 G. Alder—Propelling vessels

### Dated July 1st, 1868.

2099 R. Ward—Spinning tobacco
2100 T. Ward and W. S. Black—Twisting tobacco
2101 W. Brookes—Rotary steam engines
2102 W. Brookes—Railway brakes
2103 W. Brookes—Meters for measuring water
2104 J. A Smith—Photographic apparatus
2105 C. F. Crailsheim—Bottles for effervescing liquids

### Dated July 2nd, 1868.

2106 A. Taylor—Neck-ties or cravats
2107 A. Alexander—Carriages and locomotive engines
2108 L. Francis—Composition applicable to printing purposes
2109 H. H. Henson—Railway waggons
2110 W. Dean and R. Andrew—Machinery employed for stopping the loom upon the breaking of a weft thread
2111 J. D. Pinfold—making bricks, &c.
2112 J. E. Poynter and T. L. Patterson—Obtaining or manufacturing saltpetre
2113 E. J. Scott—Ornamenting boots
2114 F. A. Pavey—Marking board for billiards, &c.
2115 D. Hall—Construction of furnaces, &c.
2116 J. Brumwell Gregson—Preparation of lead to be used as a pigment
2117 E. Pavy—Treating and preparing certain vegetable and animal fibres
2118 D. Fender—Thrashing machines
2119 A M. Clark—Barometers
2120 A. M. Clark—Treatment or preparation of flax
2121 A. F. Robertson—Carts
2122 J H. Johnson—Shoes for horses and other animals
2123 J. H. Johnson—Construction of bridges

### Dated July 3rd, 1868.

2124 C. Rousel—Apparatus for spinning, &c., fibrous substances
2125 A. Kane—Tobacco pipes
2126 J. H. Johnson—Paper pulp
2127 G. Bennett and J. Woodcock—Effecting communication between guards, passengers, and engine drivers
2128 J. Ward and G. M. Ward—Working of locomotive engines
2129 J. B. Brown—Furnaces for calcining ores
2120 W. E. Newton—Automaton toys
2131 M. Henry—Receptacles for preserves and other provisions

### Dated July 4th, 1868.

2132 J. A. Muller—Meter for regulating and registering the flow of liquids and gases
e133 J. Head—Furnace grates
2134 A. Fryer—Concentration of saccharine and saline solutions, &c
2135 A. Albini—Compasses
2136 A. McNiel and W. Wheaton—Manufacture of salts of ammonia
2137 E. H. Newby—Reducing aluminium from its ores, &c.
2138 R. Needham—Fuel economiser
2139 T. G. Messenger—Buildings for horticultural purposes
2140 A. M. Clark—Fastenings for boots
2141 G. Slater—Plaiting machine

### Dated July 6th, 1868.

2142 J. Kilner, F. H. Oclee, and E. Burns—Improved cork drawer
2143 P. Jensen—Sewing machines
2144 A. Fryer—Treatment for evaporating and concentrating purposes cane juice, &c.
2145 G. Davies—Locomotive engines
2146 E. H. Waldenstrom—Manufacturing metallic rivets
2147 J. H. Whitehead—Saddle pads

### Dated July 7th, 1868.

2148 G. Davies—Dyeing
2149 J. Thomson—Chimney tops
2150 G. R. Wilson—Stereotype plates
2151 T. Jefferson Mayall—India rubber soles for boots
2152 E. Coppee—Coke furnaces
2153 F. Veith—Treatment of straps for driving machinery
2154 J. Lawson and E. J. Fitton—Hackling, &c. flax, &c.
2155 T. R. Crampton—Constructing forts, &c.
2156 B. P. Walker—Effecting the junction of driving bands
2157 A. P. Price—Treatment of phosphates of lime, &c.
2158 G. Morton—Ornamenting fire grates

### Dated July 8th, 1868.

2159 T. J. Mayall—Manufacture of gas tubing and other articles of india rubber
2160 T. J. Mayall—Telegraph cables
2161 C. D. Abel—Ornamenting textile fabrics
2162 J. Livcbak—Aeronautical apparatus
2163 J. F. Cooke—Improvements in the manufacture of copying ink
2164 J. Holt and G. S. Coponet—Improvements in printing machines
2165 J. Prest, W. Mather, and W. Doherty—Chaff cutters
2166 W. Brookes—Evaporating liquids
2167 A. J. Le Blanc—Manufacture of belts, bands, or ropes
2168 E. Coppee—Crushing coal
2169 T. Kerr—Firearms
2170 W. Tasker—Machinery or apparatus for elevating straw

### Dated July 9th, 1868.

2171 E. Rouget—Improved mode of fixing on paper crayon drawings, &c.
2172 M. Bebro—Apparatus for containing and delivering tickets
2173 W. Hadfield—Looms
2174 J. Chandler—Drawing and preventing waste of water
2175 T. J. Mayall—Treatment of india rubber, &c.
2176 W. Creasy—Machinery for drying and treating grain
2177 J. Harris and V. Pendred—Manufacture of wrought iron and steel
2178 J. Mahson—Apparatus for propelling persons in the water
2179 H. H. Doty—Lamps for signalling and telegraphing at sea, &c.
2180 T. Nuttall—Bearing surfaces of horse collars, &c
2181 W. R. Oswald—Formation of steam and watertight joints
2182 T. Worth—Improvements in railways and railway engines
2183 A. M. Clark—Looms for weaving
2184 J. H. Johnson—Musical instrument called the orphonium

### Dated July 10th, 1868.

2185 W. L. G. Wright—Improvements in rotary engines and pumps
2186 E T. Hughes—Wooden pavement
2187 C. E. Brooman—Cutting or utilising old railway rails
2188 G. Davies—Filling the spaces between the beams of iron floors
2189 J. Jefferys—Studs and buttons
2190 J. D. Churchill—Hot air engines
2191 F. R. A. Glover—Apparatus for fishing ships' anchors

### Dated July 11th, 1868.

2192 G Davies—Armour for the protection of vessels of war, &c.
2193 W. Russell—Machinery for making paper bags and envelopes
2194 T. Travis, W. H. Prince, and J. Tomlinson—Clearing yarn
2195 J. S. Nibbs—Portable and other pumps and water engines
2196 T. King—Improvements in bungs or corks for casks, &c.
2197 R. Mackie—Caps or bonnets
2198 J. D. Brunton—Tools for cutting slate and other rock
2199 C. E. Brooman—Locks
2200 H. Garside—File cutting machines

### Dated July 13th, 1868.

2201 E. Edwards—Photography
2202 J. N. Willis and S. Judd—Syringe to be used in combination with combs, &c.
2203 W. J. Hanson—Improvements in dyeing wool, &c.
2204 G. B. Puricelli—Apparatus for printing or endorsing
2205 A. Oldham—Improvement in the means of hanging picture frames
2206 A. Munro and W. B. Adamson—Improvements in tools
2207 A. Munro and W. B. Adamson—Manufacture of iron
2208 G. R. Mather—Machinery for grinding or mixing colours
2209 G. Betjemann, G. W. Betjemann, and J. Betjemann—Book slides
2210 W. R. Lake—Improvements in the permanent way of railways
2211 W. R. Lake—Improvements in railway carriages

### Dated July 14th, 1868.

2212 J. C. Leaver—Improvements in construction of railway sleepers
2213 J. Taylor and J. M. H. Taylor—Propelling ships
2214 J. Bastow—Bleaching or whitening textile fabrics, &c.
2215 E. F. Kittoe—Fish slices for turning over or lifting fish
2216 J. Booth—Improvements in mills for grinding bones, &c.
2217 J. Cope and J. Bradbrook—Apparatus to be used in bookbinding
2218 T. Wood—Improvements in the construction of railway carriages, &c.
2219 W. Shaw—Improvements in looms for weaving
2220 W. B. Farwell—Heating railway carriages by steam
2221 C. J. Galloway and C. H. Holt—Operating piston valves
2222 W. Payton—Improvements in breech loading firearms
2223 J. Thompson and J. G. Ingram—Caps for feeding bottles
2224 L. Hannart and N. A. Aubertin—Manufacture of door plates, &c.
2225 L. Hannart and N. A. Aubertin—Printers' type
2226 H. Lawrence—Improvements in moving furnace bars

### Dated July 15th, 1868.

2227 A. Taylor—Certain improvements in spring studs
2228 C. de Bergue and J. C. Haddan—Improvements in safes
2229 W. Hollingsworth and H. Halstead—Regulating the amount of gas supplied to street and other lamps
2230 R. Couty and J. Richard—Instruments for facilitating vocal instruction at schools
2231 R. Chamberlain—Tool or chisel for mortising machines
2232 J. H. Johnson—Lamps
2233 J. Bounall—Drills for distributing corn, seed manure, and water
2234 T. Cook—Presses for the expression of oil and other liquids
2235 W. Turner—Buckets to be employed in air pumps

### Dated July 16th, 1868.

2236 J. L. Macfarlane—Shirt fronts
2237 R. Whiston—Safety window and sash lock fastener
2238 H. W. Ripley and T. Shackleton—Winding warps
2239 R. Beraon—Universal rapid self boiler by means of charcoal fire
2240 T. F. Wintour—Apparatus for ventilating
2241 D. Russell—Masting ships
2242 J. C. Ramsden—Looms for producing a certain class of fancy fabrics
2243 W. R. Lake—Implement for cutting hay, straw, &c.
2244 W. R. Lake—Links or couplings for harness and other purposes

### Dated July 17th, 1868.

2246 G. Moulton—Improvements in pentagraph engraving machines
2247 W. I. Ellis—Cranes
2248 E. Funnell—Improvements in signalling on railways
2249 C. P. Stone—Improvements in construction of vessels of war
2250 A. Woollan—Fastener or protector for securing watches, &c.
2251 J. Duguid—Improvement in the manufacture of paper
2252 W J. C. Muir—Construction of the permanent way of railways
2253 C. J. Galloway and C. H. Holt—Boilers for generating steam
2254 W. Eades and W. T. Eades—Obtaining motive power
2255 A. Browne—Liquid meters
2256 J. Roberts—Vessels for cooling and preserving edibles, &c.
2257 S. Deacon—Improved fastening
2258 R. Meldrum—Machinery for raising and discharging fluid
2259 E. A. Cowper—Improved glass ornament

### Dated July 18th, 1868.

2260 D. Sowden and R. C. Stephenson—Shuttles employed in looms
2261 D. Webster—Manufacture of gas, &c.
2262 T. Kendrick and S. Davies—Improvements in fire irons
2263 C. G. Johnson—Kilns, &c.
2264 J. Gili—Engines for obtaining motive power
2265 J. Thomas—Furnaces
2266 W. Berry—Lighting shops, &c.
2267 F. Chome Steinbach—Joint for metallic pipes
2268 W. R. Lake—Propelling machinery

### Dated July 20th, 1868.

2269 T. Bonell—Slide valves
2270 H. B Barlow—Spinning cotton, &c.
2271 T. W. Gray—Lightning conductors
2272 W. Winter—Sewing machines
2273 W. J. Cunningham—Raising and lowering window blinds, &c.
2274 E. Beanes—Brewing
2275 R. Smyth—Propelling vessels
2276 C. P. Wilcox—Counting machine
2277 T. G. Green—Preparation of a composition to be used in the manufacture of earthenware
2278 L. Rose—Aerated liquid
2279 R. Brett and G. Daniells—Driving drums
2280 J. Raine—Obtaining panoramic pictures
2281 C Hodgson—Transporting loads
2282 W. H. Bates, A. M. Bates, and H. Faulkner—Flexible tubes
2283 A. Homfray—Separating coal, &c.
2284 C. Weekes—Application of iron for building purposes

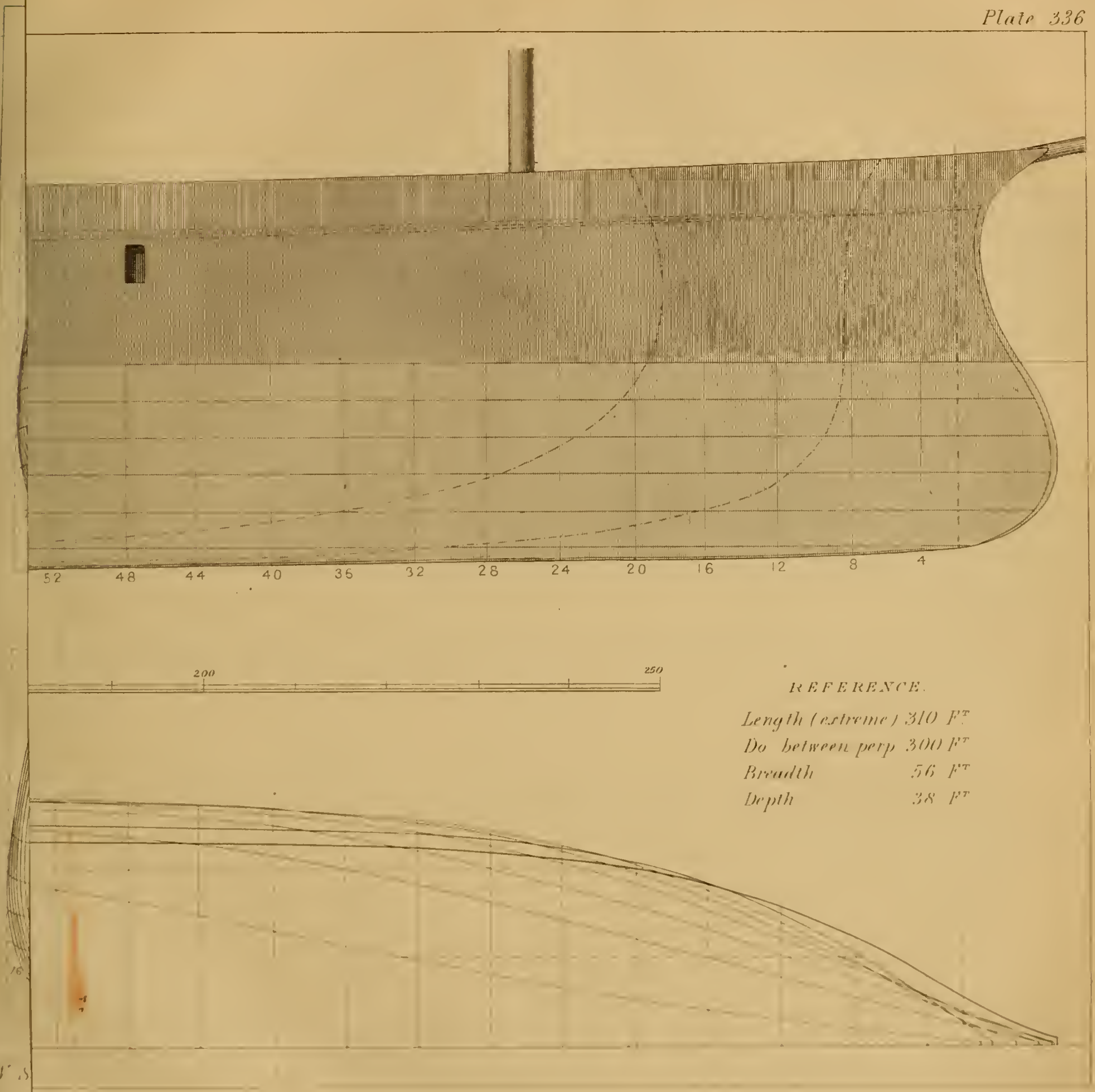
### Dated July 21st, 1868.

2285 F. Green—Lamps for burning benzine
2286 T. Kohn—Cleaning silk, &c.
2287 T. Deschamps—Fastening for gloves
2288 F. Warren—Heating water
2289 A. A. Wille—Bleaching, &c., feathers
2290 J. M. Hector—Fusee boxes
2291 J. J. Aston—Propulsion of vessels
2292 A. M. Clark—Feeding steam boilers

### Dated July 22nd, 1868.

2293 T. Gibbs—Treatment of metallic ores
2294 G. Martin—Manufacture of extract wool
2295 C. W. Pradshaw—Coupling hose
2296 J. H. Johnson—Colouring matters
2297 S. Langdale—Artificial manures
2298 P. Tasaie and I. Patchett—Plaiting textile fabrics, &c.
2299 W. T. Hamilton—Dovetailing machine
2300 C. F. Waldo—Raising water, &c.
2301 W. T. Hamilton—Converting circular into parallel motion
2302 L. Dulac—Drying threads, &c.
2303 S. H. Hadley—Decorticating wheat
2304 T. A. Ward and H. Whale—Racket bats
2305 C. E Brooman—Breech loading firearms
2306 T. F., J., C. H., and E. Firth—Looms
2307 H. Fear—Door springs
2308 F H. Hambleton—Laminated armour plates
2309 W. Dennis—Letter boxes

Plate 336



| | | | | | | |
|---|---|---|---|---|---|---|
| *Achilles* ... | 25 | 7¾ | 26 | 8¾ | 5,688·99 | 13.25 |
| *Warrior* ... | 25 | 3 | 27 | 0 | 4,752·00 | 12·00 |

The displacement of these vessels at the draughts given above, is not stated, but may be taken at about 10,060 tons for the *Minotaur*; 7,100

herself is practically useless in anything approaching to a heavy sea. The accounts of the behaviour in a heavy sea of the American monitors, inferior though they are to what could now be built, have been eminently satisfactory. Several of these vessels have made long voyages in dangerous

# LINES OF H. M. S. "BELLEROPHON."

*DESIGNED BY E. J. REED, ESQR C B*

FIG 3. *After Body*

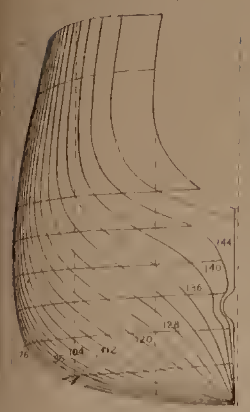


FIG 4. *Fore Body*

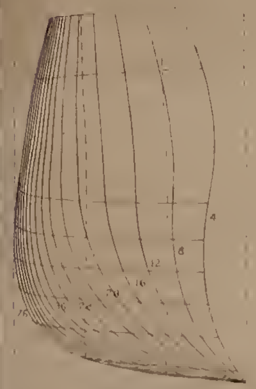


FIG. 1. ELEVATION.

SCALE OF FEET.

| *REFERENCE* | |
|---|---|
| *Length (extreme) 310 FT* | |
| *Do. between perp* | *300 FT* |
| *Breadth* | *56 FT* |
| *Depth* | *38 FT* |

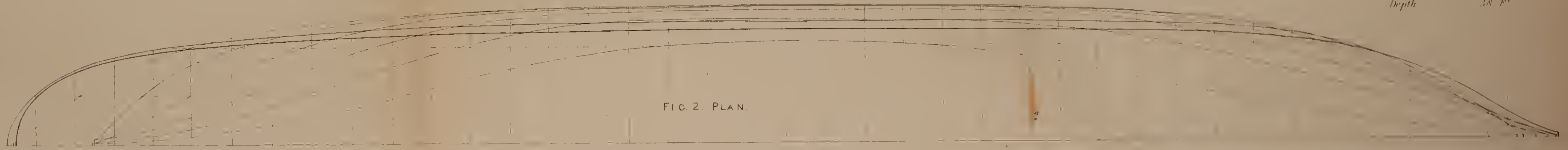


FIG. 2. PLAN.

*W. Smith C.E. direx*

2080 J. Wardman, and J. and F. Baldwin—Steam boilers
2081 W. Baxter, D. Waring, and J. S. Wooller—Drying textile fabrics, &c.
2082 R. Shaw and J. Clayton—Looms
2083 H. Jewitt—Needle gun
2084 A. V. Newton—Liquid meters
2085 C. E. Brooman—Bleaching fabrics
2086 G. H. Wilson—Watches

&c.
2158 G. Morton—Ornamenting fire grates

DATED JULY 8th, 1868.

2159 T. J. Mayall—Manufacture of gas tubing and other articles of india rubber
2160 T. J. Mayall—Telegraph cables
2161 C. D. Abel—Ornamenting textile fabrics

2223 J. Thompson and J. G. Ingram—Caps for feeding bottles
2224 L. Hannart and N. A. Aubertin—Manufacture of door plates, &c.
2225 L. Hannart and N. A. Aubertin—Printers' type
2226 H. Lawrence—Improvements in moving furnace bars

2302 L. Dulac—Drying threads, &c.
2303 S. H. Hadley—Decorticating wheat
2304 T. A. Ward and H. Whale—Racket bats
2305 C. E Brooman—Breech loading firearms
2306 T. F., J., C. H., and E. Firth—Looms
2307 H. Fear—Door springs
2308 F H. Hambleton—Laminated armour plates
2309 W. Dennis—Letter boxes

# THE ARTIZAN.

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1st. SEPTEMBER, 1868.

## LINES OF H.M.S. "BELLEROPHON."

(*Illustrated by Plate* 336).

Though this celebrated armour-clad ship has never been in action, it has already been the cause of more battles (on paper, and in the Houses of Parliament), than any other, and even now there appears to be but little prospect of peace between the opponents and supporters of the system which this vessel represents. It is exceedingly difficult, even for thoroughly practical men, to form an opinion upon the relative merits of the various ships comprising our iron-clad fleet, in consequence of the meagre information vouchsafed to the public, respecting their general performances. Trial trips of these vessels, which most of our readers understand too well to attempt to form any judgment upon the real merits of the performers, are usually the only data that can be obtained. Thus it is that the advocates of short ships, or long ships, turret ships, or broadside ships, are fighting against one another without being able to produce any practical arguments to support their respective theories. With regard to turret ships, it is of course impossible to obtain any practical data from our navy, as it does not possess one, and so far as appearances go, it will not possess one worthy of the name for an indefinite time; as it would be absurd to call either the *Monarch* or *Royal Sovereign*, the one built by and the other supplied by opponents of the system, a fair specimen of a turret ship. Within the last few months, however, in consequence of a motion made in Parliament by Mr. Laird, a copy of Admiral Warden's Report of the Trials of the Channel Fleet, in 1867, has been published, which affords much better means of estimating the respective merits of the various vessels of which it was composed, than could be before obtained. It is well known that the Chief Constructor and the Controller are in favour of short ships, and contend that they are not only much handier, but will steam and sail as fast as longer vessels, with equal displacement, and with the same power. The *Bellerophon*, the lines of which are given in plate 336, may be taken as the type of this class of vessel, although perhaps it is scarcely a fair specimen of a short ship, its length being 5·36 times its beam; still it is considerably shorter in proportion to the *Achilles*, *Warrior*, or *Minotaur*, with which it has been tried.

The following are some of the leading dimensions of the *Bellerophon* :—tonnage, 4,246; length, 300ft.; breadth (extreme), 56ft.; nominal H.P. 1000; diameter of screw 32ft. 6in.; pitch, 20ft. 1in. The *Achilles* is 6,121 tons burden; 380ft. long; 58ft. 3¼in. beam, and has 1,250 nominal horse power. The *Warrior* is 6,039 tons burden; 380ft. long; 58ft. beam; and 1,000 horse power. The *Minotaur* is 6,643 tons burden; 400ft. long; 59ft. 4¾in. beam; and 1,350 horse power.

In the report of Admiral Warden, an abstract of a full speed trial on Nov. 26th, 1867, is given, in which the four above-mentioned vessels were engaged, together with several others. We will, therefore, give in a condensed form, the results of this trial, premising that the distance was from 90 to 100 miles, the force of the wind 4, and the sea smooth.

| | Draught of Water. | | | | Mean Ind. H.P. | Speed. |
|---|---|---|---|---|---|---|
| | Forward. | | Aft. | | | Knots. |
| *Minotaur* ... | 25ft. | 8in. | 26ft. | 6in. | 5,629·25 | 11·40 |
| *Bellerophon* | 21 | 6 | 26 | 1 | 5,092·57 | 11·75 |
| *Achilles* ... | 25 | 7¾ | 26 | 8¾ | 5,688·99 | 13.25 |
| *Warrior* ... | 25 | 3 | 27 | 0 | 4,752·00 | 12·00 |

The displacement of these vessels at the draughts given above, is not stated, but may be taken at about 10,060 tons for the *Minotaur*; 7,100 for the *Bellerophon*; 9,360 for the *Achilles*; and 8,900 for the *Warrior*. Upon investigating the above figures, we find that taking the usual formula $\left(\frac{\text{Speed}^3 \times \text{Dispt.}^{\frac{2}{3}}}{\text{Ind. H.P.}}\right)$ for showing the relative merits of these four vessels that they stand thus:—*Minotaur*, 120·5; *Bellerophon*, 130·5; *Warrior*, 173·7; and the *Achilles*, 202·2. From this it will be seen that the *Minotaur* and *Bellerophon* are very low in the order of merit. The reason why the *Minotaur* should be so low in the scale does not appear as in other trials she was considerably better, but the order of merit with respect to the *Bellerophon*, *Warrior* and *Achilles*, are about the same as would be expected by practical shipbuilders. In a trial of ten hours duration, with the speed of the vessels regulated to five knots per hour, the power required to drive them through the water, was: *Minotaur*, 551·5 H.P.; *Achilles*, 453·9 H.P.; and the *Bellerophon*, 653·8 H.P.; showing an immense excess of power required to drive the latter vessel, as compared with the other two. Again is an eight hours trial, the *Minotaur* required 1,389·4 H.P.; the *Achilles*, 962·8 H.P.; and the *Bellerophon*, 1,244 H.P.; to keep them at an even rate of seven knots per hour.

Although as has been already mentioned, the results of the trial trips of any vessel are of but little value, so far as regards its performance at sea, yet it must be a tolerably correct guide by which to estimate the relative excellence of the form of such vessel; as the speed and indicated horse power are accurately taken, besides which the vessel has a clean bottom, and runs in smooth water. If, therefore, we take the performances at full power, and fully rigged, of the four ships, *Achilles*, *Bellerophon*, *Minotaur* and *Warrior*, as given in the Government returns up to June, 1867, the following is the average order of merit:—*Achilles*, 227·4; *Bellerophon*, 164·7; *Minotaur*, 208; and *Warrior*, 231·5. From the above examples taken from the Government returns, it is evident that the *Bellerophon*, so far as regards speed, is a failure, and consequently in the event of a war, the commander of any moderately well-proportioned vessel belonging to the enemy, would be enabled to engage in battle, or run away from it, at his discretion. However desirable it may be to have a vessel which shall be entirely protected by armour plating and at the same time be handy for manœuvring,, it will not do to obtain these qualities by sacrificing such an essential as speed. Moreover, the quantity of coal that can be carried in such a heavily plated ship, is utterly inadequate for anything but a Channel cruise. In the *Bellerophon* we cannot see what advantages are gained by having such an immense amount of armoured side—about 14ft. in height—all over the ship, when after all she has only a central battery. Surely, if a vessel is only required to carry guns amidships, they might have been provided for in a monitor with turrets; or, if that be too great an inovation for the authorities at the Admiralty, a fixed central battery. Either of these methods could be adopted at much less cost, while at the same time a vessel with fine lines for giving greater speed, less draught of water, and greater carrying capacity for coals would be obtained. That objections are raised against vessels of this description on account of their supposed unseaworthiness, we are, of course aware, but this assertion has yet to be proved; while on the other hand, it is a fact already demonstrated, that the *Bellerophon* herself is practically useless in anything approaching to a heavy sea. The accounts of the behaviour in a heavy sea of the American monitors, inferior though they are to what could now be built, have been eminently satisfactory. Several of these vessels have made long voyages in dangerous seas, as for instance, round Cape Horn, in perfect safety; it seems, there fore, decidedly premature to pronounce them unseaworthy.

As an instance of the seaworthiness of these vessels, we will quote the testimony of the Commodore of the American Fleet at San Francisco, as to the behaviour of the *Monadnock*, a vessel only 1,564 tons burden, on its voyage there from Philadelphia, *via* Cape Horn. The Commodore reports to the Secretary of the American Navy as follows:—

"The *Monadnock* found no weather in her voyage from Philadelphia to this place, which seemed to touch the limit of her seagoing capacity. In a gale off Point Conception, on the coast of California, two successive waves rose which interposed between my ship and the masthead light of the *Monadnock*. Upon inquiry I found that the light was elevated 75ft. above the water, my own eye being about 25ft. above the sea-level. In this sea, according to the testimony of her officers, she was very easy." This gale was of 50 hours' duration. And again, "In the long seas of the Pacific to the southward of Valparaiso I observed that the *Monadnock* took very little water upon her decks, rising over the waves easily and buoyantly." The Lieutenant-Commander of the *Monadnock* reports of her to his Commodore at San Francisco, "At sea she has never needed or received any assistance of any kind whatever from any vessel, and therefore I regard her, or any vessel of her class, as thoroughly independent cruisers."

As regards the *Miantonomoh* which crossed the Atlantic, her commander reports thus:—

"The conduct of the vessel in the rough weather we experienced on the 10th and 11th inst. confirms me in the opinion that she is an excellent sea boat, as safe and more comfortable than any vessel I ever steamed in." Mr. Fox, the Assistant-Secretary of the American Navy, who accompanied her to Europe, says:—"The extreme lurch of the *Miantonomoh* when lying broadside to a heavy sea and moderate gale was seven degrees to windward and four degrees to leeward; mean, five and one-half degrees; while the average roll of the *Augusta*, a remarkably steady ship, was 18 degrees, and the *Ashuelot* 25 degrees, both the latter vessels being steadied by sail. . . . The Monitor type of ironclads is superior to the broadside, not only for fighting purposes. but also for raising. . . . The comforts of this Monitor to the officers and men are superior to those of any other class of vessels in the navy." Admiral Popoff, of the Russian Navy, also says, "that, he was particularly struck with her good sea-going qualities in the midst of a heavy blow and sea encountered just after leaving the Elbe, and if he was in my place he would prefer being on board of her to the *Colorado*."

In the face of such testimony as quoted above it is difficult to understand how the asservations of their total unfitness to go to sea can be persisted in.

We cannot, perhaps, do better than to introduce a portion of Mr. G. P. Bidder's speech at the opening of the Mechanical Science section of the British Association on the 20th ult., as an additional support of our position on this point:—

"He next approached a question which he said had excited a great deal of public attention—viz., the state of the British Navy; and he might begin begin by saying that, however satisfactory that state might be to some departments, it was not satisfactory to the country in general. He would endeavour to point out in what way public opinion might be brought beneficially to bear upon this important subject. They would no doubt all agree with him that they had all but one desire—viz., that this country, whatever might be the cost, should have the best ships that the ocean could carry and that machinery could propel. With regard to the ships, he thought the great source of the present unsatisfactory state of things was the total absence of any system upon which their construction was conducted. Before building their ironclad navy it should have been considered what they were to be filled with, according to the plan adopted in the merchant service. They should also determine before a vessel was built what its speed would be; and no ship should be considered a success that did not accomplish a sea-going speed, while all should be as nearly as possible of the same speed, in order to enable them to act efficiently. He did not purpose entering into the relative merits of broadside guns and turret guns, but he would say that, whatever difficulty there might be in getting fine lines with broadside guns, that difficulty did not exist in the case of turret ships. Another point was that at present they did not know until they sent a ship to sea to what extent she was going to roll; but the mechanical principles upon which this depended under ordinary circumstances were so well known that the extent to which a ship would roll should be known before a quarter of million of money was spent upon her. The trials of ships in Stokes Bay he characterized as a sheer delusion, and said that trials, to be of any value, should be conducted at sea by men independent of any department or of any other influence whatever; and until that was done they would not be able to bring to bear such a check upon the Admiralty department as the country had a right to demand. With regard to the armour of ships, he contended that this was a subject that should be subordinate to the considerations he had mentioned, for it was of no use to have a ship so overweighted that she became useless as a moveable fort."

## INDIAN RAILWAYS.

The Government director of the Indian Railways Companies, Mr. Danvers, has, in his last annual report, given some very interesting statistics relative to the progress of the railways in India. From this report it appears that three hundred and forty-nine miles of new railway have been opened for traffic during the year, making the whole extent of line now open to be 3,943 miles.

Upwards of £9,000,000 has been added to the capital accounts of the companies during the year, making the whole amount of capital which has been raised for railways in India on the 31st of March to be £76,579,016. Of this sum £60,048,871 consists of shares or stock, and £16,530,145 of debentures.

The total expenditure on the railways which have been opened, and on those which are now in course of construction, amounted on the 31st of March to £75,071,656.

The expenditure during the past year was about £7,000,000, and of this upwards of £4,000,000 was expended in England for permanent way, materials, locomotives, stores, &c., sent out from this country. This is the largest expenditure which has been incurred in any one year in England.

The estimated expenditure for the current year is £5,177,000, of which £1,791,000 will be required in England and £3,386,000 in India.

The £75,000,000 just mentioned as the amount which has already been expended does not, however, represent the whole cost of the undertakings. It shows only what the railway companies have paid. In addition to that, Government has granted all the land, the value of which cannot be taken at less than £2,500,000. Inasmuch, too, as the rate of exchange for converting the pound sterling subscribed by the companies, into rupees is fixed by the contracts at 1s. 10d. the rupee, and the value of the rupee has, during the construction of the works, averaged about 2s., the Government has contributed about 8 per cent. to the capital expended in India. This upon £45,000,000 would amount to £3,600,000. The actual cost of the railways is thus raised from 75 to 81 millions.

The revenue from the railways for the years 1866-67 was only £32,337 in excess of the previous year; but there was an increase of £962,984 in that year's receipts over those of 1864-65; so that in two years the revenue has increased nearly £1,000,000.

The gross receipts for the year ending the 30th of June, 1867, were £4,878,527, as compared with £4,537,235 of the previous year. The working expenses were £2,537,812 and £2,225,495 respectively. The net receipts in 1867 were £2,337,300, and £2,304,534 in 1866. In 1867 the number of passengers was 13,746,354, of whom 13,074,980 were third class. In 1866 the number was 12,867,000. The sum paid by passengers last year for fares was £1,376,812, as against £1,278,580 of the previous year; and the amount received for the conveyance of goods was £3,320,607, as against £3,091,723. The train miles run were 10,980,319 and 10,120,920 respectively.

These results would have been more satisfactory if the trade of the country had not received so severe a check as almost to produce stagnation at times. Comparisons are more striking when taken back a few years. A better idea of the progress which has been going on may be formed by bringing the present in juxtaposition with ten years ago. Then it took about three months to convey a regiment from Calcutta to Simla; now it occupies five or six days. Then about 300 miles of railway were open throughout all India, and about 2,000,000 of people travelled on them; now there are nearly 4,000 miles, traversed by 13,746,300. The capital expended ten years ago amounted to about £20,000,000; now it amounts to upwards of £75,000,000.

In 1857-58 the net revenue derived from the railways was £111,446; last year it was £2,336,871; and, what is more remarkable, although the capital had increased from 20 to 75 millions, and the guaranteed interest in proportion, the net amount paid by the Government for guaranteed interest in the ten years 1857—1867 was about the same—viz., £700,000.

The amount for which the Government was last year responsible on account of guaranteed interest was £3,237,937. Of this sum, however, about £2,500,000 was paid by the companies themselves, so that the advances by Government really only amounted to little more than £700,000. In the previous year the net amount so advanced was £800,000, and for the year before that £1,450,000.

The whole sum which had been paid by Government for guaranteed interest since the commencement of the guarantee system now amounts to £22,212,505, of which about £9,500,000 has been recovered from the railway companies, leaving about £12,000,000 as their present debt, which is chargeable against the half surplus profits over 5 per cent. This sum represents the amount which the Government has actually paid. Spread over 18 years it gives an average annual charge upon the revenues of India of £666,666.

The success of the chief lines of railway having relieved the revenues of a burden which, by many, it was expected would have been permanent, has led to the consideration whether a portion of the funds which find their way into that Government treasury from the earnings of the railways may not advantageously be applied to the extension of a system which is conferring such benefits upon the country. The Secretary of State in Council and the Government in India have both recorded their opinions that the time has arrived for doing so.

In a despatch to the Governor-General, dated the 16th of January last, Sir Stafford Northcote regards the present as "a fitting time for taking a comprehensive view of our railway policy, past and future, for reviewing what has been already done, and for endeavouring to establish principles on which we may proceed henceforward;" and, after alluding to the two classes in which future railways should be arranged—viz., commercial and political—and expressing an opinion that the guarantee system is upon the whole the one best adapted for the extension of the commercial, while direct Government agency might be preferable for the political, the Government is requested to take a general survey of the whole of India, and to state its opinion as to the lines which are most desired, as well as to the order, mode, and rate of progress in which they should be taken up. The Government in India has at the same time invited each of the local Governments "to consider what lines of railway they would regard as desirable to construct, should the necessary funds be available, either within their respective territories, or to communicate with the most important points in the territories adjacent, whether British or foreign;" the object of the reference being to insure such a review of all possible lines as will "enable the Government of India and the Secretary of State to make a selection of those particular lines which are most needed, and which most commend themselves for early construction."

Some of the lines proposed will pass through districts and provinces as rich and populous as those which are traversed by the main lines already executed. Others will not present the same commercial advantages; but it may be presumed, from the experience which has now been gained that all will cost less than the existing lines. Past mistakes will not be repeated, and a great saving will be effected by means of the open lines in the transport of materials, which has hitherto formed a very heavy item in the capital account.

A Committee, which was appointed to consider matters connected with the Oude and Rohilkund Railway, has lately expressed the following opinion upon this subject:—

"Without any sacrifice of necessary strength and permanence, such modifications could be introduced in the system of construction as should prevent the cost of railways in any case exceeding £10,000 per mile of single line, and that under favourable circumstances most of the lines likely to be undertaken could be completed in an efficient manner at a far less cost."

## THE NEW DOCK AT BOULOGNE.

The formal opening of the Grand Dock at Boulogne, by Prince Napoleon, took place on the 18th ult. It had previously been entered by several vessels, especially by the English steamer Garrison, from Archangel, which entered it on the 11th of July, and discharged 5,471 quarters of oats in five days; and the restriction obliging the aid of a tug will no longer be obligatory when the channel leading to the lock-gates has been deepened to its full width. It will take some months before the accessories of the dock are completely finished, but it is now virtually opened for shipping and it will no doubt exercise a very considerable influence on the progress and prosperity of the port of Boulogne. The dock at Boulogne was commenced in the year 1859, and has thus been nine years in course of completion. The total cost has been a little under £300,000, but would have been much more had not the whole of the space it occupies on the west side of Boulogne harbour at Capecure, been already in the possession of the French Government, so that there was no land to purchase; while, as it partly occupies the site of the old semicircular basin, there was to that extent, less excavation required. Such an establishment had become of the utmost necessity in the port of Boulogne, which is not only one of the most important of the trading ports of France, but has for many years occupied the principal place in the international trade between France and England, which, since the introduction of a more liberal commercial system in France, has acquired such vast proportions. While, on account of the mail services, Calais divides the passenger traffic with Boulogne, the great bulk of the goods traffic is concentrated at Boulogne. In 1867 the number of vessels that entered Boulogne was 2,346, and their tonnage 384,131 tons. The tonnage weight of imported goods was 195,302, and the number of passengers arriving or departed by sea 152,931. The Customs' dues were £164,986, while at Calais they amounted only to £31,116. In the same year the movement of passengers at the Boulogne Railway station was 323.183, and of goods 388,782 tons; and the total receipts at the railway station were £169,524; at Dunkirk they were £123,718; and at Calais £114,583. The movement of bullion at Boulogne was £12,523,488, and at Calais £708,940. In 1867 the imports of coal from England were 98,848 tons. There is a large Baltic timber trade, and there were belonging to Boulogne 156 boats employed in the fisheries, of an aggregate tonnage of 6,635 tons. Moreover, the position of Boulogne, its facility of access, the rise of the tide, which exceeds that at Dunkirk by over three feet and its frequent use as a port of refuge in bad weather, all combine to make a dock, easily accessible, and permitting large vessels always to remain afloat, a matter of the first necessity. Until now ships have had to take the mud at low water. The basin now open for shipping occupies a superficies of more than 17 acres, with a quaywall frontage of 3,600ft., and a superficial quay space of over 240,000 square feet for the stowage of goods. It is of irregular shape, and about 1,300ft. in greatest length, and 630ft. in greatest breadth. It is excavated to a uniform depth of about 30ft. below high water spring tides, and is intended to contain a depth of from 20ft. to 25ft. of water. It is entered directly from the Channel between the piers of Boulogne harbour, making ingress and egress easy at all times, through a lock with two sets of gates, so constructed as to admit the largest vessels, but generally intended to act as a half-tide basin, and to accommodate several vessels of medium tonnage at a time, The lock, or half-tide basin, is 325ft. in length and 68ft. in breadth, with a depth over the cill of the gates of 29ft. at high water spring tides, and 23ft. at high water neap tides. It is evident, therefore, that if the harbour and external channel were sufficiently deepened, so as to be in harmony with the entrance to the dock, it would be always accessible to the largest trading vessels. But this is not the case, and the facility of entering it is measured not by its own depth, but by that of the channel leading to it over the bar of Boulogne harbour. This is stated by the most recent measurements to be about 24½ft. at high water spring tides, and 19ft. at high water neap tides. From those figures about 3ft. must be deducted for the fall of the waves, the allowance to be made for not following the exact channel and other causes; and, finally, the maritime authorities of Boulogne declare the harbour to be easily accessible under all circumstances to vessels drawing 21½ft. water at high water spring tides and 16ft. at high water neap tides. Consequently a vessel drawing 16ft. to 16ft. 6in. may be sure to enter the *bassin-a-flots* any day that it may present itself at the entrance of the port, and this measures at present the facilities extended to commerce and the navigation of the channel by the new dock just opened at Boulogne. As it is, vessels of this size have to wait several days before they can enter the harbour of Dunkirk if they happen to present themselves before it at neap tide, so that, even at this moment, the opening of the new dock at Boulogne marks an important improvement in the facilities presented to navigation by the harbours on the north coast of France. Rails in connexion with the station of the *Chemin de fer du Nord* run along the margin of the *bassin*, enabling vessels to discharge direct into the railway waggons without trans-shipment, and it is intended before the close of the year to provide cranes and all the most improved appliances to facilitate the the loading and unloading of vessels.

## THE SUEZ CANAL.

### By C. H. Rockwell.

*(From the Journal of the Franklin Institute.)*

In view of the commercial importance of this enterprise, as well as the diplomatic prominence which it has attained of late years, it may be interesting to note the present condition of the work, the prospects of its early completion, and the probabilities of its being maintained as one of the great highways of commerce.

The facts here presented, were gathered while on an excursion along the line of the proposed canal in March, 1867. The present article will merely glance at the history of crossing the Isthmus of Suez by water, dwelling at length upon the actual work now undertaken, and the means employed in its execution.

The traditions of the Arabs, as well as the researches of Champollion and other Egyptian scholars, attribute the cutting of the first canal, which led from the Nile to the Red Sea, to Sesostris or Rameses II., who reigned about 1300 B.C. Pliny and Aristotle also mention Sesostris as the originator of this work. It is quite certain that Neco and Psammeticus, about 600 B.C., re-opened the ancient canal, which had been allowed to become filled with sand in some places. Ptolemy Philadelphus still further improved the navigation, and added sluices to control the flow of water, which were at the same time made of sufficient capacity to allow vessels to navigate them. After the conquest of Egypt by Cambyses, Darius came from Persia to take possession of the conquered province, and, while there, caused the canal to be reconstructed. Herodotus, writing a hundred years later, gives an account in detail, of his passage through the canal, and mentions the fact that Darius had repaired it. After the battle of Actium, Cleopatra endeavoured to withdraw the Egyptian fleet through the canal to a place of safety in the Red Sea, but was prevented from so doing by the low stage of water in the Nile at that season. This circumstance drew the attention of the Roman Emperors, Trajan and Adrian, to the canal, and they caused another branch or feeder to be dug to the main body of the Nile, near to where Cairo now stands. This branch joined the ancient canal at Zagazig, and was continued thence to Suez.

The whole work was again neglected for many years, and was next repaired by order of the Caliph Omar, about A.D. 640. In 780, or thereabout, the Caliph El Munsoor Aboo Grafer caused the canal to be filled up, in order to prevent the export of breadstuffs to the province of Medunch, which was then in revolt. The Sultan, Hakem, A.D. 1,000, is said to have again put the line in navigable order; but certainly only for a short time; as the southern or Suez end has long been choked with sand. The northern or western portion of this ancient canal, from Zagazig to Gassassine, say 22 miles, has always been kept in order, for the purpose of furnishing water to irrigate a tract of land called "the Ouady," of about 30,000 acres, part of the Scripture "Land of Goschen," and where are now some 20,000 mulberry trees and excellent cultivation.

The question of direct communication from the Mediterranean to the Red Sea, has engaged the attention of several of the sultans of Turkey, but they did nothing to promote it. While in Egypt, in 1789, Napoleon ordered his engineer, Monsieur Lepèr, to run a line of surveys across the Isthmus, to ascertain if the two seas were on the same level. The order was obeyed, but the work was done hurriedly, with poor instruments, and through the midst of hostile tribes; so that when it was announced that there was a difference of level of nearly 33ft., no one placed any confidence in the report. The mathematicians, Laplace and Fourier, declared that this result was inconsistent with theory, and that there could not be any such great difference, if indeed there was any at all. Subsequent examinations have proved the correctness of their assertions; Monsieur Bourdaloue, the eminent French engineer, having ascertained in 1847 that the difference of mean tide in the two seas was only about 6½in.; the tides in the Mediterranean being from 9 to 12in.; and in the Red Sea from 50 to 70in.

In the autumn of 1854, M. Ferdinand de Lesseps visited Egypt by invitation of Mohammed Said, son of Mehamet Ali, then Viceroy, with the design of discussing the feasibility of constructing a ship canal of large dimensions, running directly from sea to sea. M. de Lesseps had been the French Consul General in Egypt for the seven years succeeding 1831, and had already given much attention and study to this question, as is well known to the Viceroy. The result of this visit was a preliminary concession, or grant, in November, 1854, from Mohammed Said, representing the Egyptian Government, authorizing M. de Lesseps to form a company for the purpose of digging the canal, and securing to such company the exclusive right of transit for 99 years, from the day when the work was finished.

A new and thorough survey of the isthmus, from Suez to the Bay of Pelusium, was commenced at once by the engineers of the viceroy, Messrs. Linant-Bey and Mougel-Bey, who completed their work in March, 1855. Their detailed plans were finished in August, 1855, and in the following October were submitted for examination to an international commission of engineers, nominated by the Governments of England, France, Austria, Holland, Piedmont, Prussia, and Spain. The commission first met in Paris, and in November five of the members went to Egypt to examine the whole question of the canal in detail upon the ground. They returned to Europe late in January, 1856, and made their report in December of that year, confirming the feasibility and safety of the enterprise. Notwithstanding the fact that the sultan had declined to confirm the concession of the viceroy, M. de Lesseps succeeded in organizing the canal company, with a capital of two hundred million francs, and obtained a second concession in January, 1856, similar to the first, but much more in detail. The constitution and regulations of the company which was organized under the French law, were also submitted to the viceroy and approved by him.

The line of the ship canal, as determined by the commission of engineers, runs nearly north and south from Port Said on the Mediterranean, to Suez at the head of the Red Sea, a distance of 100 miles. The width at the water line will be 330ft., with a uniform depth of 26ft. The alignment is very favourable, there being but eight curves; the shortest radius is 6,666ft., with an angle of 143°. For nearly three-quarters of the distance the canal will be dredged through a line of shallow lakes or basins, some of them containing brackish water filtered in from the sea, and others, being dry at present, indicating the locality where lakes existed at some former period. The intervening strips of land are parts of the Great Desert which extends over so large a portion of Egypt, Syria, and Arabia, an arid, desolate waste, with nothing to sustain either animal or vegetable life. It was, therefore, a matter of the first importance to introduce a supply of fresh water along the line of the proposed ship canal to sustain the men employed, as well as to supply the boilers of the necessary steam-engines. To accomplish this, the company dug an extension from the terminus of the ancient canal, at Gassassine, to a point on a line of the ship canal, midway between Port Said and Suez. This work was executed under the direction of M. Cazean, at an outlay of 700,000fr.; about 1,300,000 cubic yards of earth being moved. The length of this fresh-water canal is 30 miles, the width at the water line 66ft, depth 6ft., with a fall of about 2in. per mile. Its direction is nearly east, coming in at right angles to the line of the main canal at a point now called Ismailia, so named in honour of Ismail Pasha. From here the water was at first distributed to the camps along the line of the ship canal by transportation on the backs of 2,000 camels and half as many donkeys, which were employed for that purpose, for many months. Afterwards a cast iron pipe, 6¼in. in diameter, was laid from Ismailia to Port Said, a distance of 50 miles, and through this about 22,000 cubic feet of water have since been forced daily. There is now a second pipe laid parallel with the first of 10in. diameter, furnishing about 32,000 cubic feet of water per day additional. The pumping-engine at Ismailia is a beautiful piece of mechanism, made by Le Banneur & Pétan, Paris, rated at 50-horse power. It was one time necessary that it should be kept running night and day for five consecutive months, and during this period it was not once stopped. These water-pipes are tapped along the line, at such points as required, to supply the men and engines there at work. The cost of these water-works has been about 6,000,000 francs. The level of the fresh water at Ismailia is 19ft. above that of the salt water in the canal, and two locks have been constructed so as to form a navigable connexion between them, and of sufficient size to allow the passage of boats 100ft. long and 26ft. wide. At a point on the fresh-water canal, 2½ miles above Ismailia, a branch canal takes off from the southward, extending 58 miles to Suez; this line was also constructed under the direction of M. Cazean, and cost about three and a half million francs; it was finished in 1863. By this branch fresh water is furnished to the camps and engines south of Ismailia, and also the town of Suez; whereas, formerly, all drinkable water had been brought from the Nile, at Cairo, a distance of 90 miles over the railroad. In still earlier days the dependence was upon the "Wells of Moses," situated on the eastern side of the harbour, and this water, the best to be had, was decidedly brackish. It is by means of this last-mentioned branch canal that water communication has been opened between the two seas, and not through the length of the ship canal proper, as the public have been led to believe. The *northern* end of the ship canal, from Port Said to Ismailia, is, however, now sufficiently advanced to allow the passage of boats drawing 5ft. of water; and the current from the Mediterranean has been flowing through this portion for a number of months, and is daily filling up the basin of an ancient lake "Timsah," at the point of junction of the fresh-water canal, from Gassassine to Ismailia, and the ship canal. History and tradition both inform us that there once existed at this point a lake famous for the number of crocodiles to be found in it.* It must have been a fresh-water lake, and been fed by the overflow of the Nile.

The whole extent of the isthmus is covered with marine shells, similar to those which are now found in the neighbouring seas, indicating, beyond a doubt, that at no very remote period, geologically speaking, the salt water stood at a higher level than it does to-day; and that the isthmus, as such, did not then exist. There is quite a remarkable depression in this neck of land as now seen, and through this depression or valley the canal will be constructed. Port Said, at the Mediterranean entrance, is in latitude 31° 16′ north, longitude 32° 19′ east. This point was selected for the reason that just here the line of deep water is nearer to the beach than anywhere else along the coast. In the bay of Pelusium it was found that the line of 33ft. soundings was nearly 4 miles from the shore, while at Port Said the distance is only about half as great. The beach in all this region is merely a narrow strip of sand one hundred or two hundred yards in width, inside this are a number of shallow lakes, or mere salt marshes, some of them of great extent.

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* The name "Timsah" in old Arabic means Crocodile.

Through one of these shallow basins, called lake Menzaleh, the canal will be dug for a distance of nearly 30 miles. At the end of lake Menzaleh is another smaller basin, called lake Ballah, about 8 miles in extent, as crossed by the canal, and at the southern side of this is found the highest point of land to be seen on the whole line. The extreme width of this ridge, called El Guisr, is about 10 miles, with a summit 61 feet above the sea level, which, added to 26 feet, the depth of the canal, will require a cutting of 87ft. On the southern side of El Guisr is lake Timsah, through which the canal will be dredged for about 5 miles, it then crosses the ridge of Serapheum, about 8 miles in width, with a maximum cut of 61ft. After this, proceeding southwards, the line strikes the immense basin of the Bitter Lakes, where the level is, in many places, as great as will be required, and where comparatively little work will have to be done for twenty-three miles. This depression is bounded on the south by the ridge of Chalouf, about 5 miles wide, where there must be a cutting 55ft. deep, for a short distance. Between Chalouf and the Red Sea is the Plain of Suez, 10 miles in extent, as crossed by the canal, and elevated only a few feet above the sea level.

The construction of the harbour, or entrance to the canal, at the Suez end, presents no engineering obstacle of any account; the head of the Red Sea is so completely land-locked, as never to be troubled with a very heavy swell; there is no current at all; so that it will only be necessary to dredge out a channel into deep water.

At port Said, the northern terminus, there will be more trouble; nothing, however, which skill and money will not overcome. The harbour here, will be formed by two jetties or piers; the western one extending into the sea for a distance of 3,850 yards; say 2¼ miles. Its direction being north-north-east, with the extreme end curving a little more to the east. The other pier will extend 2,750 yards or a little more than 1½ miles, in a direction nearly north; its base or starting point is 1,550 yards eastwards, from the base of the other, or western jetty; and its extremity will be 440 yards distant from the line of the other; thus giving a clear passage a quarter of a mile wide, into the harbour; which will be the easiest and safest entrance of any of the ports along the eastern shore of the Mediterranean. This triangular area of 575 acres will be dredged to a depth of 30ft.; forming an outer harbour, where vessels can anchor before entering the basins, which communicate with the canal.

These piers were commenced with stone, from the quarries at Mex, a few miles south-west from Alexandria, carried to port Said in Greek sailing vessels; but the cost was so great and the progress so slow, that some other mode had to be adopted. The work is now being continued under a contract with Messrs. Dussaud, Freres, who have recently built the harbours at Cherbourg and Marseilles, gentlemen of great experience in hydraulic engineering. The material used in place of stone is a concrete, formed of hydraulic lime, from Theil, France, and the sand which is dredged out of the harbour. The proportions of the mixture are 325 kilogrammes of lime, to one cubic mètre of sand; say, 715 pounds to 37 cubic feet. The concrete is formed into large blocks, which measure 11ft. 3in. in length; 6ft. 7in. in width, by 5ft. in depth; looking like immense bricks; containing 370 cubic feet each (ten cubic mètres) and weighing 22 tons. As we saw them manufactured, the lime and sand were ground together, in large, circular, cast-iron troughs, about 12ft. in diameter; in each trough there ran 3 heavy iron wheels, which completely pulverized the lime, and thoroughly mixed the ingredients. The grinding was continued for about 20 minutes; a small quantity of sea water being added from time to time, until the mass had assumed the consistency of a thick mortar. A trap-door in the bottom of the trough was then opened, and the mortar fell into a car, standing below. A line of rails guided the car to where the moulds were set up, and into these the mortar is dumped, and carefully rammed into the corners. In about a week's time the concrete has so "set," or dried, as to retain its shape, after the planks and clamps which form the mould, are removed; these are then set up again in another part of the yard. After drying in the open air for about three months, these blocks become hard enough to bear handling without danger of being broken; they are then raised by a steam crane and placed on a car, on which they are conveyed to the dock. Here another crane lifts them from the car, and places them on the deck of a barge, fitted to receive three of the blocks at a time; they rest upon a platform which has an inclination of about 20 deg., and are retained in their position by iron "fingers," attached to an iron bar, which runs across the lower ends of the three masses. The barge is then towed to the proper position, in the line of the proposed pier, as marked by signal-flags, on shore, and by buoys. When in line, the "fingers" are made to release their hold upon the blocks, and they slide off the barge into the water. After having been submerged for a few months, the concrete becomes nearly as hard as granite. When the accumulation of blocks has approached so near to the surface of the water as to prevent the passage of the barge across the line of the pier, the blocks are lifted from the barge by a floating crane, and deposited in their destined positions, one above another, until the top of the pier is about 15ft. above the surface. There are about 30 of these blocks made per day, and the same number daily submerged. The price paid to the contractors is 400 francs each; there will be required about 30,000 of them; making the cost of the two piers, twelve million francs. About 10,000 blocks had been sunk up to March, 1867.

There is a very decided current from the west setting along this coast, which brings with it a considerable quantity of sand; this sand fills up the spaces and interstices between the blocks in the piers, thus forming a solid mass, which promises to stand for all time.

It was stipulated by the terms of the detailed concession of January, 1856, from Mohammed Said to M. de Lesseps, that four-fifths of the labourers to be employed in digging the canal, should be Fellahs, or native Egyptians, who were to be furnished by the viceroy in such numbers as might be required by the engineers of the company. They were to be paid by the company at the rate of 12½ to 15 cents per day, (2½ to 3 piastres,) for all labourers over twelve years of age; those under twelve were to receive 5 cents, or one piastre per day, as wages; but a ration for their subsistence to the value of one piastre per day, additional, was to be given to each one irrespective of age. The number of persons thus employed was usually between twenty and thirty thousand; and the principal work on the canal was prosecuted under this agreement from 1859 to 1863. But it was found to be very unsatisfactory in its operation by each of the principal parties. The company could not get the men as they were wanted; they were not easily managed when obtained; and feeling no interest in the general enterprise, they did as little work as possible. It was found that eighteen thousand of these labourers, working for ten months, had moved only four million cubic mètres of earth; being less than one cubic mètre per man per day; whereas the engineers had calculated that a mètre and a quarter would be an easy days work. Matters lingered along in this most unsatisfactory condition for two or three years; until in May, 1864, the Fellahs were wholly withdrawn from the work. Another article in the concession of Mohammed Said to the company, gave them the right to dig the fresh water canal from Ismailia to Suez, which has been before alluded to. This line was wholly in the desert, a distance of nearly 60 miles through a barren, desolate country, entirely worthless as it then was. The company were also to be allowed to own in fee simple, as much of this waste land as they could reclaim and render fit for cultivation, by means of the water, for irrigation, from the canal which they were to dig. These lands were to be exempt from all taxation for ten years, and after that time, were to pay the same revenue or tax to the Egyptian government, as was imposed on similar lands elsewhere. The company were also permitted to use the fresh-water canal for purposes of transportation, and to receive toll for boats and merchandise passing through it.

It was soon discovered that water was all that was needed, to make these sandy wastes really valuable; and the terms for their lease, which the company were prepared to offer, were so liberal, as would speedily induce a large number of French agriculturalists to settle upon them. This caused more trouble and delay at Constantinople; as the English were afraid to have a numerous French colony on the Isthmus of Suez, lest their communication with India should be endangered thereby. The sultan was induced to view the matter in this light, and to withhold his assent from such an arrangement. These difficulties caused a general stagnation in the affairs of the canal company; and for two years their work was almost entirely suspended. The whole subject of the concessions from the viceroy to the company was at last submitted to the arbitration of the Emperor Napoleon, who, in July, 1864, rendered a decision to this effect: 1st. That the concessions of November, 1854, and January, 1856, had the form of a contract, and were binding on the two parties. 2nd. That by reason of the withdrawal of the Fellahs as labourers, the cost of the work on the canal would be increased; and that the viceroy should pay on that account, an indemnity of thirty-eight million francs to the company. 3rd. That the company should cede to the viceroy all of their fresh-water canals; reserving only the right of passage through them. And that the viceroy should pay ten million francs for the canals, as representing their cost of construction, and six million francs additional, as compensation for the tolls, which the company thereby relinquished. 4th. That the company should retain only such lands along the line of the ship canal, as might be necessary for the proper working and care of it, as a line of passage between the two seas. 5th. That the company should recede to the viceroy, their right and title to all lands susceptible of cultivation by means of irrigation from the fresh-water canals; and that the viceroy should pay therefor thirty million francs. This area being estimated at sixty thousand hectares, valued at five hundred francs per hectare; say, forty dollars per acre, for the naked desert. This made a sum total of eighty-four million francs, to be paid as decreed by the Emperor. The company also agreed to sell to the viceroy, for ten million francs, the "Ouady" property, which they had purchased from El Hamy Pasha. These items, together with the balances due on the company's shares, subscribed for by the viceroy, made a sum total of one hundred and eleven million francs. From this amount there was deducted about nine million francs, as money already paid; leaving a net balance of about one hundred and two million francs still due. Of this, the viceroy paid about twenty-three and a quarter million francs, in 1866; and is now paying at the rate of three million francs per month for this year, 1867. The balance is to be paid at the rate of about one million and a half francs per month, during 1868 and 1869. It is mainly with this money, that the work on the canal is being prosecuted; the required balance being furnished by the shareholders. The total and sudden loss of the Fellahs, as labourers, had the effect of retarding the completion of the canal; it being necessary to substitute therefor steam machinery, and to organize an entirely new system for continuing the work. In this respect there has been the most gratifying success. The principal contract for the excavations along the whole line of the canal, has been awarded to Messrs. Borel and Lavalley, at the price of one hundred and twenty million francs; based upon the estimate of fifty-one million cubic metres of earth to be moved, at two francs, twenty centimes per metre. They agree to have the entire work finished by December, 1869; being stimulated by a large bonus, if completed before that date, and incurring a heavy penalty for each month of delay beyond the time specified. In this immense undertaking, M. Borel is the financial manager; and to M. Lavalley is entrusted the engineering and executive department. He is a graduate of the "Ecole Polytechnique," and had already shown himself to be one of the first mechanical engineers in Europe, before undertaking this great enterprize. The machines now in use along the line have either been invented by him, as occasion required, or have been especially adapted to do the work in hand. The principal instrument employed, is a large dredging machine, with iron buckets, which are fastened to an endless chain, revolving over two drums; one at the end of a long movable arm, to regulate the depth at which the buckets or scoops shall come in contact with the earth to be excavated, and the other at the top of a heavy frame-work of iron, standing in the centre of the body or hull of the machine. The size of these dredges varies according to the work to be done, and especially as regards the disposition to be made of the excavated material. Those first in use were of very much less capacity than the new ones of later construction. The body or hull of the smaller size is about 83ft. long by 23ft. broad; with the axis of the upper drum 28ft. above the surface of the water. These have engines of 15-horse power, and are capable of excavating about 300 cubic yards of sand per day. The size of the newer dredges was increased from time to time as was deemed prudent, and was warranted by the success of those which had preceded them; the second class having an elevation of 38ft. for their axis, while those of the third class have their drums 48ft. above the water, with their hulls 110ft. long, by 27ft. broad; the material of the hulls in all cases is boiler iron, and in shape they are rectangular. The capacity of these largest machines is equal to 2,500 cubic yards per day, of 12 hours, when working without interruption; their engines are of seventy-five horse power. The "prize dredging" for the month preceding my visit, was an average of 1,700 cubic metres per day. The sand when elevated by these dredges is disposed of in one of three ways, according to the position in which the machine is at work. If the earth is required for filling, or is wanted for making of the concrete blocks, it is then emptied into large boxes, holding about 4 cubic yards each; seven of these boxes fit into a barge of peculiar construction, and they are filled by being brought under the spout of the dredge. The barge is then floated to the desired point, where the boxes are lifted from it by a steam crane and placed upon cars, which run on tram-ways in such directions as may be required. One end of the box opens on hinges, so that the contents may be dumped quite easily.

It was in this way that the site of Port Said has been raised from the level of the shallow salt lake which surrounds it; a portion of the material which has been excavated to form the channel and ship-basin at the entrance of the canal, has been used to elevate the town plot about 15ft. above its former level; giving the foundation of an active, healthy settlement, where are now more than 8,000 inhabitants. The greater portion of the excavated material will be received from the shoots of the dredges into large barges, especially provided for the purpose; of these there are two kinds. The larger are 142ft. long by 23ft. beam, capable of carrying 275 cubic yards of sand in 5ft. of water; the space occupied by the sand is in the centre of the boat, longitudinally, and of about one-half the total length; the material is discharged through 12 trap-doors at the bottom, six on each side of the axis; the opening and shutting of these doors being controlled by chains. The bow portion of the barge is fitted up as quarters for the crew; the stern is occupied by the boiler and engine, of sufficient power to propel the vessel five miles an hour when loaded. In order to give increased buoyancy, there are two air-chambers running parallel with the axis of the boat, through the section where the sand is deposited, the interior sides of the chambers sloping from the gunwales towards the centre to facilitate the discharge of the load. These barges now convey the material which is excavated to form the channel and basin at Port Said out to sea some four or five miles and drop it in deep water; they will also be used in the lakes through which the line of canal passes where there is sufficient depth of water. The other style of barges are especially adapted for shallow water; they are smaller than the others, and can carry 125 cubic yards of waste material on a draft of less than 4ft. These have their air-chamber in the centre, parallel to the axis of the boat, with the trap-doors opening on the sides; they have engines and screw-propellers, but of less power than those first mentioned, and are not calculated to go into rough water. But the great mass of the material to be excavated in forming the canal will be discharged from the buckets of the dredges into long spouts of heavy sheet iron, which reach over the bank on either side. These spouts are sustained by a tall framework of iron, which rests upon the deck of a rectangular, iron float, about 96ft. long by 28ft. broad, requiring about 5ft. of water. The shape of the spout is a semi-ellipse, 5ft. wide from edge to edge and 2ft. deep; the slope of the spouts is graduated according to circumstances, but no trouble is found in working sand or clay when the inclination is 8 per cent. of the length; the greatest length now in use is 230ft. The contents of the buckets of the dredge when dumped into the upper end of the spout, is forced through it by means of a strong current of water, which is supplied by a rotary pump worked by a separate engine. The longest spouts are intended to be used in connexion with the largest dredges; when thus employed, their upper ends will be about 36 ft. above the surface of the water; an inclination of 8 per cent. will leave the lower end about 18ft. high; this elevation will easily clear the low bank which has been formed by the smaller dredges in digging the channel in which the larger machine operates. The float which sustains the spout is fastened by chains and braces to the hull of the dredge, so that the direction of the discharge through the spout can be changed, and its distance from the bank can be regulated by the guiding chains, which are laid out to anchors on the four sides of the principal machine. The extreme width of the canal will be 330ft., as before mentioned; by means of these long spouts a dredge can work in the centre of the channel, and at one movement can dispose of the excavated material at a good distance beyond the water line on either side. Another advantage in the use of this apparatus has been found in the very gentle slope which is taken by the sand when thus discharged. The quantity of water pumped into the spout is as great as the amount of sand, so that the material escapes in a semi-fluid state, and the water sweeps the sand along with it to a very considerable distance before depositing it. There has been found no difficulty in thus disposing of 200 cubic yards of material to each lineal yard of canal. This system of the spouts is considered as the especial invention of M. Lavalley; he has also devised means of dumping the sand over the banks in places where the cutting of the canal brings the dredges too low to render the spouts available. This is done by an inclined plane, or travelling elevator, which consists essentially of two lines of iron rails or beams, about 160ft. in length, placed at an inclination of one to four, and sustained in the middle by a frame of wrought iron, which rests on a car, running on rails, laid along the bank of the canal, and elevated about 6ft. above the surface of the water. The lower ends of the rails or beams overhang the water, and are still further supported upon a rectangular float, which also carries a steam-engine. When in operation the apparatus is placed at right angles to the axis of the canal; the inner or lower ends of the inclined plane is now about 10ft. above the water, while the upper end is some 36ft. higher, and distant 140ft., horizontally, reaching over the bank which has been already formed. A barge containing seven of the large boxes before mentioned is now floated under the inner end of the plane, and one of the boxes, filled with sand, is raised on to a truck which runs on the inclined beams; an endless wire rope draws the loaded truck to the upper end of the beams, where the contents of the box are dumped over the bank. These are the means which will be employed for digging all those portions of the canal where the earth is not more than 6ft. above the water line; amounting to a total distance of about 76 miles. The quantities to be moved are nearly as follows, viz.: seven million cubic yards, by the sand boxes and elevators, thirteen million for the barges, and thirty-five million for the spouts; being a total of fifty-five million cubic yards.

At those points where the cutting exceeds 6ft., the preliminary work must be done by hand labour before the dredges can be made available. As before mentioned, the deepest cut will be at El Guisr, about 66ft. above the water line; here was concentrated the great mass of *Fellahs*, for about three years; and this is almost the only spot where any real amount of work was done by them. They cut a narrow channel through this ridge down to a level a little below the water line. When work was resumed upon the new basis of steam power and paid labour, a contract was made with M. Couvreux to complete this deep cut for ten and a half million francs; and he is now doing the work with locomotives, which haul a train of loaded cars out of the excavation, the cars being loaded by hand. Except this point, the contract of Messrs. Borel and Lavalley covers the entire line of canal. The only section where *they* have been obliged to dig by hand labour below the water line is at Chalouf, the narrow ridge at the southern end of the Bitter Lakes. Here their borings discovered a stratum of sand-stone about 10ft. thick nearly at the bottom of the canal; its extent was not great, as it soon pitched below the required level. The quantity of rock excavated was about 34,000 cubic yards, covered by about 165,000 cubic yards of sand and clay. The material here was drawn out of the cutting upon 5 inclined planes running directly up the banks at right angles to the axis of the canal, and about 250 yards distant from each other; the motive power being a stationary engine at the top, drawing up two cars at a time, each containing about four cubic yards. The line of the fresh water canal was not far from the ship canal at this point, and some trouble was experienced from the infiltration of water. This was soon remedied by means of three large rotary pumps.

On those sections where the surface of the ground is elevated above the reach of the dredges, the preparatory work is done by Arabs; these men swarm in from the surrounding desert and work exceedingly well, taking small tasks or jobs. The engineers, having carefully measured the quantity of earth which is to be moved, name the price which is to be paid for it; reference being had to the nature of the soil, as well as the distance to which the material must be transported. The company furnish all necessary tools, wheelbarrows, running-boards, &c., and name such a price for the job as will give the men about three francs for a day's work; they usually earn more than this, as they work hard, and almost uniformly finish their work before the time appointed. These men are exceedingly avaricious and fond of money, but are generally quiet, peaceable, and easily controlled: there are now probably 10,000 of them employed along the line, and this number could easily be increased if desired. But few European labourers are engaged in the actual digging of the soil by hand labour; the Arabs, Egyptians, and Syrians having almost a monopoly in this department. The masons, carpenters, and machinists are mainly Italians, Austrians, and Dalmatians. The men who are employed on the dredges are mostly Greeks, under the direction of French engine-men and chief artizans. The staff of engineers in charge of the work, the clerks, cashiers, and warehousemen are nearly all French. The general state of health among the workmen is very good; the mortality being one and one-third per cent. per annum. Of the total amount of excavation to be done to complete the canal according to the plans adopted, only about one-third has yet been accomplished; but still, the enterprise as a whole, is looked upon as being more than half finished. An immense amount of labour has been done in works of a preparatory nature, and the contractors are now in a position to push ahead with rapidity. M. Lavalley has stated that their outlay for machinery had already exceeded ten million dollars, besides a million and a half of dollars for preliminary expenses, such as machine-shops, dwelling-houses, wharves, &c. They will have at work within a few months 60 of the large dredges and 16 of the smaller sizes. Of the former, 20 are to be fitted with the long spouts, and are each calculated to raise 440,000 cubic yards of material per annum. The other 40 large machines will be attended by 110 of the steam sand-barges to transport their product. These dredges will lose some time in shifting their spouts from one barge to another, and are counted upon for a less net result than those with the spouts, viz.: 375,000 cubic yards each per annum. These results, with the assistance of the smaller machines, will make a total of twenty-five million cubic yards per annum; so that there is every prospect of the completion of the canal in the autumn of 1869. The aggregate force of the steam-engines which will be employed when all the machines are at work will exceed ten-thousand horse-power. By means of the narrow channel through the ridge of El Guisr, there is salt water communication from Port Said to Lake Timsah, and from thence by the fresh water canal to Suez. Through this shallow, crooked passage M. Lavalley has sent his dredges; four of them are now at work in the Red Sea, five others are at a point some ten miles from Suez, floating in a section of the ship-canal, now filled with fresh water; while six more are doing good service at Serapeum, an artificial lake having been most skilfully formed there and filled from the fresh-water canal at a height of 12ft. bove the sea level.

The objections which have been urged against the impracticability of the Suez canal are now found to be almost wholly without foundation. The drifting of the sand in the desert has been carefully observed and calculated; and, so little does it amount to, that M. Lavalley declares that, with a *single one* of his dredges, he can keep the channel clear and maintain the full depth of water throughout the whole length of the canal. The opponents of the enterprise have always laid great stress on the mud from the Nile, which would be carried eastward by the currents in such quantity as to fill up any harbour which might be dredged at the Mediterranean entrance. The experienced at Port Said during the past six years has removed all anxiety on this score, there being no deposit at all. This is *now* one of the best harbours on the Egyptian or Syrian coast, as vessels drawing 15ft. of water can run in in any weather; there were 861 entries at the port in the year 1866. During the summer of 1867, the channel will be deepened so as to admit vessels of 21ft. draft; during 1868 the depth will be increased to 25ft., and a still greater depth will be afforded, sufficient to admit the largest class of merchant vessels, in 1869. There seems to be scarcely a doubt but that the canal will soon be completed, so as to afford a safe and easy passage between the two seas, when it will present a most striking evidence of diplomatic tact and perseverance on the part of M. de Lesseps, and of engineering skill by M. Lavalley.

A concession for laying a telegraph cable from the Spanish Antilles to the coast of Mexico has been granted to Senor José Caceres.

## NATIONAL AGRICULTURAL EXPOSITION AT CHILI.

### Programme.

Article 1. On the 1st day of April, 1869, there will be opened in Santiago in Chili, South America, an Agricultural Exposition, at a locality hereafter to be designated.

Article 2. The chief object of this exposition is to stimulate as well the landed proprietors of the country as national and foreign manufacturers and importers of agricultural tools and implements, to cause the adoption of the best methods introduced in husbandry, to improve the breed of animals, and to give an impetus to everything that tends to cheapen and perfect production.

Article 3. The exposition will be especially devoted to agricultural tools and implements and breeding animals; but all such things will be admitted as appertain in any way to rural industry.

Article 4. The exposition will, in consequence be divided into departments as follows: The first for tools and implements; the second for cattle; and the third for all such articles as serve for the advancement of agriculture—as seeds, wines, oil, dried fruits, timber, models of country houses, household articles, articles of rural economy, dried beef, pulse, liquors exotic and textile plants, etc., etc., etc.

Article 5. In the department of tools and implements there will be admitted to the exposition, and to the contest for premiums, the following articles:

1. Thrashing machines, operated by animal, mechanical, or steam motive power.
2. Steam motive powers, fixed or movable.
3. Machines for reaping wheat or mowing hay, or for both purposes. worked by oxen or horses.
4. Improved ploughs of every kind, single and double.
5. Harrows of every kind, both of iron and of wood.
6. Cultivators of whatever form or denomination.
7. Rollers for breaking the soil or pressing the earth.
8. Harrows with movable teeth, drawn by horses.
9. Machines for separating the grain from the ear of corn, sifting hay or straw, or grinding pulse; for crushing grain or oleaginous substances, or triturating them for the food of cattle.
10. Machines for cleaning and separating wheat and all kinds of grain.
11. Machines for winnowing wheat thrashed by horses.
12. Portable agricultural mills, single or double, moved by water, steam, or animal force.
13. Implements for the dairy, and for the making of cheese and butter.
14. Apparatus for pressing grapes.
15. Wine presses, fixed and portable.
16. Distilling apparatus for grains and liquids.
17. Machines for rooting up and breaking the earth.
18. Machines for dressing and combing hemp and flax.
19. Apparatus for irrigation, as pumps, iron sluices, etc.
20. Machines and implements for spinning and weaving silk, and ovens for developing the eggs of the silkworm.
21. Bees and all utensils relative to the care of bees.
22. Machines for sawing wood.
23. Machines for dressing hay, straw, wool, charqui, etc.

Article 9. There will be five classes of premiums for the special purposes hereinafter expressed, and which will be awarded by the different commissions combined into one.

1. A grand medal of honour and a premium of eight hundred dollars which will be awarded to the national or foreign manufacturer or manufacturing company that shall present the greatest number of machines, apparatus, or instruments of agriculture which, combined, shall be deemed to produce the most perfect results, and which, in the judgment of the commission, shall be entitled to the premium. But in this case the articles must be proved to have proceeded, and been sent directly from the manufactory in question.

2. A premium of the first class, which will consist of a gold medal and five hundred dollars for the thrashing machine that shall deliver the grain in the cleanest condition, and render the greatest quantity in a given time, regard being had for the relative power of the motor, the size of cylinder, and other conditions which it may be proper to take into consideration. There will be a second premium, which will consist of a silver medal and three hundred dollars for this class of machines, which will be awarded according to the discretion of the commission.

3. A gold medal and four hundred dollars for the best winnowing machine for wheat, worked by horses, and which, in the judgment of the commission, attains the object for which it is intended.

Article 10. All the other apparatus or instruments will be classified by the special commissioners to be appointed, in different classes, according to their character and variety, or the quantity of each kind that may appear in the exposition; and those that deserve premiums in each class will have awarded to them medals of gold and silver, and premiums ranging in value from five to ten dollars.

Article 13. In addition to the gold and silver medals and pecuniary rewards there will be given medals of bronze, whenever the commissioners deem any one of the various exhibitors entitled to the reward.

Article 14. No object shall be admitted to the exposition which, in the judgment of the commission charged with the management of the exposition, ought to be rejected as not fulfilling the required conditions.

Article 15. Every person who desires to take part in the exposition should at least two months beforehand, communicate in writing to the committee having charge of the exposition his intention of being one of the exhibitors, designating at the same time the article or articles which he wishes to present and the quantity thereof, in order to have the proper space reserved, and to make the necessary arrangements for the best and most convenient location with a previous knowledge of all the articles destined to figure in the exposition. Those who do not comply with this requirement will have no right to be admitted to the exposition.

From this condition are excepted manufactured articles and animals brought from abroad, which will be admitted up to the day preceding that of the opening of the exposition, and will be entitled to premiums like the former.

Article 16. All articles intended to appear in the exposition ought to be sent punctually, at least fifteen days before the day fixed for the opening of the exposition, except the animals, which should be entered at least three days before the opening.

Article 17. A special regulation, hereafter to be published, will determine the days on which the trial of the various machines is to take place as well as everything else concerning the arrangements of the objects that may be transmitted, and all the necessary preparations for the realization of this programme.

(Signed) FRANCISCO ECHAURREN, SANTIAGO PRADO, DOMINGO BEZANILLA, MANUEL BEAUCHEF, RUPERTO OVALLE, BENJAMIN ORTUZAR, BENJAMIN VICUNA MACKENNA.

Santiago. April 30, 1868.

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## SEWAGE EXPERIMENTS AT LEICESTER.

### SILLAR'S PROCESS.

Some important experiments in the purification of sewage were made at Leicester last month, the object of which was to put an invention, by Mr. R. G. Sillar, the nature of which will be easily understood, to a practical test. The manurial matters in town sewage exist in a state of such attenuated solution that the weak liquid is valued at only twopence or a little more per ton; mere cost of conveyance, therefore, precludes its application to any but low-lying lands, and as it cannot be stored for use except in certain seasons, it cannot be fully utilized except by some special system of husbandry capable of consuming one invariable quantity day by day throughout summer and winter. The point to be aimed, at therefore, is to separate the valuable constituents from the extremely diluted liquid, fixing them in a concentrated, dry, easily transportable manure, that could be stored for use in any season and applied in any situation. Of the many plans proposed for accomplishing this object, some have managed to separate the whole of the insoluble or sedimentary matter, and even a small proportion of the soluble constituents; but hitherto no chymical or mechanical device has succeeded in precipitating in a solid form the most valuable ingredients held in excessive dilution in the sewage. Everybody seemed to have agreed that the only feasible mode of utilizing sewage is by surface irrigation, but a short time ago a new process for accomplishing the desired result was patented by Mr, Robert George Sillar and Mr. George W. Wigner, analytical chymist. The origin of the invention is said to have been suggested, by some of the purifications enjoined upon the ancient Hebrews, "the ashes of an heifer" pointing out animal charcoal, and blood poured upon the ground prompting a use of blood and of clay. The inventors, therefore, mixed these three substances,—animal charcoal, blood, and clay,—adding alum and three other chymicals which are at present secret, but affirmed to be cheap and commercially obtainable in any quantity. Laboratory experiments showed that this "A B C compound," as it was called, had the power of precipitating nearly all the manurial constituents of sewer water, the whole settling in a flocculent mass at the bottom of a vessel in the course of a few minutes. The water was left almost pure, and the residuum when dried required only simple treatment by an acid to render soluble certain of the constituents for the use of plants. Of course, until further inquiry is made, and until the Rivers Commission authorize a publication of their own analysis, the inventors are responsible for these statements.

The mayor and corporation, at the request of the Rivers Commission, placed their sewage works and machinery at the disposal of the inventors for several days. The drainage of this, probably the very cleanest and best kept manufacturing city of 90,000 inhabitants, is discharged into the river Soar at the rate of more than four million gallons per diem, being lifted by two pumping-engines of 22-horse power each, at the Abbey-lane sewage works, about a mile north of the town. Here a company expended a great many thousands of pounds in carrying out Wickstead's milk of lime deodorizing process; finally handing over the present extensive buildings, tanks, machinery, outdoor drying vats, &c., to the Leicester corporation, who now use them. Milk of lime is mixed with the sewage, which is thus partially deodorized before flowing into the river, while the offensive black sediment, drawn from the beds of the settling tanks by horizontal screws and elevators, is drained and air-dried in embanked compartments, and then sold (to a very limited extent) to farmers at 1s. per cartload.

In order to judge of the merits of the invention the lime process was continued in one-half of the establishment, while the other was devoted to Messrs. Sillar and Wigner—that is to say, one of the pumping engines and two of the great tanks were employed as usual, while the other engine and two tanks, holding 417,000 gallons at once, were occupied in the new process. The engine works two pumps, the large one delivering about 100,000 gallons of sewage per hour into a first or receiving tank, the smaller pump at the same time injecting into the sewage about 1,000 gallons of the chymical solution, this entering the side of the huge pipe which leads from the sewage pump to the receiving tank. The agitation in the first or receiving tank causes a partial mixture; but a complete churning and intimate union are effected by the sewage passing through a number of small apertures into cells, in each of which revolves a stirrer, and thence out of the cells into two very spacious settling tanks. An artificial dam of bags of earth had been constructed to divide the receiving tank; this was frequently breached by the wash of the inflowing sewage, thus mixing a portion of the lime-sewage with the other, and so vitiating the experiment, and fair specimen samples could not be taken until a sufficient time had elapsed after a repair of the dam. The chambers which supplied the smaller pumps had also been divided, so that one pump could be fed with milk of lime and the other with the A B C solution, and, unfortunately, a leakage made some difficulty here. Worse than this, it was found that the dry granulated clay used in the compound (which was all mixed on the spot) contained some small gravel, and several times this got into the pump valve and deranged the action of the pump, stopping the injection of the solution, while the pumping of the sewage continued. Long delays were occasioned; and of course no fair sample of the effluent water discharged from the tank into the river could be taken until the charge of sewage in the tanks had been completely renewed. When the pump and the artificial tank walls were in order, the following average, but not corrected, results were obtained:—An imperial gallon of the sewage as it comes from the main culvert contains 130·2 grains of inorganic matter and 58·8 grains of organic matter; total, 189 grains per gallon. After the lime process the purified sewage-water contains 89·7 grains of inorganic and 42·7 grains of organic matters; total, 132·4 grains per gallon. But after the new process the purified sewer-water contains 43·3 grains of inorganic and 14·2 grains of organic matter; total, only 57·5 grains per gallon. Gold fish immersed in this water appeared quite comfortable. The following is an approximative analysis of the air-dried residuum or manure which the new process has removed from the sewage at Leicester:—

| | |
|---|---|
| Water | 8 per cent. |
| Organic matter | 36 |
| Phosphoric acid | 4 |
| Sulphate of lime | 1 |
| Alumina | 9 |
| Silica | 39 |
| Iron, loss, &c. | 3 |
| | 100 |
| Ammonia | 3½ |

This is considerably richer in ammonia than the Tottenham manure, which was valued at £2. 3s. per ton; in fact, reckoning ammonia at £60. per ton, and the phosphoric acid (from its equivalent in phosphate of lime) at £50. per ton the Leicester sewage manure, by the above analysis, is worth £4. per ton. These analyses were made by Mr. Wigner, the inventor, and are open to correction or to exposure from the official analyses that will be made by Dr. Frankland.

The actual cost of the A B C compound used at Leicester amounted to 8s. 7d. for each 100,000 gallons of sewage treated, whence the cost of materials for purifying the whole 4,000,000 gallons of sewage daily furnished by the town would be £17 3s. The alum, the clay, the animal charcoal, and the three unknown chymicals are all procurable, it is said, to any extent; and the blood used is only one pint to each 20,000 gallons of sewage so that the daily consumption for Leicester would be 25 gallons.

At Tottenham 40,000 gallons of sewage are reported to have yielded 8 cwts. of dried manure; and at this rate the 4,000,000 gallons of Leicester sewage should give 40 tons of manure per day, worth (as valued above) about £4. per ton. A return in manure of £160. per day for an outlay in the A B C solution of only £17 3s. seems almost too good to be correct and requires further confirmation. The patentees say that there ought to be a profit of £50,000 per annum but it is to be feared that the farmers will scarcely give the theoretical value of £4 for a ton of dried Leicester sewage.

## EXAMINATION PAPERS.

For Competitive Examination of Candidates for Appointments in the Engineer Establishment of the Department of Public Works in India, held at the India Office, London, in July 1868.

George Preston White, C.E., Engineer.

### *On Roofs, &c.*

The accompanying design[*] represents a portion of rib for a roof of 70ft. span, lately sent to Calcutta; it is calculated to withstand the tropical winds of India, and is therefore made very strong.

1. State what advantages a roof of this form (circular) has over the ordinary apex roof in such a country.

2. At what distance apart would you place the ribs? and make free-hand sketches showing how you would support the covering between these ribs, also how you would attach it to its supports.

3. The covering being of *stout* corrugated iron, describe the kind and thickness of such covering as you would use, and state its approximate value per square of 100 superficial feet.

4. How would you proceed to erect the ribs of this roof, the walls being 30ft. high, bearing in mind the ribs have little or no lateral stiffness until braced together?

The accompanying sketch represents a portion of a roof of similar form and covering made for the Calcutta Mint, but of smaller dimensions, and arranged in a series of arches; the upper portion is surmounted by a louvre ventilator, and the covering adjoining it on either side is of glass, giving an area of glass equal to about one-third of the covering.

5. Make sketches of the sections and write upon it dimensions of the iron you would employ for a 50ft. span of similar construction.

6. It is necessary in some tropical climates to provide an air space, and to promote a current of air between the outer and inner covering, for the purpose of cooling the atmosphere of the building; make sketch showing how this could be arranged in the roof above described.

7. In what manner has zinc, as a covering, been most advantageously employed? Why should it not be fastened in the same manner as iron is fastened?

### *On Iron Bridges, Foundations, &c.*

The Velletri Bridge, represented by the accompanying illustration, consisting of three spans, each 150ft, for a double line of railway, erected by Messrs. Kennard Brothers, over a deep ravine near Rome, is supported upon ornamental cast-iron piers at considerable height.

1. How would you proceed to erect the girders of such a bridge?

2. If you were designing a bridge for a similar situation, would you consider it most economical to place the level of the roadway on top or bottom of the main girders? State what would guide you in arranging for this.

3. What do you consider a proper and safe load, per square inch of section, to place upon wrought and cast iron in such structures, under load both of tension and compression?

4. What section of cast iron would you consider necessary in one of the piers of such a bridge?

5. What weight per square foot would you consider the greatest that it would be desirable to put upon the foundations under such a structure and keep within the limits of safety, the soil being compact gravel?

6. Explain some of the different methods of sinking and fixing iron screw and other piles for foundations in sandy soils, including Brunlees' system, as adopted in Morecambe Bay.

7. Have you had any experience personally in testing the strength and quality of iron? If so, state the occasions and any circumstances that occur to you as apposite from your own observations or from recognised authorities in such matters. What have you found to be the breaking strains of bar and of plate iron (of declared ordinary quality) respectively under tension and compression? Is a high power of resisting tensile strains to be easily obtained together with extreme ductility or susceptibility of bending and working, &c.? If a specification confined its test of the quality of iron to requiring it to withstand a high tensile strain, would it be easy or difficult to meet that test with iron of very inferior quality in other respects?

### *On Architecture, Building Materials, and Construction.*

Describe the style of architecture, and the period to which it belongs, of the accompanying drawing of a church.

Make a plan of the building, showing the thickness of the walls, buttresses, &c., and write on plan the names of the different parts of the church, assuming the length to be 110ft., and the breadth through nave and aisles 52ft.

Make a transverse section through nave, looking east.

Make design for open timber roof.

Prepare a short specification, introducing the general clauses, under the following heads, adopting your own data:—

1. Excavation for foundation.
2. Concrete and masonry in foundation.
3. Masonry in superstructure, specifying kind of stone you would employ.
4. Dressings and stone cutting in arches, jambs of doors and windows; tracery, quoins, water tables, and cornices, stringcourses, pillars, caps, bases, corbels, &c.
5. Seating and paving in stone or tiles.
6. Carpenters' work.
7. Joiners' work.
8. Plasterers' work.
9. Smith and founders' work.
10. Slating and covering to roofs. Plumbers' work.
11. Arrangements for warming and ventilation, &c.
12. This building would require certain modifications to suit it to a tropical climate like India. What alterations would you suggest?

N.B.—The engineer in India is frequently required to design and erect churches and other buildings. It therefore behoves him to give some attention to architecture. This subject will, therefore, be introduced at future examinations.

### *On Iron Viaducts, &c.*

The accompanying drawing represents a bridge over the Tagus, in Portugal, of sixteen spans of about 100ft. each, designed and erected by the Messrs. Kennards, of Crumlin, Monmouthshire, on the double Warren girder principle; its piers are constructed of cast iron cylinders sunk into the bed of the river to a depth of about 40ft., and carried up above the bed of the river to a height of about 50ft., making a total height of 90ft. from foundation to the top.

1. State how you would proceed to erect the piers of such a bridge, the soil to penetrate being composed of gravel and sand.

2. State how you would proceed if instead of gravel, the soil was composed of clay.

The superstructure of this bridge is designed for a railway, one pair of girders for each line, the floor and rails being carried upon them by iron cross bearers. The weight of a pair of girders with cross bearers and floor is 32 tons.

3. Give an approximate calculation of the strain at the centre of one of the main girders when loaded.

4. State the number of square inches of metal required, and make free-hand sketches of sections of iron you would employ for top and bottom flanges.

5. State how you would proceed to erect the girders of such a bridge, the depth of water being not more than a few feet, but subject to very rapid and sudden floods, which would cause it to rise 30ft. in a few hours.

What kind of girder bridge do you consider best adapted for ordinary road bridges in India, having in view their transport from Europe, the isolated positions in which they might have to be erected, and the scarcity of workmen skilled in erecting structures of this nature?

7. There are variations in the amount of triangular trussing employed in girder bridges. Sketch, by diagram, the triangulation you prefer for a girder bridge of 100ft. span, and state whether the connections between the diagonal trussing and the top and bottom members or booms would be made by means of turned pins or rivets.

8. Taking the simplest form of triangulation, known as "Warren's system," and comparing it with an arrangement giving double that amount, would the sectional area of the top member and that of the struts be affected by the points of support being closer, and by the pins being consequently of smaller dimensions.

### *On Water Supply, Filter Beds, Sewers, Irrigation, &c.*

1. What geological formations are found to produce the purest and softest water?

2. Having ascertained the mean average of rainfall, state what may be considered a fair deduction for the loss from evaporation, &c., in the hill districts, of the above formations in the northern and western districts of Britain?

3. What proportions do the years of maximum and minimum rain bear to the average annual fall, as ascertained by the most trustworthy modern investigations of the subject?

4. At what intervals of time generally occur what is called a cycle of three dry years?

5. What proportion does the average rain of three dry years bear to the mean average annual rainfall?

6. How many cubic feet of water per second, per 1,000 acres of drainage, flowing off the land, may be taken as constituting a flood in the hill districts of Britain?

7. What may be taken as the average summer or dry weather yield in a hill district, as above?

8. Describe what is known as the "Separating system" of water supply?

9. Describe and illustrate with free-hand sketch the automaton contrivance called a "leaping weir," which is often used for carrying out the separating system, above referred to.

10. When the separating system cannot be carried out, and filtration is inevitable; state the area of filtering surface required, with relation to the proposed supply, or with relation to the number of persons for whom water is to be provided?

11. What may considered as the average cost per 1,000 gallons of filtering water in London?

12. What may be considered as a fair estimate of the cost of constructing filters at or near London?

13. What may be estimated as the cost of constructing covered service reservoirs at or near London?

14. State what is the minimum velocity which should be attained in conduits for the conveyance of water for town supply, so as to prevent the growth of confervæ and similar vegetable productions?

15. What is the most economical velocity at which water can be passed through iron pipes for town use?

16. What ratio does the quantity of water consumed for town use, during the period of greatest demand, bear to the average hourly consumption of the 24 hours?

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[*] As these questions are given merely for the guidance of intending candidates as to the kind of examination they are expected to pass, it has not been thought necessary to re-produce the drawings mentioned therein.

17. In designing a system of town sewage, state the least velocity which it is desirable sewage should attain in passing through the sewers to keep them free from deposit?

18. What quantity of sewage should the sewers be capable of carrying off, having regard to the population and area to be drained?

19. State how you would provide for the water of extraordinary falls of rain?

20. Name some of the principal towns which have adopted the system of disposing of their sewage by irrigation.

21. To what crops is the liquid sewage generally applied with most advantage?

22. What quantity of sewage per acre is generally used?

23. Owing to physical peculiarities, as well as other conditions, distinct systems of canal irrigation are carried on in Northern and Southern India known as "The Bengal and Madras Systems." Describe briefly in what these differences consist.

24. Give the names of standard works of reference on the above subjects, of water supply of towns, filter beds, reservoirs, sewers, and irrigation.

*Pumping Machinery.*

1. State what you consider of advantage in the application of the double cylinder system to engines destined for the supply of water to towns, principally in regard to fuel consumption, regularity of working, and adaptability to work under varying pressures.

2. State what is the object of the small cylinder, and about what proportions between the capacities of the two cylinders, and what point of cut-off in small cylinders have been adopted with the best results in engines of this class, taking as example either the engines constructed by Messrs. Simpson and Co., for the London waterworks, described at length in the London engineering journals of last year, or any engines with which you may be acquainted in this country or abroad.

3. How would you proceed to calculate the horses' power required to pump a given quantity of water from a given depth to a given height, and through a given length of main of a given diameter?

4. It is required to erect two high-pressure expansive condensing rotatory pumping engines, which shall each, while working together into a main 18in. diameter, be able to force 151 cubic feet of water per minute through six miles of this 18in. main, the difference of dead level between water at suction and delivery being 113ft. How would you proceed to determine the dimensions of the machinery required?

A. Calculate head due to friction in this case?

B. Having ascertained the total head inclusive of friction, which, if you are unable to calculate, you may assume at 182ft., calculate the net horse-power required for each engine.

C. Having calculated the net horse-power required, and made allowances thereto for obtaining indicated horse-power, which you may take, if unable to calculate, at about 65 H.P., assume a boiler-pressure of 50lbs. per square inch above atmosphere, an expansion required of about 8 times, a stroke of 4ft., and a speed of 25 revolutions per minute; and then—

1. Calculate mean average pressure on piston during the whole length of stroke; if you cannot calculate, you may assume 18lbs. per square inch.

2. Determine the diameter of cylinder required to do the work. (If double cylinder engines are used, this diameter will be that of the large cylinder, of which the stroke will be 4ft.)

D. Supposing bucket and plunger pump to be used, and the stroke of pump to be 3ft. 4in., calculate diameter of bucket.

## NAVAL MAL-ADMINISTRATION.

A paper issued by the Financial Reform Union upon the above subject has been forwarded to us, containing such extraordinary statements respecting the selling, or rather throwing away, of our navy, that we make no apology for inserting it *in extenso.*

A very curious and instructive return has recently been laid before Parliament, on the motion of Mr. Seely, M.P. for Lincoln, showing the number of ships (whether steamers or sailing vessels) sold by the Admiralty from July, 1859, to May 9th, 1867, "stating severally the ages of the ships, the ages of the engines, the number and weight of spare screw propellers, the tonnage, horse-power, and the net amount of money obtained for each ship; also stating against each whether it was publicly advertised to be sold by auction, or was sold by public or private tender, to whom sold, and the amount, if any, paid or to be repaid to each purchaser by the Admiralty in repurchasing the stores returned bearing the broad arrow mark." "And copy of official reports relating to the sale and valuation of the said ships."

An analysis of this return shows that twenty-five of the vessels named in it were sold for a total of £23,623 12s. 6d.; the Government, however, re-purchased stores from the same vessels, bearing the "broad arrow" mark, for the sum of £32,047 9s. 2d., the result being a loss of £8,423 16s. 8d. The actual loss to the nation, however, is not shown unless the value of the ships is added. Here we are puzzled. The return does not give the value of eight of these ships, but of seventeen only, which are estimated by the dockyard officers as worth £24,468; this sum added to the £8,423 16s. 8d. shows a total loss of £32,891 16s. 8d., exclusive of the eight ships which were not valued. If these are included, and estimated at the amount paid for them by the purchasers before the re-sale of stores, the aggregate loss will appear to be not less than £37,197 9s. 2d.

In what terms can a system be characterised which sanctions such a profligate waste of the public money? Here are are twenty-five ships, of various sizes and conditions, sold over a series of years, and the country is the worse for the sale. It would have proved a considerable gain had these ships been given away, on condition that the stores marked with the "broad arrow" were returned, and the remaining portions of the ships removed at the cost of the persons to whom they were given.

One of the most striking examples given in the return is that of the *Tribune*, a screw frigate 13½ years old; the hull is valued at £4,000, but there is no value named for machinery. Messrs. Marshall were the fortunate purchasers for £3,850, and resold to the Government stores which they found on board, and of the existence of which it would appear the authorities knew nothing, amounting to £3,904 8s. 3d.; thus receiving the vessel free, and a bonus of £54 8s. 3d. for taking it. The loss to the nation being, according to the figures given in this return, £4,054 8s. 3d.

Mr. Murphy, of Bermuda, is even more fortunate than the Messrs. Marshall, for he not only received the *Medway*, a vessel of 1,768 tons, free of any charge whatever, but had a bonus in addition of £2,041 5s. 8d. for relieving the Government of the ship!

A complete analysis of this return will be found appended to this paper. The imperfect manner in which it has been prepared renders it less valuable than it would have been had its information been complete. In upwards of sixty cases no estimated value is given; in many instances the tonnage is omitted; and in cases where nothing has been repaid purchasers for stores, it does not appear whether the stores were valued and sold with the ship, or whether they were altogether overlooked by the authorities.

The ships have been divided into classes, and the following is a summary of the results:—

Class I. Comprises the twenty-five vessels already referred to, sold at a loss, or rather given away with a bonus of £8,423 16s. 8d. to pay the expenses of removal.

The cases next enumerated are those in which the return gives an estimate of the value of the ships sold, and shows a balance of gain on the transaction. The following is a summary of the result in this instance:—

| | No. of Ships. | Estimated Value. | Proceeds of Sale. |
|---|---|---|---|
| Class 2 | 8 | 5,364 0 0 | 411 18 0 |
| " 3 | 7 | 7,071 10 0 | 1,004 3 11 |
| " 4 | 13 | 33,889 3 6 | 4,750 8 11 |
| " 5 | 15 | 66,983 8 11 | 10,362 17 5 |
| " 6 | 11 | 56.264 0 0 | 17,918 8 8 |
| " 7 | 11 | 81,696 0 0 | 27,460 9 3 |
| " 8 | 4 | 36,734 0 0 | 23,506 10 5 |
| | 60 | 288,002 2 11 | 85,414 16 7 |

It appears, from these figures, that a loss has been sustained from the sale of the sixty-nine vessels of £202,587 6s. 4d. The gross amount obtained by their sale was £200,711 1s. 1d., being £87,291 1s. 10d. less than their value as estimated by the dockyard authorities. There are only two modes of explaining this discrepancy; either the dockyard valuers are incompetent, or the business is so mismanaged that vessels are sold considerably below their actual value. The larger portion of the loss is, however, to be traced to the re-purchase of stores, the sum paid on this account being £115,296 4s. 6d. In this case, also, there are four vessels to which no estimated value is affixed.

Mr. Ransom seems to be the most fortunate among the less-favoured purchasers of vessels, who have had to pay money for their bargains. Having bought the brig *Icarus* for £450, he discovered stores which he re-sold to the Admiralty for £449 8s., thus becoming the lucky purchaser of a vessel of 234 tons for twelve shillings!

The next classification (No. 9) is that of vessels sold abroad, where nothing appears to have been paid for stores re-purchased. It is a singular fact that, in every instance of a vessel being "sold abroad," no information is given as to the estimated value thereof. All that appears in the return is the sale of the ship, and the price obtained.

The same remark applies to 39 vessels contained in classes 10, 11, 12, principally Coast-guard vessels. All that can be ascertained from the return is that—

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 17 | vessels | averaged | £62 | 4s. | 3d. | each. | |
| 16 | „ | „ | £139 | 16s. | 7d. | „ | |
| 6 | „ | „ | £282 | 16s. | 1d. | „ | |
| 4 | „ | „ | £1,923 | 9s. | 0d. | „ | and |
| 1 | „ | sold for £500. | | | | | |

There is nothing whatever to show what was the real value of these ships, or whether they were sold at a profit or a loss.

The catalogue is completed by three vessels sold to the Chinese and three sold to the Prussian Government (Class 13). Of course all is *couleur de rose* here. Estimated value, gross amount, net amount, all correspond exactly, but *Quis custodiet custodes?* How do we know the official value is trustworthy, and, consequently, that the full value has been received for these vessels?

The entire loss sustained, according to the Admiralty valuation, on the sale of 101 vessels is upwards of £250,000! The facts apparent on the face of the return, however, fully warrant a much larger estimate of loss. Seventy of the ships named are sailing vessels, which, it would seem, have been retained by the Admiralty many years after they had been superseded for all practical purposes. Had these vessels been sold at an earlier date they would have realised much better prices, and a considerable annual expense would have been saved, as heavy charges are incurred yearly for the maintenance and repairs of such vessels, however useless.

As an example of the mode in which the Admiralty transacts the business of the country one pregnant instance may be quoted from correspondence appended to these returns. In January, 1867, Messrs. Castle and Beech, of Millbank, addressed the Comptroller of the Navy in reference to the purchase of some thirty-two ships, which they name, and which they describe as "ships which are reported as being for sale, or to be broken up." This communication led to a correspondence, in which, on the 7th February, 1867, the Comptroller addresses a letter to Messrs. J. and E. Marshall, of Plymouth, informing them that "their lordships had decided to sell" certain ships named, and inquiring whether they "feel disposed to purchase any or all of those ships." Copies of the list and letter were sent on the same day to Mr. White, of Cowes, and to Messrs. Castle and Beech. Mr. White declined to entertain the offer, and thus the invitation to a "private tender" was substantially confined to two firms, and between these the whole transaction was completed. It is true that two other firms inquired of the Admiralty whether they would be "allowed" to offer for the ships, and were allowed to do so. Nothing came of either. But this is not the only feature of the transaction which needs remark.

Having thus invited the "private tender, the Comptroller of the Navy addresses the captain-superintendents of the ports in which lay the ships offered for sale, requesting "a statement of the value for sale and breaking up of the hull and machinery" of each. The Admiralty, however, had previously determined the vessels should be broken up, and had invited the tenders on that condition, but why is not satisfactorily explained. The values having been given, they appeared to rate as follows:—Value for sale (hull, £240,397; machinery, £75,801) £316,198; value for breaking up, £144,284. The reason stated in the returns for preferring to sell for breaking up is that a sale for use would give an opening for fraud, inasmuch as a sale of stores with the "broad arrow" mark would be thereby sanctioned, and any prosecution under the statute for illegal possession of such stores would thereby be rendered inoperative or impossible.

Having determined on a sale for breaking up, and having obtained an official valuation, let us see what followed. The ships were divided into groups. The Chesapeake lay at Chatham, and the Leander, Cressy, Collingwood, and the Orion at Sheerness. These five formed one group. The Euryalus, Imperieuse, Arrogant, Termagant, and Colossus at Portsmouth, formed group No. 2; while the Majestic, Brunswick, and Sanspareil, at Devonport, formed group No. 3:—

| | |
|---|---|
| Official value of group No. 1 | £74,915 |
| Tender of Castle and Beech for same | 34,773 |
| Tender of Messrs. Marshall | 30,500 |
| Official value of group No. 2 | £32,980 |
| Tender of Castle and Beech | 30,010* |
| Tender of Messrs. Marshall | 28,085 |
| Official value of group No. 3 | £36,389 |
| Tender of Messrs. Castle and Beech | 20,050 |
| Tender of Messrs. Marshall | 20,770 |

The first observation that occurs on looking at these figures is, that if the two firms whose tenders are set out had pre-arranged their offers, they could not have sent them out with greater judgment. If they had agreed to differ, their variance could not have been arranged more skilfully. The second observation is, that the tenders, in all probability, were pre-arranged, and this is the more likely when we know that those two firms are the only parties from whom the Comptroller of the Navy invited tenders. Nor is this view at all affected by the fact that Mr. J. Marks, one of the parties who asked whether he might be allowed to tender, did make an offer for each ship on sale; for his tender for each is uniformly as much less than Messrs. Marshall's as the latter is less than the offer of Castle and Beech. And the third observation that occurs is, that if the Comptroller of the Navy had had an understanding with the gentlemen who tendered for the sale of the thirteen ships, he could not more dexterously have played into their hands.

Either the Government should place reliance on the competency and integrity of its own officers, or it should not. If reliance could not be placed on the competency and integrity of the dockyard authorities or *employés*, then it was idle to require them to state values. If they were competent and reliable, then their estimates of value should not have been treated with such strange neglect. Yet this is what happened. Messrs. Castle and Beech offer £34,773 for ships valued at £74,915 by the dockyard authorities, and the Comptroller of the Navy assents, and advises that this tender should be taken.

The dockyard *employés* at Devonport value the three ships there at £36,389, and the Comptroller advises that Messrs. Marshall's tender of £20,770 should be accepted for them. Such a difference between tender and value could not be entirely passed over, and accordingly the Comptroller disposes of the matter in this way:—"I have no idea whatever that anything like the value put upon these ships by the Sheerness and Devonport officers could be obtained. The estimate of the Portsmouth officers is more trustworthy." The estimate of the Portsmouth officers is surprisingly less, for they value five ships at little more than one-half the value of five ships made at Chatham and Sheerness; but how they are in any respect less reliable is not so apparent. In point of fact, the estimate of Sheerness and Chatham is corroborated by that of Devonport, while that of Portsmouth is not corroborated, except, indeed, it be a corroboration that the offer of Messrs. Marshall approaches in this instance alone the valuation of the dockyard officers.

The whole case establishes these conclusions irresistibly, that the steps taken in this case, and which it may be supposed is in accordance with the ordinary course, is a means adapted to sell with the greatest advantage to individuals and the utmost loss to the public. But this conclusion is not impeached when we find that on the ships thus sold to Messrs. Castle and Beach there were stores which those gentlemen immediately re-sold to the Government for £28,361 7s. 2d., and Messrs. Marshall received in the same way £9,743 13s. 9d., so that the sum actually paid by those gentlemen to the Government was not £88,523, but £30,417 19s. 11d. When, therefore, we find in the "submission" of the 1st March, 1857, the Comptroller of the Navy uses these words:—"If these arrangements are carried out a sum of £88,523 will be realized and paid into the exchequer for these thirteen ships," we can hardly understand the misapprehension which could permit him so to mislead the Board of Admiralty. Nor should we forget the value of these stores for return when we are comparing the values stated by the dockyard officers and the tenders made by the purchasers of those thirteen ships. If they knew of the presence of those stores, and had regard to them in their estimates, how can we account for the censure of the Comptroller of the Navy? If they did not regard them, how can we account for the extent to which the transaction appears to have mystified the Comptroller?

However these considerations may be disposed of, the whole of this return discloses a degree of unthrift and carelessness, and a systematic absence of consideration for the public interests, which are deserving of the gravest censure, and which demand the most direct and positive steps for the future prevention of so great a public scandal. But this scandal could have been avoided by simply inviting tenders by public advertisement under stated conditions "known to all the world."

But this conclusion respecting the strangely improper course adopted in relation to those sales, and the absolute necessity for a total change of system, is still more fully confirmed in the case of a sale of seven ships by "private tender" from the Messrs. Castle. Here is a case in which one firm was invited to tender, and only one had the opportunity of tendering; and what is the result? The ships were valued "for breaking up" at £35,296. The sum tendered for the seven, with all stores on board, was £33,724. But the sum actually obtained for the seven ships was £11,904 9s. 7d. only. How was this? The value of the stores on board was £21,819 10s. 5d., and this amount was handed over to the firm of Castle and Sons, and so this transaction was closed by the payment of £11,904 9s. 7d., for seven ships, valued by the dockyard officers for "breaking up" at £35,296. Does this require one other word as to the way in which the servants of the Admiralty serve the country?

These facts demonstrate the necessity for a full and ample inquiry into our system of Admiralty and dockyard management. In 1861 a Royal Commission reported that the control and management of Her Majesty's dockyards was inefficient for the following reasons:—1st. The constitution of the Board of Admiralty. 2nd. The defective organization of the subordinate departments. 3rd. The want of clear and well-defined responsibility. 4th. The absence of any means, both now and in times past, of effectually checking expenditure, from the want of accurate accounts. Recent disclosures, to which allusion will be more fully made in subsequent papers, prove that all these evils are still in full operation, and demand the active and vigilant attention of the public.

A system of management such as these returns disclose would not be tolerated in any private commercial establishment. If it were, there would be but one result—speedy bankruptcy. It is only possible because the Admiralty deals with the resources of the nation, and is able to make up its deficiencies by heavy and oppressive taxation. In reference to another public department, a very eminent authority (the Right Hon. W. E. Gladstone, M.P.) is reported to have said, "All the vices that can be enumerated are united in our present system. The money of the country is wasted; and, I believe, such are the evils of the system that nothing short of a revolutionary reform will ever bring them to an end." These impressive words are admirably descriptive of a system which permits such waste and extravagance as are disclosed in these cases. It is extravagant expenditure which imposes taxes upon many of the necessaries of existence, thus diminishing the comforts of the people, and limiting trade manufactures and employment. It is only by "pressure from without" that a remedy for this serious and growing evil will be found.

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* This was subsequently enlarged to £32,000.

## Analysis of Return of Navy Ships Sold from July, 1859, to May 9, 1867.

Class I.—*Twenty-five ships off which the stores on board at time of sale were re-purchased by the Government at larger amounts than ship and stores had brought at sale.*

| | Tons. | Gross Amount of Money obtained for each Ship. | Amount paid to each Purchaser by the Admiralty in re-purchasing Stores returned bearing "Broad Arrow." | Loss on Sale. | Value of Hull and Machinery at time of Sale, as reported by Dockyard Officers. | Total loss to the Nation. |
|---|---|---|---|---|---|---|
| | | £ s. d. | £ s. d. | £ s. d. | £ s. d. | £ s. d. |
| The *Raven*, sailing cutter | 108 | 160 0 0 | 214 15 0 | 54 15 0 | ... | 54 15 0 |
| The *Lapwing*, sailing sloop | 228 | 305 0 0 | 305 18 4 | 0 18 4 | 310 0 0 | 310 18 4 |
| The *Arrow*, screw gun vessel | 477 | 482 0 0 | 557 3 10 | 75 3 10 | 950 0 0 | 1025 3 10 |
| The *Viper*, screw gun vessel | 477 | 482 0 0 | 604 7 3 | 122 7 3 | 950 0 0 | 1072 7 3 |
| The *Lynx*, screw gun vessel | 477 | 482 0 0 | 555 8 8 | 73 8 8 | 950 0 0 | 1023 8 8 |
| The *Lively*, sailing, 5th rate | 1080 | 1215 0 0 | 1628 7 11 | 413 7 11 | 1960 0 0 | 2373 7 11 |
| The *Electra*, sailing sloop | 462 | 950 0 0 | 953 1 9 | 3 1 9 | 1386 0 0 | 1389 1 9 |
| The *Pilot*, sailing sloop | 485 | 802 0 0 | 905 0 9 | 103 0 9 | 980 0 0 | 1083 0 9 |
| The *Express*, sailig sloop | 362 | 635 0 0 | 773 5 7 | 138 5 7 | 761 0 0 | 899 5 7 |
| The *Petrel*, sailing sloop | 359 | 630 0 0 | 1142 17 10 | 512 17 10 | 761 0 0 | 1273 17 10 |
| The *Pandora*, sailing brig | 318 | 600 0 0 | 735 9 7 | 135 9 7 | 620 0 0 | 755 9 7 |
| The *Dwarf*, sailing brig | 75 | 72 7 0 | 141 0 8 | 68 13 8 | ... | 68 13 8 |
| The *Conflict*, screw sloop | 1058 | 1555 0 0 | 1641 7 9 | 86 7 9 | 2000 0 0 | 2086 7 9 |
| The *Armada*, sailing, 3rd rate | 1749 | 2600 0 0 | 3477 14 0 | 877 14 0 | 3000 0 0 | 3877 14 0 |
| The *Thames*, sailing, 5th rate | 1088 | 900 0 0 | 1429 9 8 | 529 9 8 | ... | 529 9 8 |
| The *Cuckoo*, paddle tug | 234 | 600 0 0 | 1063 16 8 | 463 16 8 | 440 0 0 | 903 16 8 |
| The *Lancaster*, sailing, 4th rate | 1478 | 3025 0 0 | 3779 4 0 | 754 4 0 | 4500 0 0 | 5254 4 0 |
| The *Dromedary*, sailing, 5th rate | 1048 | 300 0 0 | 454 6 10 | 154 6 10 | ... | 154 6 10* |
| The *Cadmus*, sailing sloop | 237 | 500 0 0 | 639 4 5 | 139 4 5 | 400 0 0 | 539 4 5 |
| The *Weymouth*, sailing, 4th rate | 826 | 300 0 0 | 1655 6 10 | 1355 6 10 | ... | 1355 6 10* |
| The *Emulous*, sailing sloop | 235 | 205 0 0 | 412 9 0 | 207 9 0 | ... | 207 9 0 |
| The *Tribune*, screw frigate | 1570 | 3850 0 0 | 3904 8 3 | 54 8 3 | 4000 0 0 | 4054 8 3 |
| The *Medway*, sailing, 3rd rate | 1768 | 2180 0 0 | 4221 5 8 | 2041 5 8 | ... | 2041 5 8* |
| The *Linnet*, sailing sloop | 361 | 605 0 0 | 641 12 1 | 36 12 1 | 500 0 0 | 536 12 1 |
| The *Royal George* | | 188 5 6 | 210 6 10 | 22 1 4 | ... | 22 1 4 |
| | | 23623 12 6 | 32047 9 2 | 8423 16 8 | 24468 0 0 | 32891 16 8 |

**Note.—No Estimated Value is given for eight of the above ships, the aggregate tonnage of which exceeded 5600 tons. Assuming that the value of these vessels was £4305 12s. 6d., the gross amount obtained for them, the loss to the nation on this transaction, as shown by the Admiralty figures, is £37,197 9s. 2d.!**

* Sold abroad.

Class 2.—*Under £100.—Eight ships, the net amount realized for each varying from 12s. to £87 10s. 8d.*

| | Tons. | Gross Amount of Money obtained for each Ship. | Amount paid to each Purchaser by the Admiralty in re-purchasing Stores bearing "Broad Arrow." | Net Amount of Money obtained for each Ship. | Estimated Value of Hull and Machinery as reported by Dockyard Officers. |
|---|---|---|---|---|---|
| | | £ s. d. | £ s. d. | £ s. d. | £ s. d. |
| *Icarus*, sailing brig | 234 | 450 0 0 | 449 8 0 | 0 12 0 | 510 0 0 |
| *Clinker*, sailing sloop | 183 | 259 0 0 | 225 13 4 | 33 6 8 | |
| *Spider*, sailing sloop | 182 | 375 0 0 | 336 16 9 | 38 3 3 | 380 0 0 |
| *Richmond*, watch vessel | 240 | 245 0 0 | 191 4 3 | 53 15 9 | 250 0 0 |
| *Shamrock*, sailing sloop | 180 | 360 0 0 | 295 14 3 | 64 5 9 | 250 0 0 |
| *Horatio*, screw mortar ship | 1090 | 3200 0 0 | 3133 6 9 | 66 13 3 | 3394 3 0 |
| *Partridge*, screw gun boat | 234 | 605 0 0 | 537 9 4 | 67 10 8 | 580 0 0 |
| *Eclipse*, sailing sloop | 235 | 344 6 6 | 256 15 10 | 87 10 8 | |
| | 2578 | 5838 6 6 | 5426 8 6 | 411 18 0 | 5364 0 0 |

Class 3.—*Above £100 and under £200.—Seven ships. the net amount realized for each varying from* £101 *to* £193 8*s.* 9*d.*

| | Tons. | Gross Amount of Money obtained for each Ship. | Amount paid to each Purchaser by the Admiralty, in re-purchasing Stores bearing "Broad Arrow." | Net Amount of Money obtained for each Ship. | Estimated Value of Hull and Machinery, as reported by Dockyard Officers. |
|---|---|---|---|---|---|
| | | £ s. d. | £ s. d. | £ s. d. | £ s. d. |
| *Lion*, cutter | ... | 297 17 1 | 178 17 1 | 101 0 0 | |
| *Gossamer*, sailing tender | 48 | 230 0 0 | 123 15 7 | 106 4 5 | 180 0 0 |
| *Partridge*, sailing sloop | 231 | 550 0 0 | 424 14 9 | 125 5 3 | 412 3 0 |
| *Snapper*, sailing brig | 184 | 302 0 0 | 146 12 1 | 155 7 11 | 412 7 6 |
| *Portland*, sailing, 4th rate | 1476 | 2250 0 0 | 2091 16 5 | 158 3 7 | 4000 0 0 |
| *Espiègle*, sailing sloop | 443 | 805 0 0 | 640 6 0 | 164 14 0 | 1500 0 0 |
| *Messenger*, late steam vessel | 733 | 360 0 0 | 166 11 3 | 193 8 9 | 567 0 0 |
| | 3115 | 4776 17 1 | 3772 13 2 | 1004 3 11 | 7071 10 6 |

Note.—Throughout the whole return there are only four instances in which any estimated value is given of "stores" on board any of the ships.

Class 4.—*Above £200 and under £500. Thirteen ships, the net amount realized for each varying from* £239 1*s.* 6*d. to* £493 17*s.* 8*d.*

| | Tons. | Gross Amount of Money obtained for each Ship. | Amount paid to each Purchaser by the Admiralty, in re-purchasing Stores bearing "Broad Arrow." | Net Amount of Money obtained for each Ship. | Estimated Value of Hull and Machinery, as reported by Dockyard Officers. |
|---|---|---|---|---|---|
| | | £ s. d. | £ s. d. | £ s. d. | £ s. d. |
| *Amazon*, sailing, 6th rate | 1078 | 1820 0 0 | 1580 18 6 | 239 1 6 | 1900 0 0 |
| *Druid*, sailing, 5th rate | 1160 | 2086 17 6 | 1844 15 9 | 242 1 9 | 4044 13 6 |
| *Tyne*, sailing store ship | 600 | 1200 0 0 | 912 13 8 | 287 6 4 | 3600 0 0 |
| *Pelican*, sailing sloop | 385 | 816 0 0 | 512 11 11 | 303 8 1 | |
| *Cleopatra*, sailing, 6th rate | 918 | 1810 0 0 | 1467 18 6 | 342 1 6 | 5040 0 0 |
| *Teazer*, screw tender | 296 | 525 0 0 | 169 13 11 | 355 6 1 | 1300 0 0 |
| *Pallas*, sailing. 5th rate | 951 | 1426 0 0 | 1055 5 4 | 370 14 8 | 1620 0 0 |
| *Vestal*, sailing, 6th rate | 913 | 1715 0 0 | 1304 7 7 | 410 12 5 | 5021 10 0 |
| *Crane*, sailing sloop | 350 | 670 0 0 | 259 2 1 | 410 17 11 | 791 0 0 |
| *Achille*, sailing, 2nd rate | 1981 | 3600 0 0 | 3189 1 8 | 410 18 4 | 3565 0 0 |
| *Mariner*, sailing sloop | 481 | 900 0 0 | 483 0 7 | 416 19 5 | 1080 0 0 |
| *Carysfort*, sailing, 6th rate | 925 | 1800 0 0 | 1332 7 9 | 467 12 3 | 3618 0 0 |
| *Spartan*, sailing, 6th rate | 918 | 1875 0 0 | 1381 2 4 | 493 17 8 | 2300 0 0 |
| | 10074 | 20241 17 6 | 15493 8 7 | 4750 8 11 | 33880 3 6 |

Class 5.—*Above £500 and under £1000. Fourteen ships (two grouped in one lot), the net amount realized for each varying from £576 6s. 1d. to £998 10s. 3d.*

| | Tons. | Gross Amount of Money obtained for each Ship. | Amount paid to each Purchaser by the Admiralty, in re-purchasing Stores bearing "Broad Arrow." | Net Amount of Money obtained for each Ship. | Estimated Value of Hull and Machinery, as reported by Dockyard Officers. |
|---|---|---|---|---|---|
| | | £ s. d. | £ s. d. | £ s. d. | £ s. d. |
| *Childers*, sailing sloop | 385 | 650 0 0 | 73 13 11 | 576 6 1 | 870 0 0 |
| *Crocodile*, sailing, 6th rate | 501 | 1015 0 0 | 401 2 10 | 613 17 2 | 3000 0 0 |
| *Akbar*, sailing, 4th rate | 1388 | 1030 0 0 | 414 0 5 | 615 19 7 | 5019 18 11 |
| *Waterwitch*, sailing sloop | 319 | 760 0 0 | 141 0 9 | 618 19 3 | 1000 0 0 |
| *Eurotas*, screw mortar ship | 1201 | 3250 0 0 | 2602 3 4 | 647 16 8 | 2937 0 0 |
| *Phœnix*, screw sloop | 809 | 8000 0 0 | 7225 14 11 | 774 5 1 | 11900 0 0 |
| *Cyclops*, paddle frigate | 1195 | | | | |
| *Retribution*, paddle frigate | 1641 | 4800 0 0 | 3971 12 9 | 828 7 3 | 4983 0 0 |
| *Colossus*, screw line-of-battle-ship | 2590 | 6865 0 0 | 5983 0 6 | 881 19 6 | 10600 0 0 |
| *Herald*, sailing, 6th rate | 500 | 1635 0 0 | 732 4 4 | 902 15 8 | 2562 10 0 |
| *Hecla*, paddle sloop | 817 | 2550 0 0 | 1600 11 9 | 949 8 3 | 2100 0 0 |
| *Ariel*, screw sloop | 486 | 1516 0 0 | 552 19 1 | 963 0 11 | 1515 0 0 |
| *Cressy*, screw, line-of-battle-ship | 2540 | 6100 0 0 | 5108 8 3 | 991 11 9 | 15016 0 0 |
| *Prometheus*, paddle sloop | 796 | 1525 0 0 | 526 9 9 | 998 10 3 | 5480 0 0 |
| | 15168 | 39696 0 0 | 29333 2 7 | 10362 17 5 | 66983 8 11 |

Class 6.—*Above 1000 and under £2000.—Eleven ships, the net amount realized for each varying from £1159 15s. 3d. to £1995 18s. 6d.*

| | Tons. | Gross Amount of Money obtained for each Ship. | Amount paid to each Purchaser by the Admiralty, in re-purchasing Stores bearing "Broad Arrow." | Net Amount of Money obtained for each Ship. | Estimated Value of Hull and Machinery, as reported by Dockyard Officers. |
|---|---|---|---|---|---|
| | | £ s. d. | £ s. d. | £ s. d. | £ s. d. |
| *Inconstant*, sailing, 5th rate | 1421 | 3500 0 0 | 1790 13 0 | 1709 7 0 | 3500 0 0 |
| *Jumna*, sailing sloop | 551 | 1650 0 0 | 304 8 8 | 1345 11 4 | 2745 0 0 |
| *Avon*, paddle, small vessel | 361 | 1225 0 0 | 32 14 1 | 1192 5 11 | 2200 0 0 |
| *Merlin*, paddle, small vessel | 889 | 3000 0 0 | 1223 5 3 | 1776 14 9 | 3000 0 0 |
| *Odin*, paddle frigate | 1310 | 4900 0 0 | 3354 15 5 | 1545 4 7 | 5096 0 0 |
| *Fury*, paddle sloop | 1124 | 4376 0 0 | 3216 4 9 | 1159 15 3 | 4511 0 0 |
| *Inflexible*, paddle frigate | 1122 | 4224 0 0 | 2387 9 9 | 1836 10 3 | 4046 0 0 |
| *Proserpine*, sailing, 5th rate | 1078 | 2460 0 0 | 621 12 1 | 1838 7 11 | 3000 0 0 |
| *Edinburgh*, screw blockship | 1772 | 6100 0 0 | 4522 17 11 | 1577 2 1 | 4667 0 3 |
| *Chesapeake*, screw frigate | 2377 | 4142 0 0 | 2200 8 11 | 1941 11 1 | 10800 0 0 |
| *Brunswick*, screw line-of-battle ship | 2492 | 6990 0 0 | 4994 1 6 | 1995 18 6 | 12699 0 0 |
| | 14497 | 42567 0 0 | 24648 11 4 | 17918 8 8 | 56264 0 0 |

[*The remainder of the Tables will be given in our next issue*].

## MANCHESTER ASSOCIATION FOR THE PREVENTION OF STEAM BOILER EXPLOSIONS.

The last ordinary monthly meeting of the Executive Committee of this Association was held at the offices, 41, Corporation-street, Manchester, on Tuesday, July 28th, 1868, Hugh Mason, Esq., Vice-President, in the chair, when Mr. L. E. Fletcher, chief engineer, presented his report, of which the following is an abstract:—

During the past month 235 visits of inspection have been made, and 516 boilers examined, 343 externally, 8 internally, 6 in the flues, and 158 entirely, while in addition 3 have been tested by hydraulic pressure. In these boilers 135 defects have been discovered, 5 of these being dangerous.

Tabular Statement of Defects, Omissions, &c., met with in the Boilers examined from June 27th, to July 24th, 1868, inclusive.

| DESCRIPTION. | Number of Cases met with. | | |
|---|---|---|---|
| | Dangerous. | Ordinary. | Total. |
| **Defects in Boiler.** | | | |
| Furnaces out of Shape | ... | 8 | 8 |
| Fracture | 1 | 22 | 23 |
| Blistered Plates | ... | 7 | 7 |
| Corrosion—Internal | ... | 22 | 22 |
| Ditto External | 3 | 16 | 19 |
| Grooving—Internal | ... | 8 | 8 |
| Ditto External | ... | 2 | 2 |
| Total Number of Defects in Boiler ... | 4 | 85 | 89 |
| **Defective Fittings.** | | | |
| Feed Apparatus out of order | ... | 2 | 2 |
| Water Gauges ditto | ... | 9 | 9 |
| Blow-out Apparatus ditto | ... | 8 | 8 |
| Fusible Plugs ditto | ... | ... | ... |
| Safety Valves ditto | ... | 2 | 2 |
| Pressure Gauges ditto | ... | 8 | 8 |
| Total Number of Defective Fittings ... | ... | 29 | 29 |
| **Omissions.** | | | |
| Boilers without Glass Water Gauges | ... | ... | ... |
| Ditto Safety Valves | ... | ... | ... |
| Ditto Pressure Gauges | ... | ... | ... |
| Ditto Blow-out Apparatus | ... | 1 | 1 |
| Ditto Feed back pressure valves | 1 | 14 | 15 |
| Total Number of Omissions | 1 | 15 | 16 |
| Cases of Over Pressure | ... | ... | ... |
| Cases of Deficiency of Water | ... | 1 | 1 |
| Gross Total | 5 | 130 | 135 |

Although five dangerous defects were discovered, these were so similar to cases previously described in detail, that it need only now be briefly stated that two of them arose from external corrosion at front cross walls and a midfeather, another from the absence of a feed back pressure valve, in consequence of which the water from the boiler was driven back into the lodge, and the furnace crown injured, and a fourth from numerous fractures at the seams of rivets at the bottom of an externally fired boiler over the furnace.

### Economy of Fuel and Prevention of Smoke.

For the last three years an extensive series of experimental trials on the evaporative power of various descriptions of coal and forms of boiler has been carried on at Wigan, and as this bears upon the subject of economy of fuel and prevention of smoke, which is one of considerable interest to our members, allusion to these trials may not be out of place on the present occasion.

The object of these trials has been two-fold,—firstly to establish the evaporative efficiency of the South Lancashire and Cheshire coals, and secondly to ascertain how they could be burnt to the greatest advantage in ordinary mill boilers without the production of smoke, as well as to decide upon the best form of boiler, so that the steam user might learn how to save coal and prevent smoke.

These trials were brought to a conclusion on Friday, the 24th July, being finished off with three general "field" days, so as to afford steam users an opportunity of seeing the results obtained. On Wednesday, the 22nd July, William Fairbairn, Esq., C.E., president of this association, with other gentlemen of the executive committee, met the members of the South Lancashire and Cheshire Coal Association, who had been at the expense of these experiments, and visited with them the trial shed in order to satisfy themselves as to the success of the trials. In preparation for this all the boilers were in full work. These are of various construction, one of them being of the marine multitubular type, and another of the patent conical water tube, while a third is an ordinary Lancashire mill boiler with steel furnace tubes, and the fourth a similar one with iron tubes. All of them were fired under different conditions, one of them mechanically by Messrs. Vicars's patent self-feeding fire-grate, and all the others by hand. Slack coal was used in the furnaces of two of the boilers, including the one to which the self-feeding fire-grate was attached, and round coal in the others, while the length of the fire-grate in one of the mill boilers was 4ft., and in the other 6ft. All the boilers were in full work and heavily fired, yet without producing any smoke beyond a slight trace of a faint colour now and then. After witnessing the experiments with the testing apparatus, and the mode of firing adopted, the company—having satisfied themselves as to the absence of smoke—adjourned to a luncheon, provided by the Association for the Prevention of Steam Boiler Explosions, in an adjoining room, kindly lent for the occasion by the Wigan Coal and Iron Company, when a brief report upon the progress and results of the trials was read, and the importance of the prevention of smoke and economy of fuel spoken to by several of the gentlemen present.

On Thursday and Friday, the 23rd and 24th July, the trial shed was thrown open to as many members of this association as wished to be present or to send a representative. A considerable number availed themselves of this opportunity, and the boilers were shown to them in full operation, as on the previous day, heavily fired, without producing any smoke, and it appeared to excite surprise in the minds of many that the results could be attained by such simple means as were then adopted.

On the first series of trials a detailed report has already been presented to the Coal Association, and thinking that there was much information with regard to these trials which would prove of general interest, I have, with the permission of the Coal Association, prepared condensed tables of the results obtained, as well as a brief account of the mode of conducting the trials for presentation to our own members. These tables, however, are somewhat elaborate, and the printers will require another fortnight or three weeks to set them up, so that they cannot accompany this report as it was previously intended they should; but I hope to issue them next month.

Of the second series of trials the condensed report presented to the meeting held on Wednesday last gives a general *resumé*, and I have obtained permission of the chairman of the South Lancashire and Cheshire Coal Association to issue it to our members, and therefore present it on this occasion, as under:—

Brief report presented by Mr. L. E. Fletcher to the gentlemen assembled at the luncheon given on Wednesday, July 22nd, by the Association for the Prevention of Steam Boiler Explosions to the members of the South Lancashire and Cheshire Coal Association, who have been at the expense of conducting the coal and boiler trials at Wigan.

Gentlemen,—It may naturally be expected that I should lay before you on the present occasion a statement of the origin of these trials with the objects proposed, and the results attained. In complying with this, I have put my remarks in writing, in order to give you the more information and occupy less of your time.

It is necessary, in the first place, to make brief reference to what are termed the "Admiralty Coal Trials." Some few years ago at a series of coal trials made by Sir Henry De La Beche and Dr. Lyon Playfair, all the bituminous and gaseous coals, those of South Lancashire and Cheshire included, were very much under-rated; and the Welsh coals, which are more or less of the anthracite class, placed very incorrectly at a much higher rank for evaporative value than the bituminous ones. The reason of this was that in these trials the coals of this district, and of the north country, which are of the same character, were not properly burnt, and thus they did not evaporate a fair share of water. For some years after, all bituminous coals stood at a disadvantage, till in the year 1855 the north country coal owners instituted a series of experiments on the evaporative power of their coals, under the superintendence of Sir W. G. Armstrong, the late Dr. Richardson, and Mr. James A. Longridge, C.E., of Westminster. These experiments showed that the Newcastle coal would not only evaporate as much as water as the Welsh, and as rapidly, but also that if properly fired, it could be burnt without smoke, and the Newcastle coals were subsequently placed on the Admiralty list.

The coal proprietors of this district, however, were still left out in the cold shade, and believing that their coal did not fear competition either with the Newcastle or Welsh, resolved to institute a similar set of trials to those previously conducted at Newcastle, and requested Dr. Richardson, of Newcastle and myself to undertake their superintendence. For this purpose the marine boiler now standing in the trial shed was specially made, which is a precise counterpart of the boiler employed for testing purposes at H.M. Dockyard, Keyham. These trials, which occupied about two years, showed that the coals of this district had a high economic value, and were able to evaporate 11·28lbs. of water at 100° to 1lb. of coal, without making any smoke beyond a slight trace of a faint colour now and then. This result is quite equal to that obtained either by the north country or Welsh coals, and was verified by the Admiralty officers who were sent down to inspect a repetition of the trials and report thereon. This report has since been published, and speaks strongly in favour of the high character of the South Lancashire and Cheshire coals.

Out of these Admiralty coal trials sprung, through the suggestion of Mr. Lancaster, the second series, which you have been invited to witness to-day, and hence the foregoing allusion to them. It was thought it might be well to extend the trials to ordinary mill boilers as well as the marine, with a two-fold object, viz., to ascertain in the first place how the coals of this district could be burnt with the greatest advantage in the ordinary mill boilers, and in the second, the best form of boiler in which to burn the coals, and thus to assist the steam user in economising fuel and preventing smoke. These are most important considerations. The question is frequently put, which is the most economical form of boiler? while everyone has its strong partisans who advocate it as superior to every other. The circumstances, however, are so various under which different boilers are worked at different mills that it is by no means easy to get it reliable data, and therefore the importance of a careful comparative test.

With this view boiler makers were invited to co-operate with the coal owners, the one party finding the boilers, the other being at the expense of setting them to work, providing the coal, and conducting the experiments. In answer to this invitation, Messrs. Hick and Hargreaves, of Bolton, supplied a two-flued boiler with steel tubes; Messrs. Clayton, of Preston, a two-flued boiler with iron tubes; and Mr. Green, of Wakefield, one of his patent water-heaters or economisers. Messrs. Petrie, of Rochdale were desirous of sending one of their patent boilers fitted with pockets in the flue tubes, and arranged to do so, but the time proving too limited the carrying out of their intention was prevented. Further, as it was thought very important to try the evaporative power of a conical water tube boiler as compared with those of two-flued construction, one was purchased second-hand, and set down alongside of the others. It is to be regretted that a still greater variety could not be obtained. The three boilers supplied hardly furnished the full means of settling the very vexed question as to which is the best form of boiler, and it may be that we are but yet on the threshold of this important inquiry. I will, however, give you the results obtained with the means in my possession, and trust they may prove a step in the right direction, and shall be glad if they are the means of leading to a yet further and more exhaustive series of investigations.

In describing the mode in which these experiments have been conducted it is hardly necessary for me to explain the testing apparatus, since you have this day seen the large tank in which the water was measured and the diagrams by which the smoke was estimated. Suffice it to say that the water evaporated was carefully measured and the coal weighed, while the smoke was observed and registered throughout every minute of each experiment.

In attempting to ascertain which of the three boilers gave the best results, it was clearly necessary to learn, in the first place, the best mode of firing them, and then to compare the highest results of each boiler with the others. In doing this, three modes of firing were adopted—No. 1, "Spreading" firing; No. 2, "Coking" firing; No. 3, "Alternate Side" firing. "Spreading" firing is that usually adopted and which makes so much smoke. In this system the coal is scattered evenly over the whole fire, beginning at the bridge and then gradually working forwards to the fire door. In "Coking" firing the coal is heaped on to the dead plate at the front of the furnace, and after lying there till coked through, the crest is pushed backwards towards the fire bridge and a fresh charge of coal thrown on to the front of the furnace in its place. By this means the gases are gradually evolved instead of being set free almost instantaneously in a cloud, as in the "spreading" system, while a bright fire is maintained at the back of the furnace over which the gases pass. "Alternate Side" firing was introduced, I believe, by the late C. Wye Williams. On this plan the coal instead of being spread across the whole width of the furnace is cast to one side only so that one side of the fire is black while the other is bright, when as soon as the fires are burnt through, the other side of the furnace is changed, and so on.

Each of the three systems was applied to the Lancashire boilers, when it was found on the whole that with round coal the highest amount of duty was obtained by the "coking" firing, and at the same time the least amount of smoke, though the adoption of "side" firing appeared of advantage with "slack," and probably both systems might be had recourse to with success according to circumstances.

Fires also of various thicknesses were tried, viz., 6in., 9in. and 12in., when it was found that the thickness of 9in. gave a better result than 6in., and 12in. than 9in., so that the thickness would have been increased still further had the size of the furnace permitted it.

Added to this, fire grates of various lengths were tried, when it was found that one of 4ft. gave a more economical result than one of 6ft., though it scarcely generated so much steam.

It has been a very vexed question which is the best part of the furnace for the admission of air above the bars to complete the combustion of the gases; some advocating its admission at the door, others at the bridge. Both these plans were therefore submitted to test, and, without troubling you with precise figures, it was found that there was little or no practical difference between the two plans, and that a slight admission of air for a minute or so after charging on the "coking" principle, whether at the fire door or bridge, was successful in preventing smoke.

These preliminaries being settled, the standard fire adopted for testing the relative merits of the three boilers was one 12in. thick, made of round coal, and fed on the "coking" system the combustion being assisted by the admission of a little air through the fire door for a minute or so after charging, by which means the smoke was practically prevented. This mode of firing was adopted on two lengths of fire-grate, one 4ft. the other 6ft. when it was found that with a fire-grate 4ft. in length nearly 10lb. of water could be evaporated by 1lb. of coal, and 150 I.H.P. per hour realised by the boiler. When the 6ft. fire-grate was adopted 9¾lb. of water were evaporated from 1lb. of fuel, and about 170 I.H.P. obtained from the boiler per hour. These results are without the assistance of a feed water heater.

The next step is to compare the results obtained from each of the three boilers, and on considering the whole of the trials, the following appears to be the result:—The patent conical water tube boiler is not practically superior to the plain two flued, as regards either evaporative economy, speed, or the prevention of smoke; nor is the plain two-flued practically superior to the patent conical water tube boiler. With regard to the steel flued boiler as compared with the iron one; the steel appeared to have no advantage over the iron, nor the iron over the steel; so that as regards economy and speed of evaporation, as well as the prevention of smoke, either one of the three boilers seem practically as good as the other. These conclusions were based on trials made with the boilers set up with external flues in the ordinary way, but it was thought it would be of interest to check the results, by altering the course of the flame so as to allow it to pass directly to the chimney on escaping from the furnace tubes, instead of passing round the boiler through the external flues. This trial corroborated the previous ones, and the results from the patent conical water tube boiler were found to be practically on a par with those of the plain two-flued. This experiment is interesting in other ways. The fuel did not evaporate so much water per pound, but the boiler developed nearly as high an I.H.P. per hour without the external flues as with them.

There is another question of interest with regard to the construction of boilers, viz., whether the introduction of water tubes into the flues of Cornish or Lancashire boiler is of advantage or not. To assist in determining this question, Mr. Clayton, of Preston, went to the expense of fixing four water tubes in each of the flues of the boiler previously supplied by him, so that the same boiler was tried with and without the tubes.

The result of the trials with the tubes certainly showed that as a rule some advantage, though slight, was gained both in economy and speed by the addition of the tubes, but it would require a little further investigation before I see my way clearly to recommend them as worth their outlay for general practice. In certain cases where boilers are distressed by heavy firing, they might be found serviceable as an expedient; but where boilers are placed under favourable circumstances, it does not appear that much advantage would be gained from them, and it is questionable whether they would repay the outlay of fixing them in the first instance, and keeping them in repair in the second, as well as atone for the complication they introduce into the boiler.

There is another point of importance in connection with ordinary mill boilers, and that is heating the feed water. It has already been stated that Messrs. Green, of Wakefield, supplied one of their patent economisers, fitted with self-acting scrapers, and the results of experiments with this apparatus clearly showed that it was a decided gain, not only in promoting economy, but also in raising more steam in a given time, so that while the coal bill is reduced, the power of the boiler is increased. The feed water heater is also of material advantage to the boiler, irrespective of the question of fuel, inasmuch as it maintains it at a more equable temperature throughout and thus promotes its longevity.

Although we succeeded in preventing the smoke without any special apparatus, and simply with the proper use of the shovel, coupled with the admission of a little air above the bars, yet it was thought desirable to try the effect of other means, and therefore Mr. D. K. Clark's patent steam jets were applied This apparatus though very successful in preventing smoke, did not realize a higher economy or speed with round coal than simple hand firing, but when "slack" was used, it was somewhat superior in economy, but more so in speed.

I must not omit to allude to the subject of mechanical firing, which is one considerable importance. All present will be more or less familiar with the self-feeding furnace introduced years ago by Mr. Jukes; this, however, as yet, has been principally applied to externally-fired boilers only; but attempts have recently been made to introduce it to those fired internally, and negotiations were entered into for its application to one of the trial boilers. It was thought, however, by the patentees that the furnaces were too small, and consequently, its application was reluctantly abandoned. Messrs. Vicars, of Liverpool, have brought out a self-feeding fire-grate, which is applicable to boilers whether fired externally or internally, and one of these grates was applied and tested. It prove very successful in the prevention of smoke, as well as in speed and economy of evaporation; but when firing with round coal, it had no superiority over hand firing in any one of those points. When fired with slack, however, it was certainly superior to hand firing both in economy and speed, and equally successful in the prevention of smoke. The constant movement of the bars seems to communicate an agitation to the mass of fuel which keeps it alive and promotes the passage of the air through it, and thus quickens the combustion, which gives this self-feeding fire-grate an advantage in this respect over hand firing.

In testing the comparative merits of the various boilers, round coal was adopted as being more equable and reliable in its results, and also as affording a standard of comparison with the prior series of admiralty trials in which round coal had been used throughout. After the earlier questions had, however, been settled, attention was directed to burning "slack," when it was found that smoke could be prevented in burning slack coal as well as round, but that it was more difficult of management as regards speed of evaporation.

With slack coal, the "coking" system proved rather slow in its action, and "side firing," though somewhat faster, is yet slower than the "spreading;" so that although an economical result can be obtained, and smoke prevented, yet the same amount of steam cannot be raised in the same time as with "spreading" firing. We have found a loss of as much as 30 I.H.P. in one boiler per hour when firing with slack in the speed of "coking" as compared with "spreading." From this it appears that when slack coal is burnt, and fired by hand, either speed must be sacrificed or smoke made. This may be met by ample boiler power, but will I fear prove a difficulty in those cases where boilers are fully tasked. In these cases the self-feeding fire-grate, previously referred to, as well as the steam jet system, promise to be of service.

From the foregoing it will be seen that in this series of trials we have taken into consideration the best mode of firing, whether with round coal or slack, with thick fires or thin, with long bars or short, the best point for the admission of the air, as well as the comparative advantages of mechanical and hand firing, also the result of forcibly injecting air among the gases by the steam jets. We have also endeavoured to arrive at the comparative efficiency of the conical water tube boiler, and the plain two-flued, as well as the merits of iron and steel furnace tubes, and with the value of introducing water tubes into the two-flued boiler. I can scarcely consider this, however, as an exhaustive series of investigations, and there are other trials which it would have been satisfactory to have made. There is the Juckes's furnace applied to boilers externally, which has its strong advocates; also, there are several recently patented boilers, with deflecting flue-tubes, which are stated to realise highly economical results; also, there is the multitubular boiler as adapted for mill purposes. All of these boilers it would be of interest to submit to a careful comparative test. In addition to this there is the gas system, which is an enlargement of the plan of coking firing already described. Much is yet left for other investigators, but I trust that these trials will prove of service to steam users, while I wish every success to those who are willing to push them further.

Though these trials may not be exhaustive, it has been found that smoke may be prevented, whether firing mechanically or by hand, without any special appliance, or when the combustion of the gases is assisted by driving in currents of air by jets of steam, and I think these trials fairly establish the conclusion that the smoke nuisance admits in all cases of considerable abatement, and in most of total removal. As already stated, the only difficulty is in those cases where boilers are overtasked, and these it would appear could be assisted by mechanical feeding, or the use of the steam jet apparatus, while in many of them the difficulty could be met by re-setting the boilers, or renewing the chimney, so as to improve the draught, or at all events by additional boiler power. With sufficient boiler power the smoke question is settled.

With regard to the form of boilers it has been found that those of the plain two-flued construction, aided by a water heater, are able to develope a very high result. We have evaporated as much as 10½lbs. of water at 100° by 1lb of coal on a fire-grate 4ft. in length, and 10¼lbs. on a fire-grate 6ft. in length. In both cases this has been done without smoke, and while evaporating as much as 100 cubic feet of water from the boiler in the course of the hour with the 6ft. fire-grate, and 80 cubic feet with the 4ft. grate, which is sufficient to develope, with a good engine, about 200 I.H.P. per hour in the first case, and 160 I.H.P. per hour in the second.

I cannot conclude these remarks without calling attention to the great influence of careful stoking simply, on smoke prevention. These trials have proved how very much depends on the proper use of the shovel. George Weekes, the stoker, who has fired the boilers throughout this series of experiments, as well as the previous one with the Admiralty boiler, takes an interest in his work, and considers stoking as his profession. In this way I think it should be viewed. Firing is an art and should be treated as such, and not as a slap-dash random process which any untaught labourer can accomplish. To a great extent our smoke producers are the stokers. Educate the stokers in their art and smoke will be prevented. They should be instructed in the first instance how to fire without producing smoke, and be stimulated to constant care by a fine on failure, and a premium on success. If steam users were united in the movement, the question would soon be settled. A stoker would then require a diploma of competence as a "smoke preventor" before obtaining a post, and his livelihood would depend upon his skill. The question, after all, is not one entirely of science. As soon as the public become sufficiently educated on the subject to demand the suppression of the nuisance, and stokers are placed in their proper position, smoke will be abolished. The question is as much a social as a scientific one, and to exhaust it fully, one must travel to other fields than those of material science only. But this I leave to other hands, though I cannot help expressing the hope that the meeting of this day, by drawing attention to the importance of the subject, will prove a step towards suppressing the smoke nuisance, and thus of promoting a most important sanitary and social reform.

I am, Gentlemen,
Yours faithfully,
Lavington E. Fletcher.

July 21st, 1868.

### Explosions.

Five explosions have occurred during the past month, by which one person has been killed and fourteen others injured. Not one of the boilers in question was under the inspection of this Association. The following is a tabular statement:—

Tabular Statement of Explosions, from June 27th, 1868, to July 24th, 1868, inclusive.

| Progressive Number for 1868. | Date. | General Description of Boiler. | Persons Killed. | Persons Injured. | Total. |
|---|---|---|---|---|---|
| 22 | July 9 | Two-flue Lancashire, Internally-fired …… | 0 | 6 | 6 |
| 23 | July 9 | Vertical furnace, heated by flames from puddling furnaces ……………… | 0 | 3 | 3 |
| 24 | July 13 | Two-flue Lancashire, Internally-fired …… | 1 | 1 | 2 |
| 25 | July 14 | Locomotive ……………… | 0 | 3 | 3 |
| 26 | July 21 | Particulars not yet fully ascertained …………… | 0 | 1 | 1 |
| | | Total……………… | 1 | 14 | 15 |

The fragments of four of the exploded boilers have been specially examined by officers of the Association, and I am provided with minute particulars. The length, however, to which this report has extended, with other matter, prevents my going into details on the present occasion. I may, therefore, very briefly state that there was nothing at all mysterious in the cause of these explosions, but that they all arose from simple causes so frequently reported in other cases, one of them being due to collapse of the furnace tubes throughout overheating of the plates consequent on shortness of water, and two others to external corrosion, one of the boilers being seated on a midfeather wall. Fuller reference to these will be made on a future occasion.

## INSTITUTION OF MECHANICAL ENGINEERS.

### ANNUAL MEETING AT LEEDS.

The annual meeting of the above society took place this year at Leeds, the lectures being delivered at the Philosophical Society's lecture hall. The attendance of members and visitors was large, and the papers read very interesting. The reading of the papers commenced on Tuesday, 28th of July, Mr. Whitworth being in the chair.

The first paper read was "On the Machinery for the Manufacture of the Boxer Cartridge," by Mr. F. Greenwood, and which was illustrated by a very complete set of drawings. Mr. Greenwood stated that the question of good rifles was so bound up with the system of cartridges, that the rifles would frequently have to be modified to suit the cartridge. The first attempt to make a breech-loader failed in England, because it was wished to use the same cartridge as that adapted to the muzzle-loader and it was only when this idea was given up that any real progress was made in perfecting the breech-loader. The defect of the Prussian and Chassepot guns was that the stopper was left exposed to the action of the powder; so that the first weapon could not be fired from the shoulder, and was fired from the hip—a serious drawback in the efficiency of the piece. The particular defect of the Chassepot rifle was that the fulminating powder was placed in the rear of the ball, and that a paper cartridge was used, leaving a residuum in the chamber of the gun, fouling the mechanism, and impeding its working. In the case of the needle gun, the needle, having to pierce the length of the charge of powder before reaching the detonating cap, was liable to get bent, in which case the point missed the fulminating powder, and the result was a miss-fire. It was thus seen that however important it was to have a first-rate breech-loading rifle, it would be comparatively worthless unless the cartridge was equally efficient. Numerous attempts had been made to produce the apparently simple articles of cartridges, but it was only after numerous failures that anything like a serviceable cartridge had been produced. The requirements of a good cartridge were that it must not miss fire, that it must be sufficient strength to prevent the escape of any gas backwards, or, in other words, be of sufficient strength not to burst with the explosion of the powder; that the case, after being fired, should be easily extracted; that, without being perfectly water-tight, it must be, to a considerable extent, impervious to damp; and that it must be of a cheap and a light construction. Mr. Greenwood then described the various machines that were used in the manufacture of the Boxer cartridge. The first was for making the Metford bullet, now used for the Boxer cartridge; the partially moulded bullets were then taken to the second machine, and after they left it they underwent the process of canneluring, or of forming four grooves on the cylindrical part of the bullet to hold the lubricating material. The next machine was for the purpose of moulding the clay plugs which were put into the conical recess at the rear of the bullet, for the purpose of expanding that part of the bullet, and pushing the lead into the grooves of the rifle at the moment of discharge; and the next made the cylindrical plug. After that the bullet was warmed in another machine, and the clay plug pressed in. The next machines described were for the purpose of forming the cartridge case and manufacturing the caps, and the operations were explained at great length, and with much minuteness; but without the drawings it would be useless to reproduce it in these columns. Altogether twenty-one machines were spoken of as being required in the manufacture of each cartridge, but the cartridges are produced at the very rapid rate of from 5,000 to 24,000 per day.

The next paper, "On the Application of Machinery to Coal-cutting," was read by Mr. John Fernie, of Leeds. The objects to be gained by the application of machinery to coal-cutting were stated to be—firstly, the cheapening of the work; secondly, the saving of a large quantity of coal, which in the ordinary process of holing or undergoing by hand labour with the pick is broken up into slack and dust; thirdly, the removal of the danger attendant upon undergoing by hand labour; fourthly, the getting of a larger quantity of coal out of the pit; and fifthly, in the case of machines worked by compressed air, the collateral advantage of better ventilation and a cooler atmosphere in the mine, owing to the discharge of the compressed air after each stroke of the tool. The difficulties attending the application of machinery, to work previously performed by hand, were said to be greatly increased in the case of coal-cutting machines, and in the very confined passages of a mine. Mr. Fernie described two machines driven by compressed air, one having a pick worked by a bell-crank lever, with an action like that of the ordinary pick used in handwork, and the other working a straight-action tool, somewhat in the manner of a horizontal traversing machine. Both of these machines have now been successfully employed in regular work for a length of time, in the neighbourhood of Leeds. A pick machine does the whole of the undercutting at the West Yorkshire Coal and Iron Company's colliery, at Tingley, holing a seam 3ft. 8in. thick, the compressed air for driving it being supplied by an air-compressing engine at the surface. In a trial recently made with this machine by the writer, it was found that a pick of 75lb. weight cutting a groove to a depth of 24in. from the face, gave about 74 blows per minute. The coal at Tingley is got by the pillar and and stall system of working, and the time occupied by the machine in undercutting the length of 56ft., forming one pillar, was 25 minutes, including all stoppages. With a pick of 90lb., to complete the previous cut to the depth of 3ft. 9in. from the face, the blows were about 60 per minute, and the half length of 28ft. was undercut in 17 minutes. The time occupied in running the machine back and changing the pick was 16 minutes. From these trials it appeared that in undercutting to the depth of 24in a single course, the work done was at the rate of about 30 square yards per hour, and in undercutting in two courses to the depth of 3ft. 9in. the work was done at the mean rate of about 15 square yards per hour, including the time required for running the machine back and changing the pick. The other coal-cutting machine—which is described as on the horizontal traversing slotting principal—is the invention of Mr. Donisthorpe, of Leeds. In this instance the machinery traverses along the working face of the coal, and cuts out a horizontal slot or groove along the bottom of the seam of coal, or along a parting in the thickness of the seam itself. The work regularly done by one of these machines, employed at the West Riding Colliery of Messrs. Pope and Pearson, at Normanton, is at the rate of 8 to 12 yards per hour, including all stoppages, and undergoing the coal to the average depth of about 3ft. 4in. from the face. At the same colliery the work done by each collier by manual labour is about 6 yards per day of 8 hours, undergoing to a depth of 3ft. in from the face. The machine, therefore, performs the work of from 12 to 18 men. Its operation was found so successful that it was now being employed for a long continuous face of work, and the different parts of the mine are being laid out as far as possible for working according to the long-wall system for the purpose of obtaining the greatest advantage from the use of the machine.

The writer of the paper then proceeded, with the assistance of some excellent drawings, to show how this machine answered the requirements stated in the first part of his paper.

On the afternoon of this day the members visited many of the various large works in Leeds and the neighbourhood, and on the 29th they reassembled at the Philosophical Society's Hall, when the first paper read was by Mr. John Fernie, of Leeds, on a "clip drum travelling crane." The writer began by stating that few mechanical improvements have been so rapidly and extensively adopted as the flying rope travelling crane, and the extension of the application of this system has been so great that at the present time there is scarcely a shop for the manufacture or repair of locomotive engines but has several of these cranes at work. The travelling crane here noticed has been invented at the Steam Plough Works, Leeds. The idea occurred that an improvement could be made by adopting a steel wire rope, working with a clip drum, instead of a cotton rope, acting by friction only, and that for out-door work, in quarries or over-docks for ship-building, where a cotton rope would be subject to injury by exposure to the weather, a steel wire rope would be preferable. The crane is employed at the Steam Plough Works, Leeds, for lifting locomotive engines and other heavy work, ranging from 15 tons downwards. It has a span of 40ft., and works in a shop 180ft. long. The three different motions, for longitudinal traverse, cross traverse, and hoisting, all are derived from one steel wire rope ⅝in. diameter, and weighing 2lb. per yard. Driven at a speed of four miles an hour, by means of the clip pulley fixed at one end of the shop, the rope is entirely unsupported between the two ends, and hangs loose with a slight tension, owing to the peculiar facility afforded by the action of the clip pulley. The clip pulley lays hold of the rope with an amount of grip proportionate to the strain of the load, releasing it from its grasp when the rope has passed the centre line. At one end of the travelling platform of the crane is fixed another pulley of the same size and construction, round which the same wire rope passes, being held up to its place by a grooved pressing pulley. The rope then passes on to the further end of the shop, and round the grooved pulley there, which has an adjusting screw, and is centred in a sliding frame. It is not proposed to have carrying pulleys for the wire rope for distances under 600ft., and in the case described, where the length of the shop is 180ft., it is found that the weight of the rope hanging in a curve is sufficient with the clip pulley to give power enough for driving the crane. The longitudinal traverse and the cross traverse gearing is of the ordinary description, the motion being communicated by friction clutches. The former has a speed of 30ft. per minute, and the latter of 20ft. per minute. The lifting gear consists of a very long cast-iron nut, or screwed barrel, and inside the nut works a short screw, sliding upon two feathers upon a long shaft, driven by a friction clutch from the clip pulley on the traveller. By the revolution of the shaft the screw is traversed along with the nut. The crane has two speeds for the lifting gear, one being at the rate of 6ft. per minute, and the other 3ft. per minute; and at the latter speed the crane is calculated to lift 15 tons. The pull required to put the wire rope in motion when the crane is standing idle is 128lb. When lifting a load of 10 tons, at the usual speed of 3ft. per minute, the additional pull upon the rope is 191lb., making the total pull 319lb. The horse-power required with the wire rope is consequently 3·4, with a load of 10 tons, and only 1·4 when standing idle, these amounts being very much less than in the case of the quick-moving cord crane. The crane has been in use at the Steam Plough Works for two years, and has been found to be easily and cheaply worked.

Mr. Wm. Inglis, of Manchester, then read a paper "On the Corliss Expansion Gear for Stationary Engines." It was stated that the Corliss engine (so called from Mr. Corliss, who introduced the engine in the United States about twenty years ago), might, in all except the cylinder, with its valves, be considered as substantially the same as any ordinary steam engine. Several principles are embodied in the arrangement of the cylinder and valve gear, which have previously been used separately. First, independant ports for admitting and exhausting the steam at each end of the cylinder are used with four separate slide valves, operated from a single eccentric. Second, cutting off the steam from the cylinder by the main steam valves without the employment of any supplementary valves for the purpose. Third, opening the steam valves against the resistance of springs, and the employment of liberating gear, by which the valves are disconnected, and left free to be closed by springs. Fourth, after the valves are closed, bringing springs to rest without shock, by the application of the contrivance known as the dash pot. The dash pot consists of a small cylinder with a close bottom, in which a piston is fitted to work easily. By a suitable arrangement of openings the air is so admitted to the cylinder in which the piston is moving, that a certain amount of air is imprisoned to prevent shock to the piston. Fifth, regulating the speed of the engine by the governor acting on the steam valve to cut off the steam earlier, instead of acting on a throttle valve to reduce its pressure. It is the embodiment of these several principles together, with the arrangement and construction of the details in the mechanism employed, rather than the application of any new or untried principle, that constitutes the special novelty of the Corliss valve gear. Cylinders with four separate passages and independent steam and exhaust slide valve were used by Seaward more than 30 years ago, The valves employed then were flat slides, but were not worked in connexion with any liberating gear. A number of marine engines were fitted with them at that time. In the earlier Corliss engines Seaward's cylinders and slides were used, but the Corliss valve now employed is a cylindrical slide, working in the arc of a circle on its seat, and receiving a rocking motion from the central valve spindle; but, although separate valves and passages were employed for steam and exhaust at each end of the cylinder, the motion imparted to the steam valves was invariable, and any expansion of the steam was effected by the lap; the speed of the engine also had to be controlled by throttling or shutting off the steam with a supplementary valve; and here there is in the Corliss gear the first step in advance by the addition of the principle of liberating the steam valves. It became necessary with the employment of liberating gear that a force should be available for closing the valves where they were detached, and for this purpose weights were used, but springs have now been substituted for the weights, because they are more quick in action, effecting a sharper cut off, and are better adapted for fast working. Liberating gear for the steam valves was actually used by Watt; but to Mr. Sickles, of New York, is due the credit of perfecting it as applied to the poppet or the double-beat valves in the well-known cut-off gear which bears his name. The action and principles of the gear which have been mentioned were described with much minuteness in the paper, and with the aid of a number of drawings. New cylinders, with improved Corliss expansion gear, have been erected at Saltaire from designs by the writer. The engines are beam engines, with 50in. cylinders and 7ft. stroke, working at 30 revolutions per minute. There are two pairs of engines, four cylinders in all, the same size as the cylinders with double beat valves, which they have replaced. The valve gear has double clip valve rods, central dash pots, &c. The cylinders, as well as the cylinder covers, are steam jacketted; the valve chambers are cast with the cylinders; the steam valves are in front, and the exhaust valves at the back of the cylinders, while the valve gear is placed on the sides of the cylinders between each pair of engines. Steam and exhaust passages are cast separate from the cylinders, and provided with expansion joints. The double clip gear, as far as experience goes, works works with satisfaction, and is reliable and effective at 100 or 120 revolutions per minute, and could be worked at speeds considerably greater. More than 60 land engines, most of them of large size, are now at work in this country fitted with this gear; many of these have been at work for several years, giving great satisfaction both for economy of fuel and regularity of speed, and a considerable number had also been made and sent abroad. They are also being extensively used for marine purposes. The valves and gear are easy of access either for inspection or repair, and from the number of engines at work it is proved that with good workmanship they can be kept in order at a very trifling expense. The consumption of fuel with these engines is about two and a half pounds per indicated horse-power, per hour, which includes all the coal used for raising steam or banking fires.

Mr. Wm. Wield, of Manchester, read a paper "On the Machinery for Weaving Brussels Carpet by Power." The weaving of carpets and other pile fabrics by self-acting machinery, instead of the previous hand labour, has occupied the particular attention of machinists from about the year 1842, and many inventions were made to effect the arrangement, but it was only between the years 1851 and 1856 that machinery for the manufacture was so far perfected as to be commercially successful. The paper related to one of the two classes of pile fabrics, that in which the pile is formed by the warp, the threads passing lengthwise. After giving a description, by the aid of diagrams, of the tapestry, Brussels, and velvet fabrics manufactured, and the processes employed, it was stated that in the first attempts at applying self-acting machinery, the wires were drawn out one by one from a bundle as required, and carried through the shed by a pair of nippers fixed at the end of a reciprocating rod, the wires being returned by hand to the bundle after having been woven into the fabric, and then withdrawn from the loops. The whole operation was made self-acting by dipping the wires successively from a hopper into a longitudinal groove in a rod, that was pushed through the shed in guides, and was then caused to make a half revolution by a screw-inclined rod, which thus dropped the wire into its place into the shed. The wires were then withdrawn successively by reciprocating nippers, and carried up again into the hopper by endless chains. Afterwards an improvement was made by placing the wires singly in a triangle, from which they were pushed into the shed, and the wires were made with a hook at the back end of each, by means of which each wire was drawn out of the fabric successively by an endless chain, and then transferred to the triangle for re-insertion. Various contrivances were afterwards employed for supporting the wire as it passed through the shed, the wire being pushed from a trough used as a guide. It has since, however, been found practicable to introduce wires without having supports in the shed, and this is done in the loom now extensively employed by Messrs. Crossley, of Halifax Besides the loose wire there was another method called the fast wire system. There is an uncertainty of action in the loose wire system, which the writer considers may be entirely obviated in an improved loom invented and made by Messrs. Sharp, Stewart, and Co. This construction of loom is known as the roller wire motion, and is now extensively used. Diagrams of the mechanism in the improved form were shown and explained at considerable length. This invention embraces the advantages of both systems of working wires—good quality in the fabric produced by using a number of wires, and the advantage of the certainty of action, and belongs to the fast two-wire loom. It will weave 3in. of cloth per minute and as many as 47 yards have been woven in one day of 10 hours, including stoppages, the average production being 42 yards during the same period.

This being the last meeting for the reading of papers, the chairman proposed votes of thanks to the Council of the Philosophical Society for the facilities afforded for the annual meeting; to the local committee and the honorary local secretaries, Mr. J. Fernie, and Mr. W. E. Marshall, for the very complete arrangements they had made; and to the several railway companies for the advantages they had given in travelling. A vote of thanks was also passed to Mr. Whitworth and Mr. Fairbairn for presiding. Altogether this meeting passed off very successfully, both as regards the attendance, and also the interest attached to the papers read, and the discussions upon them.

## MEETING OF THE BRITISH ASSOCIATION AT NORWICH.

August 19th to 27th.

[We defer until our next publishing the sectional arrangements and list of papers read during the sittings, but the following are amongst the most interesting read in Section G for which we can find space.]

## ON THE RECENT PROGRESS OF STEEL MANUFACTURE.

By Frederick Kohn, C.E.

At the last meeting of the British Association in Dundee, I had the honour to draw the attention of this section upon a new mode of steel manufacture, which at that time had commenced to gain ground on the continent, but which had not been brought into commercial practice in any one of the numerous steel works of this country.

I refer to the process of manufacturing steel upon the open hearth of a Siemens furnace by the mutual reaction of pig iron and decarburised iron, or "wrought iron," upon each other—a process which in France has received the name of "Martin Process," from its inventors, Messrs. Emile and Pierre Martin, of Paris, but which, in justice to both the inventors to whom the practical and commercial success of this innovation is due, should bear the name "Siemens-Martin Process." Within this last year the Siemens-Martin process has been brought into operation in this country, and I have now the pleasure to lay before this meeting a few samples of steel which have been made by that new process in the Cleveland district, and in a very considerable proportion from Cleveland iron.

I hope, therefore, that it will not be out of place to give to this section a brief account of the technical detail of this new mode of steel manufacture, and to make a few remarks upon its commercial prospects, so far as the latter can be judged at present.

The Siemens-Martin process realises the old and repeatedly proposed idea of melting wrought iron in a bath of liquid pig iron, and thereby converting the whole mass into steel. The principal elements of its successful operation, and the points which distinguish it from all previous abortive attempts are, 1st, the high temperature and the neutral or non-oxidising flame produced by the regenerative furnace of Mr. Siemens; and, secondly, the method of charging the decarburised iron into the bath of pig iron in measured quantities or doses.

These doses of wrought iron or steel are added to the bath in regular intervals, so that each following charge in melting or in being dissolved in the bath increases the quantity of the liquid mass, and adds to the dissolving power of the bath until the stage of complete decarburisation is arrived at. The charge is then completed by adding to the decarburised mass a certain percentage of pig iron, or of the well known alloys of iron and manganese, such as spiegeleisen or ferromanganese, and the degree of hardness or temper of the steel produced depends on the proportion of this final addition.

The process as characterized above has been experimented with at the Model Steel Works, in Birmingham, by Mr. Siemens, and on a larger scale at the Bolton Steel Works. From this latter establishment a railway tyre made from Bessemer steel scrap and pig iron upon the open hearth of a Siemens furnace, has been sent for exhibition to this meeting. The first and, as yet, the only steel works in this country which is working this process commercially, and which is laid out for the manufacture of steel by the Siemens-Martin process exclusively, is the Newport Steel Works, at Middlesbro'-on-Tees, belonging to the well-known firm of Messrs. Samuelson and Co.

The Newport Steel Works has commenced operations about two months ago, and have been working since that time with great regularity, and almost without interruption day and night. There is one steel melting furnace constructed from the designs of Mr. C. Siemens in operation at present, and a second similar furnace is to be erected very shortly.

The roof of the furnace is made of Dinas brick, and the bed upon which the charges are melted is made of ganister or pure silicious sand mixed with a red sand containing a small percentage of alumina, both kinds of sand being found in the Cleveland district. The preparation of the furnace bottom requires great care, and a certain amount of skill on the part of the workmen. All materials charged into the furnace are previously heated to redness in an auxiliary heating furnace. The pig iron employed for forming the bath is principally Swedish charcoal pig iron, and it enters into the charges in the proportion of about one-third of the total weight. The tables annexed to this paper,* which are copies of the records of some interesting charges kindly placed at my disposal by Messrs. Samuelson & Co., give a clear idea of the precise mode of conducting the charge. Table No. 1 is the record of a charge made of Swedish pig iron (1,680lb.) and of puddled bars from Cleveland iron (3,136lb.) A small quantity of hematite ironstone was added to the charge during the operation, with the intention to reduce the time required for the process, which occupied 13 hours; but from the large proportion of spiegeleisen (1,560lb.) required at the end, it appears that decarburization had been carried too far, and the charge could have been completed several hours earlier. At the same time this example shows the great facility which the Siemens-Martin process affords with regard to the correction of errors committed in conducting a charge. The production of any desired temper of steel can be relied on with absolute certainty, since the ultimate success is a mere question of time, and it is of comparatively little consequence how far the decarburization may have been overstepped or neglected during the operation, if the final addition brings the charge back to the proper temper and quality.

Table No. 2 is a record of an attempt to use Cleveland pig iron for the bath. The puddled bars added to the charge were of the same kind as those used with the Swedish pig iron, and the addition of hematite—an iron ore containing a high percentage of titanium—was made with a hope to remove phosphorus from the bath. With a similar idea a quantity of so-called patent slag—a mixture of ingredients to which a similar power is ascribed in the Cleveland district—has been added, but without success. The product was found cold, short, and brittle, and the Cleveland pig iron has thereby been proved unsuitable for the Siemens-Martin process.

Table No. 3 records a charge made with grey hematite pig iron and Cleveland puddled iron. The product is a steel of less ductility and malleability than that derived from Swedish pig iron. There is also an excessive loss amounting to 17.04 per cent. of the total weight charged into the furnace shown by this table. This seems to indicate a high percentage of silicon in the pig iron, to the partial and imperfect removal of which both the hardness of the steel and the great waste may be due. It is not possible, however, from this single experiment to draw a reliable conclusion with regard to this class of pig iron.

Tables No. 4 and 5 show some of the most successful charges made at Messrs. Samuelson and Co.'s works. From these charges the samples which I have exhibited here are taken. The bath of pig iron in these charges is made of a mixture of white Swedish iron and of spiegeleisen, besides this, a quantity of spiegeleisen is added at the end of the operation. In these charges Cleveland bars enter into the proportion of about one-half. The steel produced in this manner is very soft, and of a very fine quality, it is principally used for boiler plates and for similar articles. Some tests with regard to the strength and elasticity of this steel are now in progress at Mr. Kirkaldy's testing works, but the results have not reached me as yet.

The quantity of fuel used in this process of steel melting, including the fuel for the auxiliary heating furnaces, is about one ton of coal per ton of steel produced.

From the above data the question of prime cost may be answered approximately.

Taking the price of Swedish pig iron and of spiegeleisen at £5 per ton. that of Cleveland bars at £5, and the average waste in the furnace at 10 per cent., we require for 1 ton of steel ingots:—

| | £ | s. |
|---|---|---|
| 11 cwt. of pig iron at £6 ... ... ... | 3 | 6 |
| 11 cwt. of puddled bars at £5 ... ... ... | 2 | 15 |
| 1 ton of coal ... ... ... ... ... | 0 | 5 |
| Cost of materials ... ... ... | 6 | 6 |

The expenses for wages, repairs of plant, and royalties to both the patentees will bring the prime cost of the Siemens-Martin steel ingots to about £7 10s. per ton, which is precisely the same as the prime cost of Bessemer steel ingots made from hematite pig iron in this country.

The Siemens-Martin process seems to have a vast importance for the ironmasters of many localities. It is applicable to the conversion of old materials (wrought iron and steel), it can utilise the waste of all other processes of steel manufacture, it is not limited to grey or highly carburised pig iron, and it can for all these reasons be introduced into localities which have hitherto been in an unfavourable position for the production of steel. The question naturally arises how this new process will affect the progress of the Bessemer process, of which it seems to be a rival. In my opinion the only influence which the Siemens-Martin process can have upon the Bessemer steel trade is to stimulate and assist the latter, and to widen the sphere of its application. The two processes, working with two different classes of raw materials, can never come into direct rivalry. Wherever grey pig iron can be had of sufficient purity for direct conversion the Bessemer process will be the most advantageous, and, indeed, the only suitable mode of steel manufacture; but in all cases where the raw material is wrought iron, white pig iron, or pig iron, which must be freed from its impurities by puddling before it can serve as a material for steel manufacture, the Siemens-Martin process will find its place. By working up the waste offal of the Bessemer Steel-works, the crop ends of steel rails, and similar material, the new process will assist in cheapening the prime cost of Bessemer steel, in which the waste plays an important part.

The Siemens-Martin process—although it is not capable of employing the inferior kinds of pig iron for the manufacture of steel direct—is a process of steel manufacture applicable to the inferior classes of iron. It seems destined, therefore, to render a most important service to all those great centres of an old established iron manufacture, the future existence of which had been endangered by the irresistable competition of the Bessemer process, which itself was inapplicable to the raw materials available in those localities.

The new process will therefore render another important service to the Bessemer process, and to steel manufacture in general, by introducing steel manufacture into localities which have been hitherto debarred from it by unfavourable natural conditions. This will, to a great extent, destroy the great and organised opposition which has been raised against the general introduction of steel instead of iron for engineering purposes, and will thereby remove one of the most powerful drawbacks now hampering the spread and progress of steel manufacture in this country.

## ON THE IRRIGATION OF UPPER LOMBARDY BY NEW CANALS TO BE DERIVED FROM THE LAKES OF LUGANO AND MAGGIORE.

By P. Le Neve Foster, Jun., C.E.

Northern Italy abounds in canals and works of irrigation, many of which are of ancient date. In Lombardy especially, irrigation has been carried on to a high pitch of perfection, the natural features of the country being admirably suited for this purpose. The plains, which slope in a south-easterly direction from the heights of Somma and from the hills of the Brianza towards the Po and the Adda,* derive their fertility from the mountain regions which fill those great sub-Alpine reservoirs, the lakes of Como, Maggiore and Garda, with water, which is carried down by the numerous rivers and torrents, and serves to flood the adjacent land in the plain.

To facilitate this irrigation, and for the purpose of navigation, many canals have been derived from the Ticino, Adda, and other rivers; and amongst the most important are the Naviglio Grande, which was commenced in 1177, and completed in 1272. The Pavia Canal, the canal of Martesana, and many others of more recent date.

These canals, however, only serve to irrigate the lower part of Lombardy, whilst the whole tract of country north of the Naviglio Grande from Abbiategrasso to Milan, and north of the Martesana Canal from Milan to Canonica on the Adda, and extending to the foot of the hills of Varese and the Brianza, is almost without irrigation. The soil is in many places dry, and the supply of water from the streams which take their rise in the hills is only sufficient to water a very small portion of the land. The subterraneous waters are also very deep; in many places the wells are some hundreds of feet below the surface. The land is chiefly cultivated in wheat, rye, Indian corn (which suffers much from the drought), buckwheat, millet, and, above all, in mulberry and fruit trees. The lands to which irrigation does not reach are often to a great extent covered with heath.

The superficial area of this region is estimated at about 100,000 hectares (247,114 acres.)

Many propositions have from time to time been made with a view of improving the agricultural and industrial condition of this district by bringing down by canals the waters of the various lakes laying north of Lombardy.

The whole of this tract of country lays considerably below the level of the Lake of Lugano, the highest part to be irrigated being 20 metres (64′ 7″) below the surface of the lake. Although this district from its relative position might be irrigated by a canal from the Lake of Lugano, the quantity of water which could be obtained there would not be suffi-

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* These tables will be given in our next issue.

* The fall is about 1 in 1,000.

cient, and great difficulties, both financial and engineering, would be met with. An unlimited supply of water, however, might be had from the Lake Maggiore, but from its position being at 77·60 metres (254′ 6″) lower level than the Lake of Lugano, only a part of the district requiring water could be irrigated.

From this it may be naturally inferred that the irrigation canals for the higher lands must be supplied from the Lake of Lugano, whilst the lower lands should be watered by canals from the Lago Maggiore.

It is on these facts that are based the projects of Signor Villoresi and Meraviglia of Milan. These engineers have obtained from the Italian Government a concession for the construction and working of the new canals in Upper Lombardy.

The district to be irrigated is divided into two Zones: the first is bounded on the north by a line passing through the communes of Vergiate, Somma, Cassorate, Cedrate, Rovellasco, Barlassina, Leniate, Meda, Seregno, to Albiate on the River Lambro, and shows the highest possible limit of the irrigation from the Lake of Lugano.

The southern boundary of this zone is a line commencing at Vergiate following the River Ticino to Tornavento, where it takes an easterly direction, passing through the territories of Castano, Parrabiago, Lainate, Vedano, and crossing the River Lambro above the town of Monza. This line is also the highest limit of the irrigation from the Lake Maggiore. The second zone extends south of this line to the Naviglio grande and to the Martesana Canal.

The first is the only natural area which could be profitably irrigated from the Lake of Lugano; and the second that which should be irrigated from the Lago Maggiore.

We will now consider the available quantity of water which could be obtained from the two lakes.

Extended observations on a large scale on the volume of floods, the length of droughts during a period of half a century, have enabled a large amount of valuable facts to be collected, and these leave no doubt as to the certainty of the supply.

The area of the Lake of Lugano is 48 square kilometres in droughts, and 50 square kilometres (about 20 square miles) in floods. The total drainage area of the lake is about 540 square kilometres (208 square miles) The mean discharge of the River Tresa, which is the outlet of the Lake of Lugano into the Lago Maggiore, is 32 cubic metres per second. This discharge corresponds with a height of water in the lake of ·33m.; above the zero on the vertical scale or water-gauge at Pente Tresa, and the level of the lake is at this point for about 120 days in the year, during the months of May, June, October, and November.

The maximum flood discharge is 280·86 cubic metres per second, and corresponds to a level of water in the lake at 2·45m. above zero on the vertical scale. The floods last about 15 days in the year, and take place in the spring, at the end of April or beginning of May, and in the autumn at the end of October or beginning of November.

The minimum discharge is 11·65 cubic metres per second, and corresponds with a height of water in the lake of 0·11 below zero. The waters are at this level for about 20 days in the summer, during the months of July and August, and for 40 days in the winter, during December, January, and February.

The ordinary high level is ·83m. above zero, giving a discharge of 65·94 cubic metres per second, and the waters of the lake are at this level for about 40 days in the year, in the months of May, October, and November.

In order to obtain a constant supply of 18 cubic metres per second in winter, and from 24 to 30 cubic metres per second in the summer for irrigation, and to insure 4 cubic metres per second for supplying the various mills on the River Tresa, it is proposed and has been sanctioned by the Swiss government to shore up the flood waters in the lake, and to utilise them in droughts by regulating the flow in such a manner that the lowest water should never be below 0·25 above zero on the guage at Pente Tresa. The ordinary level 0·85, and the maximum level never to exceed 2·00 above zero.

The total area of the Lago Maggiore is 202 square kilometres when the waters are low, and 208 square kilometres in floods. The total drainage area may be estimated at about 6,466 square kilometres. The following are the levels of the water in the lake under various circumstances at the fixed vertical scale or guage at Sesto Calende:—

| | |
|---|---|
| Lowest level corresponding with Zero on Scale. | |
| Ordinary low level ... ... | 0·20 above Zero. |
| Mean level ... ... ... | 1·50 „ |
| Ordinary flood level ... ... | 3·50 „ |
| Highest flood level ... ... | 4·77 „ |

The total quantity of Water discharged from the Lake Maggiore in the course of a year is estimated at 10,000,000,000 cubic metres, which gives a mean discharge of 322 cubic metres per second. This discharge corresponds with a height of water of 1.03 above Zero on the scale at Sesto Calende, and for 43 days in the year, during the months of March, June, December, and part of April and July, the level of the lake is at this point.

The maximum flood discharge is 2,200 cubic metres per second. The floods usually take place from the end of May to the end of June in the spring, and the autumn floods about the end of September to end of November, and last about six days with a height of water at 3.50 above Zero, and from eight to nine days with a height of 3.00 above Zero.

The mean discharge at the ordinary level of the lake of 1·50 above Zero is 480·30 cubic metres per second.

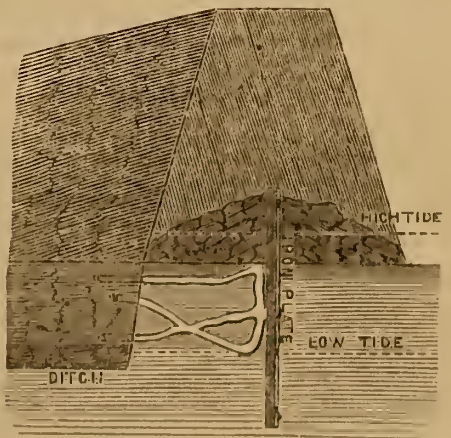
The minimum discharge at the lowest level (Zero) is 72 cubic metres per second.

*(To be continued.)*

## THE EMPLOYMENT OF IRON IN THE CONSTRUCTION OF DYKES.

The advantages derived by draining and cultivating swamps and marsh lands, both from a pecuniary and sanitary point of view, are well known to be very great. Notwithstanding the enormous first cost and constant expenses for repairs and supervision, the land thus reclaimed, generally affords ample compensation, and in fact the only exception to this rule is when the embankment gives way and the land returns once more to its former state of unfruitfulness. One of the principal sources of expense in keeping up these embankments or dykes, arises from the holes made by rats and crabs, which not unfrequently perforate entirely through the structure and allow the water to run through, which, if not speedily stopped, would soon increase in volume, and swamp the whole of the enclosed land. In order to guard against these injuries, Mr. S. B. Driggs, of New York, has invented a system of iron dyking which seems admirably adapted to the purpose.

The following account taken from the *Scientific American*, will, with the accompanying drawing shewing a section of the embankment, sufficiently explain the mode of carrying out a work of this description:—



The dykes of Holland are embankments made with heavy timbers and filled in with stone, the surfaces being covered with bundles of flags and reeds fastened down by stakes. Also piles are driven into the sand and protected by planking, as well as by earth, turf and stones. In some places wicker work is used to cover and protect slopes, and the willow is cultivated extensively to supply the material for this purpose. In places of great exposure, walls of masonry with piles driven upon the side towards the sea, are used to protect the embankments from the action of the waves.

The fens of Lincolnshire and the Bedford levels are examples of the reclaiming of worthless and unproductive swamp lands and transmuting them into fertile and productive fields.

An annual expense of 30,000 dols. each is required to keep the dykes of Helder and West Cappel, at the western extremity of the island of Walcheren, in repair. The annual expenditure in Holland for maintaining its dykes and the regulation of its water level is from two to two and one half million dollars. Watchmen to patrol the dykes and to give the alarm when danger threatens, and engineers to apply the proper means in cases of emergency, are constantly employed.

As we have said, these measures are only partially successful. Water percolates through such artificial embankments. Even if practically waterproof at the outset, the rats and land crabs soon destroy their integrity, and what they commence the action of the tides accelerates, and thus the necessity of constant watchfulness and repair arises. The want of an impenetrable core which should defy the whole tribe of borers, individually or unitedly, has caused the failures in the science of draining which have hitherto marked its progress.

The iron dyke invented by Mr. S. B. Driggs, of New York, seems to put an effectual barrier in the way of these destructive agents. It is constructed by driving iron plates into the soil and joining them end to end, thus presenting an unbroken and impenetrable iron wall, which may be extended to any required length, and the durability of which is unquestionable. If, from causes not taken into account, repairs should ever be needed, the replacing of one of these plates is an operation quickly and easily effected.

We have already said that these dykes are constructed with iron plates driven into the soil. The plates are so constructed and driven as to form a continuous wall. They are of cast iron, as thin and sharp at the bottom as the metal will run. They are made of sufficient width to reach both the high and low water marks, and are pressed or driven into the soil by any convenient power. The weight of workmen transferred by means of an ordinary fence rail, or blows upon the tops with stones, is sufficient in very soft mucky soils, while in stiff soils some superior force might in some cases prove necessary. The plates are so joined to each other as to prevent their overlapping, and the earth forced into the joints renders them sufficiently tight. When the turf is too tough and unyielding to drive these broad plates with facility, it is cut by a process called chiseling. After the plates are driven to a sufficient depth, a large and deep ditch is excavated on the inland side, into which other cross ditches empty. The earth thrown up over the iron wall forms a fine substantial embankment, covering the portion of the iron left exposed in driving. The bank is protected from the action of weather by grass and such creeping plants as have long interlacing roots.

To prevent oxydation, the iron used is refined so little as to be scarcely changed in character from the crude metal. It is well known that refining iron increases its tendency to oxydize, and it is claimed that the iron used for these plates will at least rust so slowly as not to materially affect their durability.

It is claimed that this improvement is applicable not only to dykes, but to banks of canals.

There can be little doubt as to its applicability to the reclamation of the large tracts of waste swamp lands to be found in Mississippi, Louisiana, Arkansas, Missouri, Tennessee, and other parts of the United States. Experience has proved the extraordinary fertility of lands thus reclaimed and the benefit of iron dykes may thus prove to be a boon not only to our own country, but to the world at large.

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**The Royal Insurance Company.**—At the annual meeting of the shareholders of the Royal Insurance Company, which has just taken place, it appeared that in 1867 the fire premiums received amounted to the sum of £460,553 14s., being an increase on the preceding year of £13,282 12s. The losses which accrued in the year 1867 reached the sum of £292,125. The result of the year at the close of the books left on account of the fire business to the credit of profit and loss the sum of £56,373. As regards the Life Department, the fact that new participating assurances will now receive three-fourths of the profits, instead of two-thirds as heretofore, cannot fail to induce a large influx of fresh business from this time forward; but, so far as the past is concerned, it appears that the average annual amount of new sums assured during the three expired years of the present quinquennial period (1865-7) was £801,000, while the annual average amount for the last quinquennial period (1859-64), during which the Company's life business made a most remarkable spring in advance, was yet only about £688,000; whilst in the preceding like period (1854-59) it was only £331,000. The lives declined during the same three years (1865-67), number 1,163, the aggregate sum proposed for assurance thereon being £638,484—a sufficient proof of care in selection. The mortality for the last year has been moderate. The increase of the Life and Annuity Funds in the year 1867, after paying every claim and every expense, reached the sum of £128,583. The total amount of these funds now exceeds one million sterling. The statements contained in this report are so satisfactory that we feel we need not add a single argument further to commend them to the attention of the public.

## NOTES AND NOVELTIES.

### MISCELLANEOUS.

**The** Grand Challenge Yacht Race round the Isle of Wight by the American clipper yacht *Sappho* and the English yachts *Condor*, *Omaira*, *Aline*, and *Cambria*, has resulted in favour of the latter vessel. The yachts left Cowes Roads on the 25th ult at 10 a.m. proceeding eastward on making the Needles passage. They had a fine leading wind up the West Channel, and after a splendid and exciting race between the four English yachts—the American being some ten miles behind—arrived off the Club House the same evening in the following order. *Cambria*, schooner, at 6.17; *Aline*, schooner, at 6.19; *Omaira* cutter, at 6.22; *Condor*, cutter, at 6.25; and the American schooner *Sappho* at 7.55. The *Cambria* is Cowes built, the *Aline* Gosport built, and the *Omaira* and *Condor* Scotch built.

**Ordnance Survey of Mount Sinai.**—Sir Roderick Murchison, Sir John Herschel, and Sir Henry James have consented to act as trustees of a fund which has been set on foot for the purpose of carrying out a survey of the peninsula of Mount Sinai, with a view to determine the line of march of the Israelites and the true Mountain of the Law.

**The China Ocean Race**—By a telegram it seems that four of the China clippers had passed Anger—viz., the *Taeping*, *Ariel*, and *Sir Lancelot*, on the 22d June, and the *Lahloo* on the 23th June. The two former ships left Foo-choo-Foo together on the 28th May, and the *Ariel*, on the day before them, while the *Lahloo* left two days after the two former. The new clipper *Spindrift*, built by Messrs Conuell, Glasgow, which left the day before the *Lahloo*, was not reported from Anger, but probably she has gone outside during the night as some of the ships at times do.

The following characteristic receipt is extracted from the *Mining Press* of San Francisco —**To Clean a Brass Clock.**—*Boil it whole.* The water used should be pure rain-water. Dry on a warm stove to prevent subsequent rusting. This plan saves trouble, and works well when the only trouble is accumulated dirt, or thickened oil.

A **Memorial** to the Lord Chancellor, praying for a remedy for the evils which exist in connection with the patenting of inventions, has been adopted by the Manchester Patent Law Reform Association. It is suggested that commissioners should be appointed to represent mechanical, chemical, and natural science, and the memorialists express a belief that facility of access to the library of the Patent-office, and a moderate supervision would lead to a voluntary abandonment of many patents, or to a revision of the applications for new ones.

Two new branches of industry have been introduced in California—the cultivation of silk and of beetroot sugar. With regard to silk it is alleged that the rank luxuriance of the mulberry plantations in that State, the extraordinary fecundity of the California silkworm, and the superiority of the silk will fully counterbalance the disadvantage of the deficiency of labour as compared with Italy and France; while, as regards beet sugar the reported peculiarities are, that the beet reaches a great size, that it has an unusually heavy proportion of saccharine matter, and that the root grows ten months in the year against seven in France. A company, with a capital of £20,000, has been organized to put up a factory in Sacramento.

### NAVAL ENGINEERING.

**The** shipwrights of Chatham dockyard have completed laying the blocks and ways for the new armour-clad turret ship *Glatton*, which is ordered to be forthwith built at that establishment. The drawings and plans received at Chatham Dockyard from the Admiralty show the *Glatton* to be a vessel of 2,700 tons burden, with a length of 245ft. and a breadth of beam of 49ft. It is, however, in her armour-plating that she will surpass in defensive powers every ship yet constructed, it being intended to plate her with armour twelve inches in thickness along her most exposed parts, while on her turrets the *Glatton* will carry armour of fourteen inches in thickness, laid on a 10in. backing of teak, with the usual inner "skin" plating. Unlike the *Monarch*—the deck of which is encumbered with a topgallant forecastle—the single turret of the *Glatton* will have an all round fire. Her offensive powers also will be very formidable it being intended to arm her with a couple of 25-ton guns. Her engine power will be of 500 horse (nominal).

**The** *Magpie*, 3, twin screw (unarmoured wooden) gun-vessel, 665 tons, 160-horse power, has been put through her final official trial of speed at Portsmouth previous to commission for foreign service. Her machinery has been constructed for the Admiralty by Day and Co., of Southampton, and drives two three-bladed Griffiths's screws, each of 8ft. 6½in. diameter and 12ft. 7in. pitch. In entering upon her trial her draught of water was 8ft. 8in. forward and 10ft. 3in. aft, with 115 tons of coal in her bunkers. Her rig complete, her stores partly so, but no part of her ammunition on board. The wind was from south-east, with the vessel in her runs over the mile to the westward, and, of course, against her on her return. The mean of six runs made with full boiler power gave the vessel a speed of 10·362 knots, and a mean of runs made with half boiler power a speed of 9·259 knots.

### MILITARY ENGINEERING.

A **68-Pounder** cast-iron gun, converted on the principle proposed by Mr. Parsons, by the insertion of a tough steel tube reinforced at the breech end by another steel tube, secured into the gun by a breech screw, underwent a trial on the 17th ult at the proof butt Royal Arsenal, Woolwich, by firing two rounds with charges of 37½lb. of powder and and a shot weighing 150lb., with satisfactory results. The gun, which originally weighed 96 cwt. 1 qr., fired about 400 rounds in its smoothbore state, and was condemmed as unserviceable from fissures in the vent. Its present weight on Parsons' system is 103 cwt. It is further to be tested by firing 1,000 rounds, with charges of 30lb. of powder and a shot of 150lbs.

### LAUNCHES.

**Messrs, Schlesinger, Davis,** and Co., launched from their yard at Wallsend, on the Tyne, the *Keilder Castle*, steamer. She 226ft. 9in. over all, 220ft. between the perpendiculars, 28ft. 6in. breadth, moulded; 18ft. 7in. depth, moulded; 17ft. 9in. depth of hold; is fitted with engines of 100 horse-power nominal, and will carry about 300 tons. She is intended for the Northumberland Steam Shipping Company.

**From** the building yard of Messrs. Henderson, Coulbourn. and Co., Renfrew, a screw-steamer of 500 tons, named the *Horsa*. She is the property of the Aarhuns Steamship Company, intended for their cattle trade between Aarhuus and Scotland, and is fitted with their compound surface condensers.

**Messrs. Caird** and Company, of Greenock, have launched a screw for the North German Lloyd, named the *Rein*. The burden of the *Rein*, which is intended for the Hamburg and American trade, is 3,100 tons, and she will be propelled by engines of 600 horse-power, supplied by the builders.

### TELEGRAPHIC ENGINEERING.

**Telegraphs.**—A special report in connexion with the Electric Telegraphs Bill has just appeared, which includes, among other interesting particulars, a statement showing the mileage of railways under agreement with the telegraph companies, and the number of years which the agreements have to run, as well as the mileage of wires on such railways

A summary of the statement shows there are 1,280 miles of line and 4,226 miles of wire under a term of agreement of from one to five years; 3,938 miles of line and 20,308 of wire under a term of agreement of from six to ten years; 3,211½ miles of line and 13,397 of wire under a term of agreement of from 11 to 20 years; 340½ miles of line and 1,247 of wire under a term of agreement of from 21 to 30 years; and 4,650 miles of line and 1,554 of wire with a term of agreement of from 31 to 99 years—making a total of 13,470 miles of line and 54,744 of wire, under various terms of agreement with the telegraph companies, the average duration of these agreements being 26 2-3 years per mile of line and 25½ years per mile of wire.

The Indo-European Telegraph.—From the report of the progress of this undertaking by the engineer of the company by which the project has been devised. "The whole of the materials of the line in Persia, comprising 11,000 iron posts, 33,400 insulators, and 900 miles of wire of large section, have already been shipped at St. Petersburg, and are in course of being transported on the Neva and the Volga to Astracan, where they will be transhipped again into the steamers of the Caspian designed for the three northern ports of Persia—Lineoran, Astora, and Resht—where they are expected to arrive in the month of September next. Each cargo of stores is accompanied by a trustworthy person to prevent loss and delay; and a staff of working engineers have already left for Persia, *via* Tiflis, to receive them at the ports and convey them, by relays of mules, to their final destination. The Persian Government have given their good offices to facilitate the work. The line of Persia will pass over a high plateau of comparatively level ground, which is cold in winter, fertile, and inhabited by a settled population. It is expected that this portion of the work will be finished in May, 1869. Her Majesty's Government for India have taken advantage of these organised transports by instructing the contracting firms to furnish them with iron posts and insulators of the same description for reconstructing the present lines (between Teheran and Bushire) in a thoroughly substantial manner, agreeing at the same time to add another line of wire, subject to the consent of the Persian Government, for the special accommodation of the Indo-European Telegraph Company. The materials for the remaining portion of the land lines are also in course of manufacture, and several cargoes of iron posts, insulators, and wires, will be despatched to Poti and Kertch in the course of August and September. The lines along the southern slope of the Caucasian range and thence to Tiflis, Tabris, and Djulfa will be constructed during the winter months by a staff of engineers who are now engaged upon soundings in the Black Sea, and who will be recruited by others. The climate in these parts is warm and genial, but the country is intersected by mountain ranges of moderate height. The high range of the Caucasian mountains and the unsettled population of these districts will be avoided by the submarine cable in the Black Sea, which will be nearly 100 nautical miles in length and will contain three well insulated conductors. This cable will not be made before the early spring of next year, to be submerged during the summer of 1869. The materials for constructing the lines from the Caucasian mountains through the Crimea to Odessa will be manufactured and shipped during the winter, and will consist of the heaviest description of iron posts and extra powerful insulators placed at frequent intervals, in order to resist heavy deposits of hoar-frost which occasionally settle upon the telegraph wires in those regions. The lines extended from Balta northward to the Prusso-Russian frontier will pass through vast plains rich in timber, and will therefore be constructed of wooden posts (oak and pine) of extraordinary dimensions, which are sufficiently durable in these northern climates. The timber for these lines will be felled and transported upon sledges to its final destination during the winter months, to be in readiness for the erection of the line during the summer of 1869. Having thus prepared for the active exeution of different sections of their important work the contracting firms entertain a confident hope that they will be able to deliver the whole line in good working order over to the company before the end of next year, which is the time stipulated for its completion in their contract.

## RAILWAYS.

In the new act on the regulation of railways, the following provisions appears:—"All railway companies, except the Metropolitan, shall from and after the 1st of October next in every passenger train where there are more carriages than one of each class, provide smoking compartments for each class of passengers, unless exempted by the Board of Trade." Another clause in the act states that "Every company shall provide and maintain in good working order in every train working by it which carries passengers and travels more than twenty miles without stopping such efficient means of communication between the passengers and the servants of the company in charge of the train as the Board of Trade may approve. If any company makes default in complying with this section it shall be liable to a penalty not exceeding £10 for each case of default. Any passenger who makes use of the means of communication without reasonable and sufficient cause shall be liable for each offence to a penalty not exceeding £5."

It has been arranged that on the 1st of this month the train services of the Mont Cenis Railway shall be in direct correspondence with the French and Italian railways. Through booking will also commence at the same date. The entire time occupied between Paris and Florence will be reduced to 30 hours, and the letters will be delivered a day earlier in Florence.

The piercing of the tunnel through Mont-Cenis continues to advance satisfactorily On the 1st June 8,344 metres had been completed. During that month 60 metres additional have been finished on the southern side, and 54 on the northern, making a total of 8,498 out of the whole lenth of 12,220, leaving 3,722 metres yet to be executed.

The London, Brighton, and South Coast Company's direct line from Brighton to Tunbridge Wells was opened on the 3rd ult. for public traffic. The opening of this line shortens the distance between these two places by about 15 miles. The surrounding scenery is interesting, and a prominent feature in the line is a viaduct between Rotherfield and Buxted, about 75ft. high, having eleven spans, crossing a beautiful valley. The stations are Brighton, Falmer, Barcombe, Isfield, Uckfield, Buxted, Rotherfield, Eridge, Groombridge, and Tunbridge Wells.

## ACCIDENTS.

Boiler Explosion—Two Men Killed and Several Injured.—On the 8th. ult, a painful accident occurred near to the Hill of Fearn, in the county of Ross. The cause of the accident was the bursting of the boiler of an engine attached to a portable thrashing-machine. The engine had been converted into a locomotive for conveying the machine from place to place, and the explosion occurred while the engine was on its way from the Hill of Fearn to the parish of Tarbat. Six men accompanied the machine and it had only proceeded about two miles when the explosion took place. The owner, William Telford, was thrown off the engine a distance of some yards, his body being frightfully mangled. Duncan Ross was pitched into a neighbouring field. In both cases death must have been instantaneous. The other men were all more or less injured, and as regards two of them their recovery is considered doubtful.

## DOCKS, HARBOURS, BRIDGES.

The cables for the new suspension bridge at Niagara Falls have been completed, and are being stretched across the river and placed upon the towers. It is expected that the bridge will be opened to the public about the 15th of October.

## LATEST PRICES IN THE LONDON METAL MARKET.

| | From | | | To | | |
|---|---|---|---|---|---|---|
| | £ | s. | d. | £ | s. | d. |
| COPPER. | | | | | | |
| Best selected, per ton | 76 | 0 | 0 | 77 | 0 | 0 |
| Tough cake and tile do. | 73 | 0 | 0 | 75 | 0 | 0 |
| Sheathing and sheets do. | 78 | 0 | 0 | 80 | 0 | 0 |
| Bolts do. | 80 | 0 | 0 | ,, | ,, | ,, |
| Bottoms do. | 83 | 0 | 0 | 84 | 0 | 0 |
| Old (exchange) do. | 68 | 0 | 0 | 70 | 0 | 0 |
| Burra Burra do. | 80 | 0 | 0 | ,, | ,, | ,, |
| Wire, per lb. | 0 | 1 | 10½ | ,, | ,, | ,, |
| Tubes do. | 0 | 0 | 11½ | ,, | ,, | ,, |
| BRASS. | | | | | | |
| Sheets, per lb. | 0 | 0 | 7¾ | 0 | 0 | 8¼ |
| Wire do. | 0 | 0 | 8¼ | ,, | ,, | ,, |
| Tubes do. | 0 | 0 | 10¼ | ,, | ,, | ,, |
| Yellow metal sheath do. | 0 | 0 | 6¾ | 0 | 0 | 7 |
| Sheets do. | 0 | 0 | 6¾ | 0 | 0 | 7 |
| SPELTER. | | | | | | |
| Foreign on the spot, per ton | 20 | 2 | 6 | ,, | ,, | ,, |
| Do. to arrive | 20 | 2 | 6 | ,, | ,, | ,, |
| ZINC. | | | | | | |
| In sheets, per ton | 24 | 10 | 0 | 25 | 0 | 0 |
| TIN. | | | | | | |
| English blocks, per ton | 96 | 0 | 0 | ,, | ,, | ,, |
| Do. bars (in barrels) do. | 97 | 0 | 0 | ,, | ,, | ,, |
| Do. refined do. | 98 | 0 | 0 | ,, | ,, | ,, |
| Banca do. | 94 | 0 | 0 | ,, | ,, | ,, |
| Straits do. | 93 | 0 | 0 | ,, | ,, | ,, |
| TIN PLATES.* | | | | | | |
| IC. charcoal, 1st quality, per box | 1 | 5 | 6 | 1 | 8 | 6 |
| IX. do. 1st quality do. | 1 | 11 | 6 | 1 | 14 | 6 |
| IC. do. 2nd quality do. | 1 | 4 | 6 | 1 | 5 | 6 |
| IX. do. 2nd quality do. | 1 | 10 | 6 | 1 | 11 | 6 |
| IC. Coke do. | 1 | 2 | 6 | 1 | 3 | 0 |
| IX. do. do | 1 | 8 | 6 | 1 | 9 | 0 |
| Canada plates, per ton | 13 | 10 | 0 | ,, | ,, | ,, |
| Do. at works do. | 12 | 10 | 0 | ,, | ,, | ,, |
| IRON. | | | | | | |
| Bars, Welsh, in London, per ton | 6 | 7 | 6 | ,, | ,, | ,, |
| Do. to arrive do. | 6 | 5 | 0 | ,, | ,, | ,, |
| Nail rods do. | 6 | 15 | 0 | 7 | 0 | 0 |
| Stafford in London do. | 7 | 10 | 6 | 8 | 10 | 0 |
| Bars do. do. | 7 | 5 | 0 | 9 | 10 | 0 |
| Hoops do. do. | 8 | 2 | 6 | 9 | 15 | 0 |
| Sheets, single, do. | 9 | 0 | 0 | 11 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 5 | 12 | 6 | 5 | 15 | 0 |
| Do. mrch. Tyne or Tees do. | 6 | 10 | 0 | ,, | ,, | ,, |
| Do. railway, in Wales, do. | 5 | 17 | 6 | 6 | 0 | 0 |
| Do. Swedish in London do. | 9 | 17 | 6 | 10 | 2 | 6 |
| To arrive do. | 10 | 0 | 0 | 10 | 2 | 6 |
| Pig No. 1 in Clyde do. | 2 | 13 | 0 | 2 | 17 | 3 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | ,, | ,, | ,, |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 7 | 0 | 0 | 7 | 10 | 0 |
| STEEL. | | | | | | |
| Swedish in kegs (rolled), per ton | 14 | 5 | 0 | ,, | ,, | ,, |
| Do. (hammered) do. | 14 | 15 | 0 | 15 | 0 | 0 |
| Do. in faggots do. | 16 | 0 | 0 | ,, | ,, | ,, |
| English spring do. | 17 | 0 | 0 | 23 | 0 | 0 |
| Quicksilver, per bottle | 6 | 17 | 0 | ,, | ,, | ,, |
| LEAD. | | | | | | |
| English pig, common, per ton | 18 | 17 | 6 | ,, | ,, | ,, |
| Ditto. L.B. do. | 19 | 0 | 0 | ,, | ,, | ,, |
| Do. W.B. do. | 21 | 5 | 0 | ,, | ,, | ,, |
| Do. sheet, do. | 19 | 17 | 6 | 20 | 5 | 0 |
| Do. red lead do. | 20 | 0 | 0 | 20 | 10 | 0 |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 10 | 0 | ,, | ,, | ,, |
| Spanish do. | 18 | 5 | 0 | 18 | 10 | 0 |

* At the works 1s. to 1s. 6d. per box less.

## 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 July 23rd, 1868.

2310 J. Bowron and G. Lunge—Manufacture of iron and steel
2311 A. Buchan—Ploughs
2312 E. T. Hughes—Treating flax
2318 W. Gilbert—Lockets
2314 P. Pearson—Treatment and preparation of cocoa
2315 T. Hart—Manufacture of banding cords from cotton, &c.
2316 F. Horner—Application of copper to the surfaces of inferior metals
2317 W. S. Harrison—Clocks, &c.
2318 M. T. Shaw and T. H. Head—Hydraulic apparatus
2319 J. Purdey—Firearms
2320 C. E. Brooman—Rotary steam engines
2321 J. Kilner—Manufacturing glass
2322 J. S Bromhead and J. Whitmee—Dry gas regulators

### Dated July 24th, 1868.

2323 A. Bochkoltz—Valves
2324 R. G. Hatfield—Door rollers, &c.
2325 F. H. Danchell—Utilising fuel
2326 N. Barnaby—Sheathing iron or steel ships with zinc, &c.
2327 W. R. Lake—Teeth for machines for picking cotton wool
2328 G. Smith—Obtaining rotary motion
2329 G. A. Thibierge—Preserving animal and vegetable substances
2330 R. Young—Dressing millstones
2331 T. Wrigley and W. E. Yates—Looms for weaving
2332 W. E. Gedge—Feeding steam boilers
2333 B. G George—Bronzing printed work
2334 J. H. Johnson—Cast iron, &c.

### Dated July 25th, 1868.

2335 C. Ritchie—Portable head dress
2336 J. Young, R. Pollock, and J. Morrison—Apparatus for preventing smoke
2337 J. Steel—Cask washing apparatus
2338 J. Greenhalgh—Opening cotton, &c.
2339 C. E. Brooman—Drying filamentous matters, tissues, &c.
2340 C. D. Abel—Separating the zinc from the argentiferous alloys, &c.
2341 J. Brigham and R. Bickerton—Drill rollers
2342 A. V. Newton—Portable railway
2343 L. Wray—Separating metals from their ores, matrices, &c.
2344 R. Newton—Opening fibres
2345 A. C. M. Prince—Bell pull
2346 W. R. Lake—Steam boilers
2347 A. M. Clark—Steering steam vessels

### Dated July 27th, 1868.

2348 A. J. Thorman—Obtaining and applying motive power
2349 J. A. Hogg—Improved lamp
2350 G. R. V. Loughton and E. B. Jackson—Bosses for flax spinning
2351 J. Higgin—Printing textile fabrics, &c.
2352 J. Lewis—Increasing heat
2353 C. J. Laureodeau—Life preserving apparatus
2354 H. A. Dufrene—Indicator of time and distance for vehicles
2355 A. V. Newton—Propeller for steam vessels
2356 F. Lambe, A. C Sterry, and J. Fordred—Treating oils, &c.
2357 A. M. Clark—Artificial ice

### Dated July 28th, 1868.

2358 C. A. McCurd—Sewing machines
2359 W. F. M. Green—Loading of muzzle loading big guns
2360 W. Lewis—Needle wrappers
2361 H. Watts—Rails for railways
2362 E. S. T. Steane—Soap
2363 T. Hydes—Facilitating the transit and application of caloric, &c.
2364 J. Webster—Manufacture of gas, &c.
2365 G. Hodgson, H. Bottomley, and E. Cockroft—Looms for weaving
2366 J. Bullough—Looms for weaving
2367 C. A. La Mont—Preparation of eggs
2368 W. R. Lake—Improvements in glue, &c.
2369 S. M. Martin and S. A. Varley—Train intercommunication, &c.
2370 A. Morrall—Needles

### Dated July 29th, 1868.

2371 J. Onions—Means employed to ascertain the number of passengers, &c., received by omnibus conductors
2372 J. Simpson—Moulding toothed wheels
2373 F. Winser—Manufacture of sulphate of magnesia, &c.
2374 J. Mabson—Cinder sifter
2375 E. Herring—Treatment of saccharine solutions, &c.
2376 W. R. Lake—Compound to be used as a substitute for linseed oil
2377 W. R. Lake—Breech loading firearms
2378 W. R Lake—Sawing machines
2379 A. V. Newton—Cutting and polishing powder
2380 J. R. Harper—Strips of zinc, &c.
2381 J. Radcliffe—Apparatus employed in the manufacture of iron, &c.
2382 H. O. Robinson—Dredger
2383 S C. Lister—Cut pile fabrics
2384 J. Jeffreys—Preserving animal and vegetable substances

### Dated July 30th, 1868.

2385 J. Wolstenholme—Valves
2386 G Woodhouse and J. G. McMinnies—Construction of mills
2387 A. Watkins—Watches
2388 C. H. Roeckner—Manufacture of paper
2389 S. C. Lister—Silk velvets
2390 T. H. Roberts and B. C. Cross—Retarding carriages
2391 G. Davies—Obtaining heliographic plates for printing
2392 G. Davies—Pile or battery for generating electricity
2393 J. Duguid—Dressing flour
2394 J. Rawsthorn—Dressing millstones
2385 J. H. Johnson—Flame spreader
2396 T. Prosser—Distillation
2397 J. C. Haddon, Cannon, &c.
2398 J. Gwynne and H. A. Gwynne—Employing centrifugal pumps, &c.
2399 T. C. Fidler—Rolling stock of railways
2400 C. D. Fox—Repairing railway rails, &c.

### Dated July 31st, 1868.

2401 W. T. Royle—Folding paper, &c.
2402 F. A. Le gh—Carding engines
2403 J. Ratcliffe—Increasing the motive power of steam engines
2404 A. G. Day—Artificial compound
2405 J. F. Lackersteen—Preservation of organic substances
2406 P. N. J. Macabiss—Water feeding apparatus for boilers
2407 B. Sharpe—Construction of ships, &c.
2408 G. D. Kittoe and B. Brotherhood—Cooling, &c., liquids
2409 H. Moule—Fireplaces
2410 R. E. Drinhaus—Instrument to be used in the treatment of rheumatism
2411 W. W. Symington—Cutting up loaf sugar
2412 A. F. Leale—Preventing incrustation in steam boilers
2413 H. Moritz and J. Reinach—File planing machine
2414 H. Moritz and J. Reinach—File cutting machine
2415 G. Harvey—Holding cravat bows, &c.
2416 A. Taylor—Fastenings for brooches
2417 J. Heaton—Treatment of cast iron
2418 J. Heaton—Production of steel
2419 T. Hunt—Breech loading firearms

### Dated August 1st, 1868.

2420 J. E. Outridge—Slide valves
2421 C. J. L. Nicholson—Closing apertures to meat, vegetables, &c
2422 J. A. McKean—Metallic eyelets
2423 M. Samuelson—Hydraulic press boxes
2424 M. Wilkin and J. Clark—Improvements in steam boilers
2425 A. Arnold—Fastening for buttons, &c.
2426 C. J. Geoghegan—Self acting regulators
2427 G. Wilson—Ships' logs
2428 J. Scott—Food for horses, &c.
2429 H. O. Robinson—Dredging machines
2430 S. Plimsoll—Facilitating the unloading of coals
2431 J. R. Croskey—Looms
2432 L. C. Bailey—Drawing pens
2433 G. N. Shore—Railway brakes, &c.
2434 G. T. Bousfield—Bindings for skirts

### Dated August 3rd, 1868.

2435 S. R. Renaudin—Offensive and defensive war machine
2436 H. W. Garrett and G. Holcroft—Firearms and ordnance
2437 C. Wilson—Reefing sails
2438 T. Ward—Desks

### Dated August 4th, 1868.

2439 W. Spence—Treatment of ores
2440 H. A. Bonneville—Preserving meat
2441 H. A. Bonneville—Process of dyeing textile fabrics, &c.
2442 A. L. Hoffman—Yards for carrying ships' square sails
2443 R. Schomburg—Bricks, &c.
2444 B. J. B. Mills—Harvesting machines
2445 C. F. C. Cretin—Lamps
2446 E. Evans—Mills for grinding wheat, &c.
2437 J. Frazer and W. Naar—Mattresses and camp beds
2448 A. V. Newton—Boot sewing machinery
2449 F. W. Kitson and P. Chalis—Friction clutches for driving shafts
2450 C. G. Johnson—Making bricks, &c.

### Dated August 5th, 1868.

2451 J. Hamilton—Artificial fuel
2452 T. R. Oswald—Ships of war
2453 A. V. Newton—Manufacture of iron and steel
2454 N. D. Spartali—Propelling vessels

### Dated August 6th, 1868.

2455 W. Millard—Looms
2456 H. Churchman—Cleaning boots
2457 E. Edwards—Pumps
2458 M. Benson—Low water indicators and safety valves
2459 L. Price—Improvements in spring slides for candlesticks
2460 W. Pearson, W. Spurr, and H. Bradbury—Looms
2461 J. Hargreaves—Improvements in the manufacture of steel, &c.
2462 H. F. Freutal—Manufacture of hats and caps, &c.
2463 A. M. Clark—Scissors
2464 W. Hann and E. M. Hann—Improvements in safety lamps
2465 W. R. Lake—Felted fabrics
2465 A. V. Newton—Manufacture of boots and shoes
2467 W. M. Moore—Invoice holders

### Dated August 7th, 1868.

2468 T. W. Stapleton—Improvements in breech loading firearms
2469 C. J. Curtis and A. Fiddes—Safes and strong rooms
2470 G. W. Maddick—Improvements in forks and spoons
2471 B. Hunt—India rubber fabrics
2472 J. Whitehead—Dandy rollers used in the manufacture of paper
2473 N. Salmon—Sewing machines
2474 H. Benjamin—Washing machine
2475 J. Litchfield—Manufacture of lace fabrics
2576 W. E. Newton—Regulating the speed of machinery
2477 G. Leach—Machinery for carding wool and other fibrous substances, &c.
2478 W. E. Newton—Firearms
2479 J. Arnold—Improvements in the construction of steam boilers

### Dated August 8th, 1868

2480 S. Gardner—Improved annealing pot and stand
2481 J. Broadfoot—Waterclosets
2482 A. Hunt—Blind furniture
2483 J. Kirk and J. Batstone—Shield for protecting fortifications
2484 J Standen—Multitubular boilers
2485 A. V. Newton—Construction of steam engine governor
2486 W. E. Newton—Screws, &c.
2487 D. Nickols—Cocks or taps
2488 H Duhs—Steam crane and locomotive engine combined
2489 F. Walton—Treatment of resins or resinous gums, &c.
2490 J. Hird—Obtaining and applying motive power

### Dated August 10th, 1868.

2491 T. Kenyon—Sulphuric acid
2492 F Le Roy—Non-conducting composition for preventing radiation of heat, &c.
2493 T. Corfield—Self-sealing paper bags
2494 B. Hunt—An improved machine for making eyelets
2495 B. Hellwagg—Telegraphing on board of steam ships
2496 W. W. Hughes—Fans for forcing or drawing air
2497 A. V. Newton—Automatic indicators for steam boilers
2498 D. F. Fruwirth and A. Hawkins—Producing raised printing surfaces.

### Dated August 11th, 1868.

2499 R. Robinson—Apparatus for regulating and for varying speed.
2500 W. H. Hunt—Baskets.
2501 J. Brown—Rolling iron, &c.
2502 A. M. Clark—Propelling vessels.
2503 J. Salmon—Improvements in Printing Machinery.
2504 H. Moore T. Moore, and G. Moore—Window cornices, poles, &c.
2505 M. Gray—Apparatus for manufacturing telegraphic wires.
2506 J. H. Johnson—Improvements in permanent way of railways.
2507 A. Argamakoff—Printing surfaces.
2508 J. McFarlane—Rollers for paper-making machines.
2509 J. R. Croskey—Improvents in looms for weaving.

### Dated August 12th, 1868.

2510 E. P. G. Headly—Apparatus for watering streets, &c.
2511 D. Hill, J. Richardson, G. N. Duck, C. G. Johnson, and W. F. Musterman—Manufacture of iron and steel.
2512 J. Winsborrow—Measuring water and other liquids.
2513 J. T. Pendlebury and T. Pendlebury—Valve motion
2514 J. Thompson—Utilizing scrap homogeneous iron or steel.
2515 J. Broad—Treatment of carboniferous plants for the manfacture of paper.
2516 H. H. Henson—Improvements in metallic ropes.
2517 C. D. J. Seitz—Recovery of the soda from the waste lyes.
2518 J. Wilson—Outside blinds, or sun shades for windows.
2519 R. H. Southall and W. Hallam—Protecting side-springs of elastic boots.
2623 H. Dewhurst, J. W. Dewhurst, and R. E. Dewhurst—Ornamenting seal-skin cloths.
2521. H. Lunn—Improvements in postal sample bags.
2522 J. Cleaver—Ornamenting bobbin net lace and other fabrics.
2523 R. C. Rapier—Electric clocks.
2524 H. B. Walker—Extracting burs from wool.
2525 W. Payne—Steam cocks or valves, applicable for hot or cold water.
2526 G. A. Buchholz—Improved machinery for hulling grain.
2527 J. Petrie—Apparatus for washing wool.
2528 W. E Newton—Photographic frames.
2529 R. Sim—Preventing the fouling of ships' bottoms.

### Dated August 13th, 1868.

2530 F. Barnett—Apparatus for swimming
2531 W. Thorold—Railways, and rolling stock therefor
2532 R. Saunders—Anchors
2533 J Grant—Turning over the leaves of music books
2534 I. M. Milbank—Breech-loading fire arms and cartridges
2525 B. Ingham—Dyeing warps of worsted, cotton, silk, &c.
2536 H. Steffanson and J. Hadley—Machinery for decorticating grain
2537 J. Holding—Healds or harness in looms for weaving
2538 S C. Lister—Combing wool, &c.
2539 T. R. Crampton—Grinding coal
2540 H. K. York—Treatment of cast iron and other metals

### Dated August 14th 1868.

2541 H. B. Binko—Treament of indigo
2542 W Shaen—Improvements in explosive compounds
2543 C. Evotte—Turning, dividing, and cutting wooden cogs
2544 G. Nelson—Disinfecting clothing, &c.
2545 J. B. Thompson—Coating iron and steel with gold, silver, and copper
2546 W. E. Newton—Combing silk, &c.

### Dated August 15th, 1868.

2547 J. Mcintosh—Improvements in submarine telegraphy
2548 C. D Abel—Brown colouring matter for dyeing and printing
2549 J. Fletcher sen., J. Fletcher jun., and W. Fletcher—Grinding
2550—J. Hickisson—Pencil for markig linen
2551 R. Robinson and G. D. Edmeston—Lathes
2552 A. J. Leak and E. Leak—Apparatus for manufacturing pottery.
2553 H. Reissmann—Apparatus for dispersing or throwing liquids
2554 H. Y. D. Scott—Pottery and other kilns
2555 C. Mohr and S. E. Smith—Cages, baskets, and guards
2556 A. M. Clark—Improvements in the manufacture of size
2557 J. H Dearle—Tents.
2558 W. B. Espeut—Curing, drying, and extracting molasses from sugar

### Dated August 17th, 1868.

2559 W. J. Hinde—Holding candles in the sockets of candlesticks
2560 A. Smith—Improvements in the manufacture of sugar
2561 E Beanes—Brewers' finings
2562 B. Hunt—Decomposing the sulphurets of iron in ores, coal, &c.
2563 B. P. Stockman—Water meters
2564 W. E. Newton—Fog alarm to produce audible signals
2565 J. Palmer—Elliptic springs for carriages and other vehicles
2566 W. Edwards—Improvements in sewing machine needles
2567 J. H. Johnson—Cleaning grain
2568 G. F. Bradbury and T. Chadwick—Sewing machines
2569 W. Corbitt—Decorating the surfaces of stoves, fenders, &c.
2570 C. J. Simpson, W Simpson, A. Simpson, and F. Simpson—Sizing and drying yarns for weaving
2571 A. Albini and J. Vaglica—Electro-magnets
2572 H. J. Behrens and E. Dart—Improvements in rotative engines
2573 J Phillips—Stoves and fireplaces.

### Dated August 18th, 1868.

2574 J. Briggs—Cutting shives, bungs, corks, splices, and vent pegs
2575 J G. Tongue—Mills for grinding
2576 D. G. Fitz-Gerald—Electric telegraphs and voltaic batteries.
2577 J. S. Starnes—Ships' signal lamps
2578 P. R. Hodge and W. Hodge—Black or brown pigments in the manufacture of paints or printing ink
2579 D. Fraser—Softening, preparing, and spinning flax
2580 J. Landless—Boilers
2581 E. Ledger—Motive and mechanical hydraulic power
2582 L. Gay—Washing wool, &c.
2583 W. Tomson—Expanding and cutting tubes and metallic rings

### Dated August 19th, 1868.

2584 E. Deane—Stove and cooking apparatus
2585 J. Neumann—Generating and purifying coal lighting gas
2586 J. H. Atterbury—Machinery for the manufacture of earthenware
2587 J. Norbury and J. Shaw—Force pumps in connection with hydraulic presses
2588 F. Brady—Utilizing waste sulphate of iron solution
2589 A. Clark—Tanning leather
2590 W. H. Davey—Drying linen, &c.
2591 J. Heaton—Rails for the permanent way of railways

### Dated August 20th, 1868.

2592 T. R. Shaw—Oil testers
2593 W. J. Almond—Preparing threads of cotton, silk, wool, &c.
2594 J. Sawyer—Hanging window sashes
2595 G. Calkin—Facilitating study of pianoforte.
2596 H. N. Waters—Feed water heaters for steam generators
2597 P. Robertson—Breaks for railway purposes.
2598 A. Rollason—Purifying coal gas
2599 H. Hughes—Sewing machines
2600 H. C. Rusell—Smelting copper
2601 A. V. Newton—Rotary engines.

# AMERICAN DEAD STROKE POWER HAMMER.

MANUFACTURED BY W. COLLIER & Co

SALFORD.

FIG. 1.

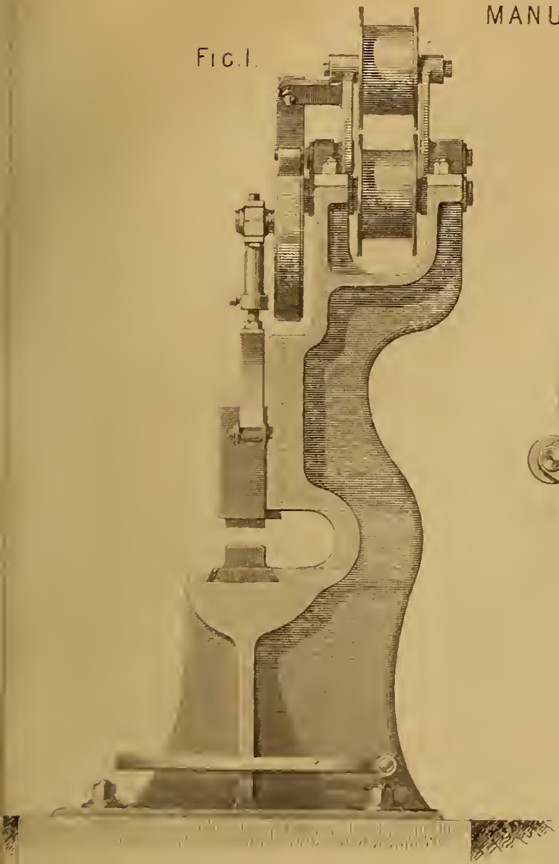


FIG. 5.

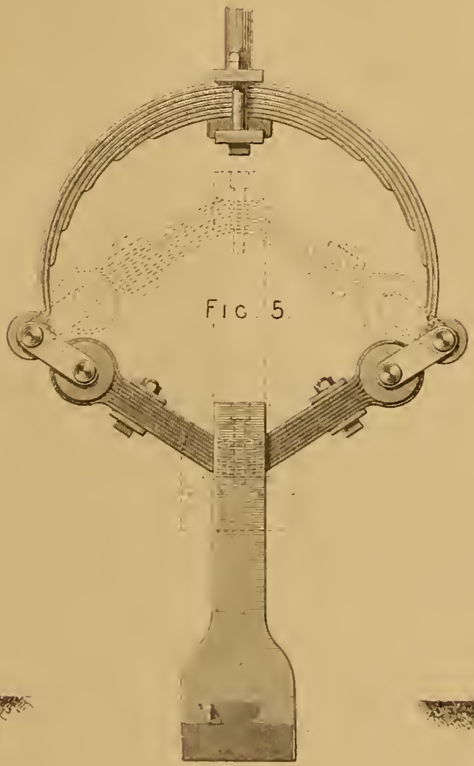


FIG. 2.

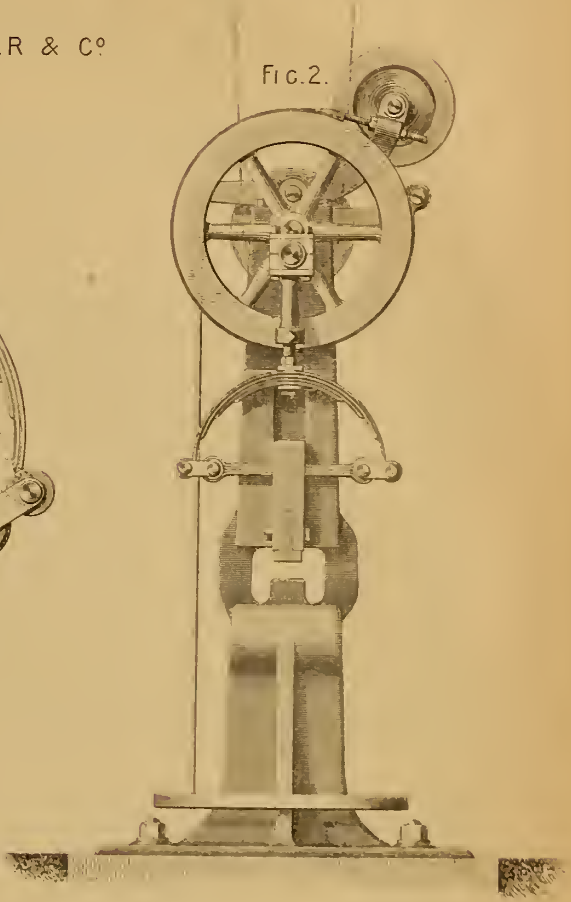


FIG. 3.

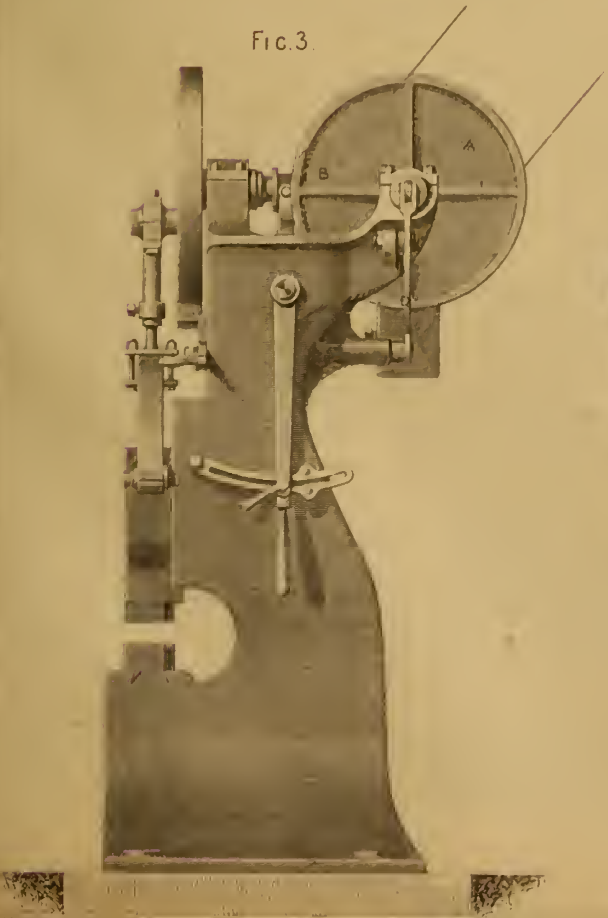


FIG. 6

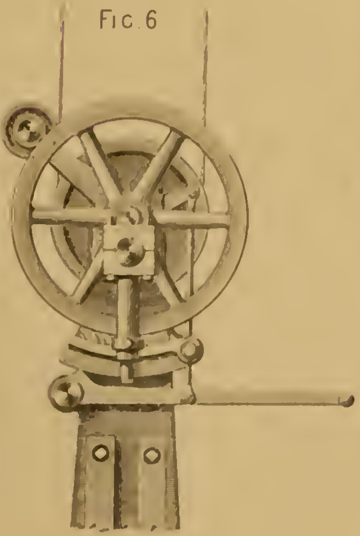
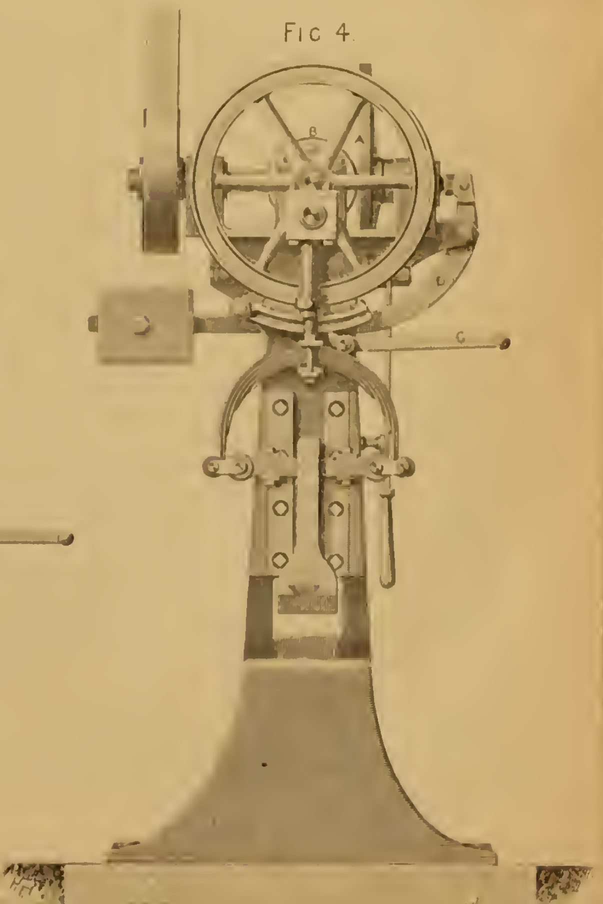


FIG. 4.



# THE ARTIZAN.

No. 10.—Vol. II.—Fourth Series.—Vol. XXVI. From the Commencement.

1st. OCTOBER, 1868.

## SHAW AND JUSTICE'S DEAD STROKE POWER HAMMER.

Manufactured by W. Collier and Co., Salford, Manchester.

(*Illustrated by Plate* 337).

This peculiar looking hammer which, like so many other useful labour-saving machines, is of American origin, was designed to meet the great want so often felt in engine shops, of a handy power hammer that can be driven by a strap from a line of shafting, and at the same time be capable of varying both the strength and rapidity of the blows. The old helve and tilt hammers are of but little use for general smithwork, as the speed and strength of blow are always uniform; they have consequently given way either to steam or atmospheric hammers. Both of these arrangements, however, have their disadvantages; thus, in the case of the steam hammer, it is not always advisable to use it, from the situation being too far from a steam boiler, while the other description of hammers usually absorb too much power. It is claimed for this hammer that the power required to drive it is very small in comparison with the force of the blow, this fact being accounted for almost entirely by the peculiar action of the semi-circular spring.

In Plate 337, two modifications of Messrs. Shaw and Justice's hammer are shown, Figs. 1 and 2 being a side and front elevation respectively of the arrangement most commonly used in America, while Figs. 3 and 4 are similar views, but showing a somewhat different arrangement of driving gear which has more recently been adapted. In this latter arrangement the machine is driven by means of a strap (shown broken off in Figs. 3 and 4), from any convenient line of shafting, or counter-shaft, and upon the spindle of the driving pulley is fitted a circular friction disc (A), turned true on its face, and supported by brackets formed on the main casting of the hammer. This spindle is capable of being moved in a lateral direction, and by this means the hammer is started or stopped by pressing the disc (A) against the periphery of the friction pulley (B), which is fitted by means of a sliding feather to the crank shaft of the hammer. The connecting rod is made in two parts, or telescopic, the lower part sliding in the upper and fixed to any desired length by a set screw. The lower part of the connecting rod is attached to a spring by cramps, plates and bolts. This spring, which is the principal feature in the hammer, is of semi-circular form, and consists of a number of steel springs put together in the same manner as a coach spring. The ends of the outside, or upper plate, projecting a little below the other plates of the spring, are formed in the shape of a hook and fitted with brass bushes, through which a pin passes. A strong leather strap which passes through a slot in the tup is connected at each end to these pins by means of links. The tup, which is of Bessemer steel, has a dove-tailed slot in the bottom, so that different shapes of swages or dies may be introduced.

The speed of the hammer may be varied to any desired extent by means of a lever, one end of which has jaws working in a groove turned in the boss of the friction pulley B, and having near the other end a sliding block working in a quadrant, and which may be fixed in any required position. Thus, by bringing the friction pulley B nearer to, or taking it farther from, the centre of the disc A, the maximum speed of the hammer is lessened or increased, as desired.

A very ingenious arrangement is adopted for starting, stopping, or varying the speed of the hammer and, consequently, the strength of blow, while running. A lever (C) is placed in a convenient position towards the front of the hammer, having a short arm or cam, which bears against the break acting upon a fly wheel turned on its outer edge, and keyed on the crank shaft. Upon reference to Fig. 4, it will be seen that when the lever (C) is depressed it presses the break against the fly-wheel, and of course stops the machine. This lever (C) is also keyed on a spindle running through the framing of the hammer, so that when the lever is moved this spindle revolves. At the end of this spindle is fitted a cam, which acts against the bent lever D. The upper end of this bent lever (D) is furnished with a steel pin, which presses against the driving shaft and keeps the friction disc A against the pulley B; the other end of the lever being suitably weighted for the purpose. When, however, the machine is to be stopped the lever C is depressed and the spindle fitted with the cam, as before-mentioned, turns with it, elevating the weighted end of the lever D, which thus allows the face of the disc A to recede from the pulley B. In order to regulate the speed and strength of the blows while the hammer is in action, it is only necessary to regulate the pressure of the hand upon the handle of the lever C, so as to allow any desired amount of slip between the disc (A) and the pulley (B). It will thus be seen that the action of only one lever (C) is necessary for stopping, starting, or varying the strength of the blow of the hammer.

Another method of varying the speed and blow has been extensively used in America, and is shown in Fig. 6. In this case it is necessary that the driving pulley should be immediately over that on the hammer, making it sometimes compulsory to employ a countershaft. The driving pulley is made with a flange on each side, to guide the strap, which is left so long and slack that when the hammer is not in motion it runs loosely between the flanges, without touching the body of the pulley. The same break motion and stopping and starting lever are employed as previously described, but instead of friction pulleys, and the weighted lever and cam motion, a lever is fixed on the back of the frame, carrying a jockey or pressure pulley; when this lever is lowered, it relieves the cam from the break, and presses the jockey pulley against the strap, thus tightening it upon the driving pulley, and setting the hammer in motion; the pressure put upon the strap by the jockey pulley regulating the speed of the hammer by allowing the strap to slip when running slowly, and tightening it as the speed is to be increased.

A somewhat similar action, also extensively used in America, is shown in Figs. 1 and 2, but in this case the hand lever is dispensed with, and a treddle is substituted instead. This is a very handy arrangement for small work, leaving the hands of the smith free to manipulate the forging.

As was remarked above the great peculiarity of this hammer is the action of the spring. When the hammer is at rest, and the crank pin on the bottom centre, it will be observed from Figs. 1, 2, 3, and 4 that the face of the upper hammer does not touch the anvil block. When the hammer is running, the moment the crank pin passes the bottom centre it plucks, or snatches at the tup, through the spring and leather band, but the tup being in a state of rest cannot necessarily be so suddenly raised as it would were it directly attached by a connecting-rod to the crank pin. But the spring giving way, as shown in Fig. 5, it moves slowly at first, and gradually increases its upward speed by the combined action of the spring and crank pin, the former of which is endeavouring to stretch or pull the leather band in a straight line.

By the time the crank pin has arrived at the top centre, the spring has extended itself; but the tup have gathered so much impetus declines to stop, and still going upwards, it is met by the downward action of the crank pin, which again collapses the spring, when the tup, assisted by the spring, crank pin, and its own weight, comes down with great force. The tup, when going at full speed, traverses about double the throw of the crank.

In consequence of the spring being placed between the crank pin and the hammer, the weight comes gently upon the crank pin, causing very little strain. The connecting rod being in two parts (through which all the strain passes) is held together by only one steel screw.

The weight of the blow is entirely dependent on the speed at which the hammer runs, striking a light blow upon when running slowly, and a heavy one when running quickly.

The following are some of the advantages claimed for this hammer:—

It can be fixed in any desired situation wherever there is a driving shaft, and is independent of boilers.

It takes less powor than any other; in fact it is said that the same amount of steam which it takes to work a steam hammer would drive, by means of an engine, at least three of these hammers, each doing the same amount of work.

It has very few working parts, is not at all liable to get out of order, and the cost in repairs is merely nominal.

There are no cylinder, valve rods, or joints, no packing required, or any attention after working hours; the bearings are brass, and made very long. It is so simple to work and easy to control that no instructions are necessary, and any boy in the smithy can manage it.

It is self-contained, and requires but little foundation. For tilting steel, it will be found an excellent substitute for ordinary tilt hammers with wooden shafts, which are constantly breaking. In this case it may be further simplified by being driven by a pair of cone pulleys, and thrown out of gear by means of a clutch box, or friction clutch. By driving it this way, the speed can be varied according to the size of steel required to be tilted, and the hammer would run at a regular speed while at work.

## MEETING OF THE BRITISH ASSOCIATION AT NORWICH.

### THE REGULATIONS AFFECTING THE SAFETY OF MERCHANT SHIPS AND THEIR PASSENGERS.

The Committee appointed to report on "The Regulations affecting the safety of Merchant ships and their Passengers" report as follows:—

"As far as the committee has been able to pursue its enquiry it appears that no legal regulations are in force in Great Britain affecting the loading of merchant ships; but there are regulations in force by the Board of Trade, relating simply to vessels carrying passengers or emigrants, and these only relating to space or sanitary condition of such passengers, totally ignoring their safety as far as the stowage of cargo or deck loads are concerned, the matter on which this committee has to report.

"The following particulars have been chiefly gathered from nautical men belonging to the port of Hull, who possess a thorough practical knowledge on these matters.

"Referring to ships employed on long voyages or the foreign trade from India bound to Europe it appears to be an established custom that they shall have three inches clear side for every foot of immersion—that this regulation has been closely observed for several years, and therefore no objection can be offered to its adoption in Great Britain. It is, however, considered that looking to the nature of the cargoes in the Baltic trade that two and a half inches would be sufficient. In order to carry out effectively any such regulations, some precise agreement should be entered into with all the great maritime powers, and that the deep draught of any vessel should be distinctly indicated by a fixed and clearly defined mark, such as a painted white ribbon extending about six feet on such side of the stem as well as stern post (not in midship) and so distinctly scribed in wooden, and cut into in iron ships, that it could not be tampered with; and when a ship is loaded by the stern an average should not be taken, but when so loaded the load line there marked should not be immersed. The load line should not, as regards safety or capacity for cargo, be measured from the ship's draught or depth of keel, but from the upper side of the kelson, carried parallel fore and aft.

"But as the safety of ships laden to such marks is not dependent on the weight of cargo alone, but upon the stowage of *dead weights*, it has been suggested that every ship's hold should be divided into compartments, and the tonnage which each compartment should properly contain (especially the extremes or fore and aft sections, where no dead weights should be permitted, such as coal, iron, or cargo which could not immediately be removed in a gale or any sudden grounding) should be marked on the beams of the hold by the constructor. This is now done on most of the great steam ships.

"Each vessel carrying passengers should be visited before departure by an officer of customs and if any well grounded complaint on protest should be presented (at the risk of such objector) the vessel should be detained until any valid objection was remedied.

"Referring to the port of Hull it is stated that 'The great loss of steamers sailing from this port has been occasioned either by overloading or by shipping heavy seas in quick succession—the apertures for the escape of water not permitting the ship to free herself before succeeding seas have overwhelmed the vessels. Indeed, in such cases, the crew are unable to to perform any duties beyond self-preservation. In most cases these disasters could be traced to heavy or undue deck loads, improperly secured, or, indeed, under the character of dead weights, recklessly placed above the load level. To lessen the risk of loss from shipping seas as above referred to, a place has been adopted in construction of steamers at Hull of covering in the deck amidships the entire length of the engine and boiler rooms (and in some instances the whole of the after deck), and thus, whilst effectually securing the engine room from being flooded, lessens the danger of admitting such bodies of water as would tend to render the vessel water-logged or unmanageable under steam.'

"Deck Loads.—As regards these, there may be no danger in carrying during the summer months articles of bulk, if light, such as machinery, or carriages, but it should be clearly understood by the parties thus shipping them that they must at any moment be sacrificed where the vessel or crews are imperilled by their presence.

"But in all these matters the acts of underwriters would tend more than any legal enactments to keep down such undue lading if they would but combine to refuse to insure any vessel, or goods, if certain regulations were not observed.

"One captain observed, 'that in bad weather he would prefer a deck load of cotton well protected, and that in a deep-waisted vessel it would be safe to have such a deck load.'

"In a dry safe ship this might on an Atlantic run be safe, but it must be remembered that sodden cotton would be as bad as water, and that each bale would represent about one ton dead weight. Moreover, the moment law yields to opinion, safety may be sacrificed to gain by freight.

"Boats.—Boats when stowed in-board should be placed at least 2 feet above deck so as to permit the free passage of the sea beneath. They should be securely lashed by bands and slip-shackles, so that they could be instantly released should the masts go by the board, and it became expedient to launch them at a heavy roll of the ship. They should never be used for the stowage of sheep, fowls, or other matters which demand fittings or coverings, and which delay their immediate appropriation for their proper service.

"During calm, or when the voyage would not be impeded, the crew should be practised in the rapid clearing away and lowering of boats, and specially so in saving men who may fall overboard; so also in hoisting up. In both instances many lives are lost by the incapacity of merchant seamen, and not being accustomed to boat service. Merchant seamen frequently are put on board at the moment of leaving dock; they are towed to sea, and possibly never have an opportunity of handling boats or oars during their voyages. Indeed it is very doubtful if one third of a crew when shipped could be properly entitled to be designated as able seamen, the word of the "crimp" or shipper being deemed quite sufficient.

"If the Government should attempt the adoption of regulations they should apply to each great maritime power to consent to the formation of a code which should become law in every part of the world and be observed in all cases as the 'Rule of the Road at Sea' is supposed to be.

"All regulations should operate equally so as not to prejudice the mercantile marine in any port which may be visited, and thus equality of wages, the keystone of commerce, would enable vessels to obtain crews at known terms in any foreign ports with more facility than is now experienced.

"Although the safety of ships and passengers be important the general well-being of our trade regulations demands more consideration than seems at present to be extended to it.

"In order to obtain more complete information we should be willing that this committee be re-appointed.*

"Edward Belcher, Chairman.
"William Smith, C.E.
"James Oldham, C.E.
"William Sissons."

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* This Committee was re-appointed at the last meeting of the "Committee of Recommendations," and confirmed at the final General Committee at Norwich, on August 26th, 1868.—Ed. Artizan.

## ON A PROBABLE CONNECTION BETWEEN THE RESISTANCE OF SHIPS AND THEIR MEAN DEPTH OF IMMERSION.

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

1. It was pointed out some time ago, that when a wave in water is raised by a floating solid body which is propelled at a speed greater than the natural speed of the wave, the ridge of the wave assumes an oblique position, and the wave advances obliquely; so that while it travels at its own natural speed in a direction perpendicular to its ridge-line, it at the same time accompanies the motion of the solid body at a greater speed. The angle of obliquity of the advance of the wave is such, that its cosine is the ratio of the natural speed of the wave to the speed of the solid body. It was at the same time pointed out, that under those circumstances there is an additional breadth of wave raised in each second, expressed by the product of the speed of the solid body into the sine of the obliquity; or, in other words, by the third side of a right angled triangle, of which the speed of the solid body is the hypothenuse, and the natural speed of the wave the base; that in raising that additional breadth of wave per second, energy is expended; and thus that a rapidly increasing additional term is introduced into the resistance to the motion of the solid body, so soon as its speed exceeds the natural speed of the waves which it raises.

2. The waves taken into account in Mr. Scott Russell's theory of the resistance of ships, are waves whose speed depends on their length alone; and that theory accounts for a rapid increase in the resistance of a ship, when her speed exceeds the natural speed of certain waves of lengths depending on her length.

3. In a paper read to the Royal Society in May, 1868, it was shown that for all waves whatsoever, there is a relation between the natural speed and the virtual depth of uniform disturbance, that is to say, the depth to which an uniform disturbance equal to the disturbance of the surface particles would have to extend in order to make a total volume of disturbance of the water equal to the actual volume of disturbance. That relation is, that the speed of advance of the wave is that due to a fall of half the virtual depth. In a paper read to the Institution of Naval Architects in 1868, it was pointed out that every ship is probably accompanied by waves, whose natural speed depends on the virtual depth to which she disturbs the water; and that ,consequently, when the speed of the ship exceeds that natural speed, there is probably an additional term in the resistance depending on such excess.

4. The object of the present paper is to call the attention of the British Association, and especially of the committee on Steam Ship Performance, to the probable existence of this hitherto neglected element in the resistance of ships; and to suggest that suitable observations and calculations should be made in order to discover its amount and its laws. Amongst observations which would be serviceable for that purpose may be mentioned the measurement of the angles of divergence of the wave-ridges raised by various vessels at given speeds, and the determination of the figures of those ridges which are well-known to be curved; and amongst results of calculation the *mean depth of immersion*, as found by dividing the volume of displacement by the area of the plane of flotation; and that not only for the whole ship, but for her fore and after bodies separately, for it is probable that the virtual depth of uniform disturbance, if not equal to the mean depth of immersion, is connected with it by some definite relation.

*Results of Observations.*—In an Appendix are given the results of the only three observations, which I have hitherto found it practicable to make, of the speed of advance of the obliquely diverging waves raised by ships. The waves in each case were those which follow the stern of the vessel; the vessels were all paddle-steamers; but care was taken to observe the positions of the wave-ridges where they were beyond the influence of the paddle-race. The virtual depth corresponding to the speed of advance of those waves is calculated in each case, and it is found to agree very nearly with the mean depth of immersion. It is to be observed, however, that the mean depth of immersion of one vessel only, viz., the *Iona*, has been measured from her plans. For each of the other vessels, a probable value of the mean depth of immersion has been obtained, by assuming that it bears the same proportion nearly to the total draught of water in them as in the *Iona*. That assumption cannot be very far from the truth, for the three vessels belong to the same class of forms, being of shallow draught, and very flat-bottomed amidships, but having very fine sharp ends. Few as those observations are, they seem sufficient to prove the existence of waves whose speed of advance depends on the depth to which the vessel disturbs the water. The connexion between those waves and the resistance remains as a subject for future investigation.

Glasgow University, 15th August, 1868.

### Appendix.

1. *Steam Vessel "Iona."*—Speed of vessel at time of observation, 15 knots=25·35ft. per sec.; angle made by ridges of stern waves with course of vessel, $22\frac{1}{2}°$; sine of that angle = 0·383; product, being velocity of advance of stern-waves, 9·71ft. per sec.; virtual depth corresponding to that velocity, $9{\cdot}71^2 \div 32{\cdot}2 = 2{\cdot}93$ft.; mean depth of immersion of vessel as measured on her plans, 3·18ft. N.B.—The draught of water was 5ft., so the mean depth of immersion was 0·64 of the draught, nearly.

2. *Granton and Burntisland Ferry Steamer.*—Speed of vessel at time of observation, 10 knots = 16·9ft. per sec.; angle made by ridges of stern-waves with course of vessel 45°, sine of that angle, 0·7071; product, being velocity of advance of the stern-waves, 11·95ft. per sec.; virtual depth corresponding to that velocity, $11{\cdot}95^2 \div 32{\cdot}2 = 4{\cdot}44$ft.; draught of water of the vessel, 6·67ft.; probable mean depth of immersion on the supposition that it is 0·64 of the draught, 4·3ft.

3. *Steam Vessel "Chancellor."*—Speed of vessel at time of observation, 12·64 knots = 21·36ft. per sec.; angle made by ridges of stern-waves with course of vessel, 22°; sine of that angle, 0·375; product, being velocity of advance of the stern-waves, 801ft. per sec.; virtual depth corresponding to that velocity $8{\cdot}01^2 \div 32{\cdot}2 = 2{\cdot}0$ft.; draught of water of the vessel, 3·5ft.; probable mean depth of immersion, on the supposition that it is 0·64 of the draught, 2·24ft.

*Table of Virtual Depths Corresponding to Different Velocities of Advance.*

| Velocity of Advance. | | | Virtual Depth. | |
|---|---|---|---|---|
| Knots | Feet per second | Metres per second | Feet | Metres |
| 1 | 1·69 | 0·515 | 0·09 | 0·027 |
| 2 | 3·38 | 1·03 | 0·35 | 0·108 |
| 3 | 5·06 | 1·54 | 0·80 | 0·243 |
| 4 | 6·75 | 2·06 | 1·41 | 0·433 |
| 5 | 8·44 | 2·57 | 2·21 | 0·676 |
| 6 | 10·13 | 3·09 | 3·18 | 0·973 |
| 7 | 11·8 | 3·60 | 4·33 | 1·325 |
| 8 | 13·5 | 4·12 | 5·66 | 1·73 |
| 9 | 15·2 | 4·63 | 7·16 | 2·19 |
| 10 | 16·9 | 5·15 | 8·84 | 2·70 |
| 11 | 18·6 | 5·66 | 10·7 | 3·27 |
| 12 | 20·3 | 6·18 | 12·7 | 3·89 |
| 13 | 21·9 | 6·69 | 14·9 | 4·57 |
| 14 | 23·6 | 7·20 | 17·3 | 5·30 |
| 15 | 25·3 | 7·72 | 19·9 | 6·08 |
| 16 | 27·0 | 8·24 | 22·6 | 6·92 |
| 17 | 28·7 | 8·75 | 25·6 | 7·81 |

## ON THE IRRIGATION OF UPPER LOMBARDY BY NEW CANALS TO BE DERIVED FROM THE LAKES OF LUGANO AND MAGGIORE.

By P. Le Neve Foster, Jun.

(*Concluded from page* 213.)

The length of time that the level of the lake remained between Zero and 0·10m. above Zero was only 3 days in 1850; 7 days in 1857; 37 days in 1854; and 40 days in 1858, and took place in the months of February, March, and April. The ordinary low water level of the lake varies from 0 10m. to 0.60m. above Zero, with a discharge of from 90 to 202 cubic metres per second, and in 10 years observation the lake is in this state on the average for 123 days in the year, with a maximum of 154 days, and a minimum of 86 days, during the months of January, February, March, half April, half December, and during a few days in the months of May, August, September, and November.

The outlet of the Lago Maggiore is the river Ticino, which falls into the Po at Pavia.

In order to obtain a supply of water for the new canals in the summer of from 44 to 60 cubic metres per second, and in the winter of 20 to 30 cubic metres per second, without interfering with the supply of water to the existing canals derived from the Ticino, and whose rights amount to upwards of 81 cubic metres per second, and without damaging the navigation; the originators of the new scheme (Signors Villoresi and Meraviglia) propose, by storing up the flood waters, to raise the level of the lake, and to regulate the flow in such a manner as to supply the new canal with the requisite quantity of water, and to allow a discharge of not less than 120 cubic metres per second down the Ticino to supply the existing canals, and to maintain a sufficient depth of water in the lower part of the river for the navigation.

To fulfil these conditions, the level of the water in the lakes should never be allowed to be below 0.30m. above Zero, and the ordinary level to be 0.60m. above Zero.

The storing of the flood waters in both lakes will be obtained by throwing a massive masonry dam (provided with sluices and other appliances for the purpose of regulating the discharge) across the rivers.

At the Lake of Lugano the existing bridge over the River Tresa will be converted into a dam. Four of the five arches will be provided with six sluices each, 1·60m. in width, and the other arch will communicate with a lock, for the passage of boats from the lake into the river. The sill of the sluices are to be placed at 0·45m. below Zero on the scale. These sluices will regulate the height of the water in the lake, and retain the flood waters. From these outlets the water will flow into the river by a tumbling bay, consisting of five steps each, 0.50m. in height, so as to prevent damage to the river bed by breaking up the great fall into a series of small ones, each incapable of damaging the platform or apron which receives it. The channel below the dam will be regulated to a uniform section for a distance of about 2,780 metres, with a width of 30 metres at bottom, and with a fall of 2·00 metres in this length. At this place another masonry dam will be thrown across the river with a similar number of sluices as the first. The sills of the sluices are to be 5.45m. below Zero, and the bed of the river below the sluices to be 7.50m. below Zero. This fall will be broken up by a tumbling bay.

The canal will begin on the right hand side of the dam. The level of the bottom of the canal to be 4·45m. below zero, or 1 metre above the sill of the sluices in the dam. The canal on the left hand, or river side, will be provided with six outlets or waste sluices, 1 metre in width each, their sills bring at the same level as the bottom of the canal.

The works for retaining the flood waters in the Lago Maggiore and for regulating their flow, will consist in the rectification of the bed of the Ticino. and the construction of a massive masonry dam or weir across the river at a point 7,000 metres below Sestro Calende.

The river channel will be straightened and reduced to a uniform section, with a regular fall of 0·50 in 1,000 from Sesto Calende to the weir. At Sesto Calende the width of the bottom of the channel is to be 180 metres, which will be reduced to 120 metres at a distance of 3 kilo. below Sesto Calende, this section will be retained till within 500 metres of the weir, and the channel will then be widened out to 220 metres at the dam, so as to form a reach or pond of comparatively still water in a place where the river would otherwise be shallow and rapid. The weir, which will be 220 metres in length, will be provided with 73 sluices, 1·60m. in width each; and will also be provided with locks for the passage of boats from the canal to the Ticino.

This dam will be capable of retaining all the waters in the lake in times of the highest floods; or, if required, of discharging a volume of water equal to 2,500 cubic metres per second, a quantity greater than during the highest flood ever known.

The level of the sill of the sluices will be 7·03m. below the zero of the scale at Sesto Calende. The upper part of the dam will be used as a bridge, and will be 10·50m. above the sills.

Besides insuring a constant and sufficient supply of water to the new canals, the conversion of the lakes of Lugano and Maggiore into store reservoirs will benefit the actual condition of the rivers by increasing their ordinary or available flow, and the evil consequences of droughts will be be prevented, as there will at all times be a sufficient quantity of water for the existing canals and navigation. The damage to the country below the dam by floods will also be prevented.

The water will be distributed by means of principal canals, secondary canals, communal canals, and private canals.

The principal canals will be five in number :—

1st. From Ticino to Parrabiago, and thence to Milan.[*]
2nd. From Parrabiago to Monza.
3rd. From Monza to River Adda.
4th. From Ponte Tresa to Gallerate and Parrabiago.
5th. From Gallerate to River Lambro, near village Albiate.

The secondary canals will be those which supply water for irrigation and motive power to several communes.

The communal canals are those which supply water to a commune, and may be drawn either from a principal or from a secondary canal.

The private canals are those which may be derived from any of the above for supplying the lands or mills of any single proprietor.

The upper trunk of the first canal from the Ticino to Parrabiago will be 35,900 metres in length, with a uniform section of 21 metres in width at bottom and slopes of 1 to 1 and with a depth of 4 metres of water. It will be constructed for a discharge of 126 cubic metres per second.

The difference of level between Sesto Calende and Parrabiago will be 14·50m., and there are not to be any locks on this trunk. The line of canal from the dam will follow the course of the Ticino to Tornavento, where it will take an easterly direction to Parrabiago, where a large basin or dock will be constructed which will also receive the canal from the Lake of Lugano.

The lower trunk of this canal from Parrabiago to Milan will follow the Milan and Gallerate Railway, and join the Naviglio Grande at the basin near the Porta Ticinese at Milan. The length of this trunk will be 24,000 metres, with a uniform section of 10 metres in width at bottom and a depth of 2·50 metres. The difference of level between Parrabiago and Milan will be 63 metres, and this fall will be distributed amongst 23 locks.

The area to be irrigated by this canal will be 52,222 hectares (129,000 acres), with a population of 344,000.

The second canal will be from Parrabiago to Monza, a distance of 27 kilometres. This canal will be 14 metres in width at bottom, with a depth of 3·50 metres of water and a fall of 15 in 1,000. The area to be irrigated by this canal is 16,970 hectares (41,916 acres), with a population of 79,854.

The third canal from Monza to the Adda will have the same dimensions as the previous one; the total length will be 22,200 metres with a fall of 15 in 1,000, The area to be irrigated will be 18,040 hectares (62,460 acres), with a population of 55,000.

The principal works to be executed between Parrabiago and the Adda will be an aqueduct to carry the canal over the River Olona, with waste sluice to discharge the surplus water from the canal into the river; an aqueduct for crossing the railway from Monza to Camerlata, with head-works of a secondary canal; and various aqueducts for crossing the Lambro and other smaller streams.

The fourth canal will commence at the second dam across the river Tresa. The width at the bottom will be 14 metres from Ponte Tresa to Gallerate, and 12 metros from Gallerate to Parrabiago, then it will join the Ticino Canal. The length of this canal will be 79,137 metres with a fall of 75·23 metres. The canal will follow the right bank of the Tresa for a distance of about 6 kilometres, where it will be carried across the river by an acqueduct, and will enter the valley of the Margorabbia, and will follow this valley and cross the high ridge which separates it from the valley of Cuvio, in a deep cutting and reach the postal road from Gavirate to Lavino, a little below the village of Gemonia. The line of canal will then take a southerly direction to the valley of Bardello, and along the banks of the lake of Varese to Vergiate, to Gallerate, (where the fifth canal branches off) and then passing Busto Arsizio, to Parrabiago.

The area to be irrigated by this canal will be 42,000 hectares (103,740 acres), with a population of 130,000.

The fifth canal from Gallerate to the Lambro will follow the high ground at the foot of the hills, and be upwards of 40 kilometres in length. No data as regards this canal can be given as yet, as the surveys are not completed.

The total number of works to be constructed, such as locks, bridges, acqueducts, syphons, &c., will be about 260, of which 47 will be locks. The canals are estimated to supply upwards of 8,000-horse power, for mills, &c., and to irrigate 400 communes.

The total cost of construction will not exceed 56,000,000fr. (£2,240,000.)

The height at which the canal reaches the Adda will permit of its eventually being extended beyond that river into the province of Bergamo to the river Oglio, near Palazzolo.

One of the most remarkable features in this scheme, is the mode in which the concessionaires, Signors Villoresi and Meraviglia, are authorized to raise the necessary capital. Consorzii, or societies of consumers of water are to be formed, these consorzii are to be promoted by the local authorities, and will bind themselves to take a certain quantity of water at the prices established by the concession.

These consorzii are to consist of private consorzii, when two or more land owners agree to take a certain quantity of water for their own exclusive use, either from the principal or from the secondary canals.

The commercial consorzii are formed when all the consumers in a commune unite and agree to take a certain quantity of water, the concessionaires bringing the required body of water to the highest part of the commune, and this is to be afterwards distributed amongst the consumers, in any way they may think fit.

The district consorzii are formed of the representatives of all the consumers of water from a secondary canal.

The regional consorzii are formed of representatives from all the district consorzu who have a united interest in one of the principal canals.

The principal consorzii is composed of representatives from all the regional consorzii in the province.

Finally the general consorzii, which is composed of representatives from all the provincial consorzii.

In this manner the provinces, communes, and other corporated bodies will become purchasers of water by the payment of an annual sum, and will be able to guarantee this payment from the revenue derived from the sale of water, or, if necessary, from three other sources of revenue.

The concession for the construction and working of these canals has been obtained from the Italian Government by Signors Villoresi and Meraviglia, the authors of the project, for 90 years. The revenue derived from the canals will, for the first 40 years, be the property of the concessionaries, for the purpose of paying off the capital required for the construction and for their own benefit. During the remaining 50 years the canals will become the property of the consorzii, who will apply the revenue that will be obtained

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[*] The first four canals will be navigable.

in any manner they may think fit, and at the end of 90 years the canals will become the property of the State.

The province of Milan will contribute a sum of five million francs towards this undertaking, and the remainder of the capital required for the works will be raised on the bonds of the various consorzii, who undertake to purchase a certain quantity of water, either by the payment of a fixed sum, or by an annual payment during the 40 years, as soon as the works are completed.

The amount that has been fixed for the purchase of water during the whole term of the concession is:—

50,000fr. per hectolitre per second for Summer irrigation.
2,000fr. " " " Winter "
1,000fr. for each horse power (Dynamic)* of motive power.

Taking the water by a yearly payment, the following charges will be made.

3,500fr. per hectolitre per second, for Summer irrigation.
150fr. " " " Winter "
75fr. for each dynamic horse power.

These sums may be paid part in money, or part in land, which is required for the principal or secondary canals, or in finding labour.

As soon as the consorzii are all formed, and the bonds signed, the works will be commenced.

The works of the Ticino Canal to Parrabiago. will probably be commenced in October.

## ON PUDDLING IRON.

By C. W. Siemens, F.R.S.

Notwithstanding the recent introduction of cast steel for structural purposes, the production of wrought iron (and puddled steel) by the puddling process ranks among the most important branches of British manufacture, representing an annual production exceeding one and a half millions of tons, and a money value of about nine millions sterling.

Notwithstanding its great national importance and the interesting chemical problems involved, the puddling process has received less scientific attention than other processes of more recent origin and inferior importance, owing, probably, to the mistaken sentiment that a time honoured practice implies perfect adaptation of the best means to the end and leaves little scope for improvement.

The scanty scientific literature on the subject will be found in Dr. Percy's important work on iron and steel. Messrs Crace Calvert and Richard Johnson, of Manchester, have supplied most valuable information by a series of analyses of the contents of a puddling furnace during the different stages of the process.

These prove that the molten pig metal is mixed intimately in the first place with a molten portion of the oxides (or cinder) which forms the lining (or protecting covering) to the cast-iron tray of the puddling chamber, that the silicon is first separated from the iron, that the carbon only leaves the iron during the "boil" or period of ebullition, and that the sulphur and phosphorus separate last of all while the metal is "coming to nature."

The investigations by Price and Nicholson, and by M. Lari, confirm these results, from which Dr. Percy draws some important general conclusions, which have only to be following up and supplemented by some additional chemical facts and observations, in order to render the puddling process perfectly intelligible, and to bring into relief the defective manner in which it is at present put into practice, involving, as it does, great loss of metal, waste of fuel, and of human labour and an imperfect separation of the two hurtful ingredients, sulphur and phosphorus.

*Silicon.*—In forming (by means of the rabble) an intimate mechanical mixture between the fluid cast metal and the cinder, the silicon contained in the iron is brought into intimate contact with metallic oxide, being found afterwards in the form of silicic acid (combined with oxide of iron), it follows that it must have reduced its equivalent of iron from the cinder to the metallic state.

The fluid cinder may be taken to consist of $Fe^3 O^4$ (this being the fusible combination of peroxide and protoxide), and silicic acid or silica is represented by $Si O^3$, from which it may be inferred that for every four atoms of silicon leaving the metal, nine atoms of metallic iron are liberated, and taking the atomic weights of Iron $=28$, and of silicic acid $=22{\cdot}5$, it follows that for every $4 \times 22{\cdot}5 = 90{\cdot}0$ grains of silicon abstracted from the metal, $9 \times 28 = 252$ grains of metallic iron ore are liberated from the cinder.

*Carbon.*—The disappearance of the carbon from the metal is accompanied by violent ebullition and the appearance of carbonic oxide, which, in rising in innumerable bubbles to the surface of the bath, burns with the blue flame peculiar to that gas.

It is popularly believed that the oxygen, acting upon the carbon of the metal, is derived directly from the flame, which should, on that account, be made to contain an excess of oxygen, but the very appearance of the process proves that the combination between the carbon and oxygen does not take place on the surface, but throughout the body of the fluid mass, and must be attributed to reaction of the carbon upon the fluid cinder in separating from it metallic iron.

But it has been argued that, although the reaction takes place below the surface, the oxygen may, nevertheless, be derived from the flame which may oxidise the iron on the surface, and become transferred to the carbon at the bottom, in consequence of the general agitation of the mass.

This view I am, however, in a position to disprove by my recent experience of melting cast steel upon the flame bed of a furnace, having invariably observed that no oxidation of the unprotected *fluid metal* takes place so long as it contains carbon in however slight a proportion.

Supported by this observation, I feel convinced that the oxidising action of the flame in a puddling furnace commences only after the malleable iron has been formed already.

Carbonic oxide being represented by CO, and the cinder by $Fe^3 O^4$, it follows that for every four atoms of carbon, three atoms of metallic iron are liberated; and, taking into account the atomic weights of $C=6$ and of $Fe=28$, it follows that for every $6 \times 4 = 24$ grains of carbon, $28 \times 3 = 84$ grains of metallic iron is added to the bath.

Assuming ordinary forge pig to contain about 3 per cent. of carbon and the same amount of silicon, it follows from the foregoing that in removing this silicon, $\frac{252}{90} \times 3 = 8{\cdot}4$ per cent., and in removing the carbon $\frac{84}{24} \times 3 = 10{\cdot}5$ per cent. of metallic iron is added to the bath, making a total increase of $8{\cdot}4 + 10{\cdot}5 - 6 = 12{\cdot}9$ per cent., or a charge of 420lb. of forge pig metal, ought to yield 474lb. of wrought metal, whereas the actnal yield would generally amount to 370lb. (or 12 per cent, less then the charge), showing a difference of 104lb. between the theoretical and actual yield in each charge.

In order to realise the theoretical result a sufficient amount of cinder must have been supplied, the quantity of which can be readily ascertained. In taking the expression, $Fe^3 O^4$, the atomic weight of which is $3 \times 28 + 4 \times 8 = 116$, while that of the three atoms of iron alone is $3 \times 28 = 84$. It follows that $\frac{116}{84} \times 54 = 74$lb. of cinder is requisite to produce the 54lb. of reduced iron.

There must, however, remain a sufficient quantity of fluid cinder in the bath to form with the silicon (extracted from the iron), a tribasic silicate of iron, or about 50lb., making in all 166lb. of fettling which would have to be added for each charge, a quantity which is generally exceeded in practice notwithstanding the inferior results universally obtained.

There remains for our consideration the sulphur and phosphorus, which being generally contained in English forge pig in the proportion of from ·2 to ·6 per cent. each, can hardly affect the foregoing quantitative results although they are of great importance respecting the *quality* of the metal produced.

It has been asserted by Percy that the separation of these ingredients is due to *liquation*. This I understand to mean that the crystals of metallic iron, which form throughout the boiling mass when the metal "comes to nature," excludes foreign substances in the same way that the ice formed upon sea water excludes the *salt*, and yields sweet water when re-melted.

According to this view, pig metal of inferior quality will really yield iron almost chemically pure, to which foreign ingredients are again added by mechanical admixture with the surrounding cinder, or semi-reduced metal.

It may be safely inferred that the amount of impurities thus taken up will mainly depend upon the *temperature*, which should be high, in order to ensure perfect fluidity, and complete separation of the cinder.

The following was the result of an analysis of an inferior English pig iron before and after being puddled:

| *Pig Metal.* | | *Puddled Bar.* | |
|---|---|---|---|
| Iron ... | 96.079 | Iron ... | 99.276 |
| Sulphur ... | .008 | Sulphur ... | .017 |
| Phosphorus | 1.096 | Phosphorus | .237 |
| Silicon ... | 1.097 | Silicon ... | .047 |
| | 100.000 | | 100.000 |

showing the extent to which foreign matters are actually removed by the process of puddling.

These analyses were made a few days since by Mr. A. Willis in my laboratory at Birmingham.

Led by these chemical considerations, and by practical attention to the subject, extending over several years, I am brought to the conclusion that the process of puddling, as practised at present, is extremely wasteful in iron and fuel, immensely laborious, and yielding a metal only imperfectly separated from its impurities.

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* Dynamic horse power equals 100 kilometres raised 1 metre in height per second, whilst with ordinary horse power it is 75 kilometres.

How nearly we shall be able to approach the results indicated by the chemical reasoning here adopted, I am not prepared to say, but that much can be accomplished by the means actually at our doors is proved by the result of eighteen months working of a puddling furnace erected to my designs by the Bolton Steel and Ironworks, in Lancashire.

This furnace consists of a puddling chamber of very nearly the ordinary form, which is heated, however, by means of a regenerative gas furnace, the principle of which is sufficiently well sstablished at present to render a special description here unnecessary. The advantages of the furnace for puddling, are that the heat can be raised to an almost unlimited degree, that the flame can be made at will oxidising, neutral, or reducing without interfering with the temperature; that indraughts of air and cutting flames are avoided, and that the gas fuel is free from pyrites and other impurities, which are carried into the puddling chamber from an ordinary grate. In this respect the new furnace presents the same advantages as puddling with charcoal.

The following Table gives the working results which were obtained from this furnace, as compared with the results obtained at the same time in an ordinary furnace from the same pig (the ordinary forge mixture):

## REGENERATIVE GAS FURNACE.

### Table No. 1.

*First Shift.*

| Date. 1867. | Nos. of Heat. | Time charged. | First Ball out. | Metal Charged. | Yield. |
|---|---|---|---|---|---|
| | | | | lb. | lb. |
| May 27 | 1 | 5„ „ 25 | 6 „ 32 | 410 | 392 |
| | 2 | 6 „ 45 | 7 „ 50 | 433 | 396 |
| | 3 | 8 „ 8 | 9 „ 9 | 430 | 410 |
| | 4 | 9 „ 15 | 10 „ 7 | 425 | 426 |
| | 5 | 10 „ 20 | 11 „ 22 | 426 | 430 |
| | 6 | 11 „ 40 | 12 „ 46 | 412 | 412 |
| *Second Shift.* | | | | | |
| „ | 1 | 1 , 48 | 2 „ 47 | 428 | 410 |
| | 2 | 2 „ 50 | 3 „ 47 | 420 | 414 |
| | 3 | 3 „ 56 | 4 „ 53 | 426 | 418 |
| | 4 | 5 „ 0 | 6 „ 3 | 432 | 417 |
| | 5 | 6 „ 5 | 7 ., 12 | 425 | 407 |
| | 6 | 7 „ 20 | 8 ., 15 | 420 | 422 |
| *Third Shift* | | | | | |
| „ | 1 | 9 „ 10 | 10 „ 15 | 423 | 414 |
| | 2 | 10 „ 25 | 11 „ 30 | 422 | 412 |
| | 3 | 11 „ 35 | 12 „ 40 | 420 | 420 |
| | 4 | 12 „ 45 | 2 „ 0 | 430 | 410 |
| | 5 | 2 „ 10 | 3 „ 10 | 424 | 411 |
| | 6 | 3 „ 16 | 4 „ 20 | 420 | 400 |
| *First Shift.* | | | | | |
| 28 | 1 | 5 „ 38 | 6 „ 45 | 423 | 402 |
| | 2 | 6 „ 50 | 8 „ 0 | 422 | 400 |
| | 3 | 8 „ 6 | 9 „ 8 | 430 | 390 |
| | 4 | 9 „ 15 | 10 „ 25 | 426 | 407 |
| | 5 | 10 „ 35 | 11 „ 45 | 426 | 420 |
| | 6 | 11 „ 55 | 1 „ 8 | 430 | 416 |
| *Second Shift.* | | | | | |
| „ | 1 | 2 „ 0 | ... | 422 | 422 |
| | 2 | 3 „ 6 | 4 „ 0 | 424 | 415 |
| | 3 | 4 „ 5 | 5 „ 18 | 423 | 424 |
| | 4 | 5 „ 23 | 6 „ 27 | 423 | 415 |
| | 5 | 6 „ 33 | 7 „ 46 | 427 | 420 |
| | 6 | 7 „ 49 | 8 „ 50 | 420 | 406 |
| *Third Shift.* | | | | | |
| May 28 | 1 | 10 „ 0 | 11 „ 20 | 420 | 424 |
| | 2 | 11 „ 25 | 11 „ 33 | 420 | 410 |
| | 3 | 12 „ 40 | 1 „ 45 | 423 | 412 |
| | 4 | 1 „ 50 | 2 „ 58 | 425 | 420 |
| | 5 | 3 „ 13 | 4 „ 20 | 430 | 418 |
| | 6 | 4 „ 30 | 4 „ 35 | 422 | 426 |

| | cwt. | qr. | lb. |
|---|---|---|---|
| Total charge | 136 | 1 | 2 |
| „ yield | 132 | 3 | 7 |

being at the rate of 20 cwt. 2qr. 2lb. of pig iron per ton of puddled bar.

## ORDINARY FURNACE.

### Table No. 2.

| Date. 1867. | Time. | Weight of Metal Charged. | Weight of Puddled Bar Produce. |
|---|---|---|---|
| May 17 | These times were not taken for each charge, but six heats were produced every 12 hours. | Mean 484lb. | lb. |
| | | | 424 |
| | | | 425 |
| | | | 405 |
| | | | 430 |
| | | | 430 |
| | | | 438 |
| | | | 416 |
| | | | 410 |
| | | | 432 |
| | | | 426 |
| | | | 420 |
| | | | 422 |
| | | | 422 |
| | | | 425 |
| | | | 430 |
| | | | 450 |
| | | | 410 |

| | lb. |
|---|---|
| Mean charge | 484 |
| „ yield | 426 |

or 22cwt. 2qr. 20lb. of pig iron per ton of puddled bar.

It will be observed that the ordinary furnace received charges of 484lb. each, and yielded on an average 426lb., representing a loss of 12 per cent., whereas tho gas furnace received charges averaging 428lb., and yielded 413lb., representing a loss of 3·5 per cent.

It is important to observe, moveover, that the gas furnaces turned out eighteen heats in three shifts per twenty-four hours, instead of only twelve heats per twenty-four hours, which was the limit of production in the ordinary furnace.

The quality of the iron produced from tho gas furnace was proved decidedly superior to that from the ordinary furnace, being "*best best*" in the one and "*best*" in the other case from the same pig.

The consumption of fuel was greatly in favour of the gas furnace, but could not be accurately ascertained, because some mill furnaces were worked from the same set of producers.

The consumption of fettlings was, however, greater in the gas furnace, and the superior yield was naturally attributed by the forge managers to that cause, although I held a different opinion.

Finding, however, that the gas furnace had not been provided with water bridges, these were subsequently added, and the furnace put to work again in November last, since which time it has been worked continously.

The result of the water bridges has been that the amount of fettling required is reduced to an ordinary proportion, the averago quantity of red ore used being 93·3lb. per charge besides the usual allowance of bulldog, while the yield per charge of 475·3lb. of grey forge pig has been increased to 476·4lb. of puddled bar, as results from the following observations during one turn.

| Pig charged. | | Puddled bar returned. |
|---|---|---|
| lb. | | lb. |
| 470 | ... ... ... | 470 |
| 480 | ... ... ... | 482 |
| 486 | ... ... ... | 460 |
| 468 | ... ... ... | 470 |
| 470 | ... ... ... | 500 |
| 478 | ... ... ... | 476 |
| Mean result 475·6 | ... ... ... | 476·4 |

proving an average gain of fully 12 per cent. over the yields of ordinary furnaces, while the superiority of quality in favour of the gas furnace is fully maintained.

It is also worthy of remark that these results are obtained regularly by the ordinary puddlers of the works, and that no repairs have been necessary to the gas puddling furnace since November last, the roof being reported to be still in excellent condition.

In these investigations I have confined myself to the puddling of ordinary English forge pig in order to avoid confusion, but it is self-evident that the same reasoning also applies in a modified degree to white pig metal or refined metal, the use of which I should not, however, advocate.

*Water Bridges.*—Regarding the water bridges, I was desirous to ascertain the expenditure of heat at which the saving of fettling and greater ease of working was effected. The water passing through the bridges was accordingly measured by Mr. W. Hackney (who has also furnished me with the other working data) and found to amount to 25lb. per minute, heated 40° Fahr. This represents 60,000 units of heat per hour, or a consumption not exceeding 8lb. to 10lb. of solid fuel per hour, an expenditure very much exceeded by the advantages obtained where water or cooling cisterns are available.

The labour of the puddler and of his under-hand being very much shortened and facilitated by means of the furnace, I should strongly recommend the introduction of three working shifts of 8 hours each for 24 hours, each shift representing the usual number of heats, by which arrangement both the employer and the employed would be materially benefitted. The labour of the puddler may be further reduced with advantage by the introduction of the mechanical rabble which has already made considerable progress on the Continent.

By working in this manner a regenerative gas puddling furnace of ordinary dimensions would produce an annual yield of about 940 tons of bar iron of superior quality from the same weight of grey pig metal and the ordinary proportion of fettling.

In conclusion, I may state that a considerable number of these puddling furnaces have been erected by me abroad, and that in this country they are also being taken up by Messrs. Kitson, of Leeds, and a few other enterprising firms.

## ON SOME POINTS AFFECTING THE ECONOMICAL MANUFACTURE OF IRON.

By Mr. Jno. Jones, F.G.S., Secretary of the North of England Iron Trade.

The object of the following paper is to consider briefly the merits of certain methods which have recently been proposed for cheapening the cost of manufacturing iron.

It is almost impossible to overrate the importance of this question. A distinguished member of this Association has raised a warning voice against the reckless manner in which our resources of coal are being exhausted, but since that time no great changes have been devised for producing a more economical application of fuel on a national scale. The supremacy of the British iron trade depends upon the comparative abundance of fuel in close proximity to the ironstone; and, in proportion as the mineral treasures of coal and ironstone are exhausted, so will the position of this national industry decline, for the importation of the raw material is quite out of the question. Therefore, the economical use of the minerals we still possess is a subject of great importance. This country is now making about 4,500,000 tons of pig iron per annum, and is capable of producing at least 3,000,000 tons of finished iron. Speaking approximately, it may be said that the iron manufacture alone consumes about 15,000,000 tons of coal per annum, or rather more than one-seventh of the total quantity raised from the various coalfields. These facts are adduced to show the immense issues involved in certain changes in the mode of manufacturing iron, to which special attention will presently be invited.

These improvements will be considered under two heads. (1.) The economical application of fuel. (2.) Simplification of manufacturing processes.

The first subject naturally leads us to examine critically the whole process of manufacturing iron from the ironstone to the finished plate or rail. In smelting operations large quantities of fuel are consumed, and it must be admitted that in many cases large quantities are also wasted. Still, in the newer iron-fields, where the smelting works have been recently constructed, no such waste is allowed. The greatest possible care is taken to utilise the products of combustion and to make the gas from the furnace tops available for raising the temperature of the blast and for generating steam. The attention of blast furnace engineers has, indeed, of late years been mainly directed to the full utilization of the fuel employed. There can be no question as to the great saving that has resulted from the elaborate arrangements now in operation at the principal smelting works of modern construction; but these plans do not admit of being readily adapted to the older type of blast furnace. In many districts the mineral resources have been so far exhausted as to preclude capitalists from making changes that would involve a large expenditure without the prospect of a satisfactory return. All that can be expected in such cases is a partial adoption of the economical arrangements alluded to above, and it is satisfactory to find that a gradual change is taking place in this respect. The older plant is, in fact, being assimilated to that of the newer iron smelting districts, as far as special circumstances will allow. It seems, then, that the economical use of fuel is fully understood and acted upon in the manufacture of pig iron, at all events in the modern class of works. There it has been found practicable to make pig iron with about 20cwt. of coke to the ton of iron produced, including heating, blast, and raising steam. It is thought, also, that even more gratifying results may yet be obtained, but at this figure it is not easy to understand how any radical change for the more economical use of fuel can be brought about. The only waste of heat-producing elements appears to be during the conversion of coal into coke, when a considerable quantity of combustible material is driven off, and is completely lost, but it is by no means certain that the conversion of the coal into an intensely hard mass does not more than compensate for the loss, unless the volatile hydrocarbons driven off in coking could be made available in the furnace. It may be said, however, speaking generally, that we have now arrived at a point in the smelting of iron that is approaching theoretical perfection very closely, and what now mainly remains to be done is to bring the older blast furnaces as nearly as may be up to the modern standard, as far to the use of fuel is concerned.

When, however, we follow up the finished iron a stage further, we come to processes where there is a marked lack of economy in the appliances used, as well as great want of skill in the agents using them. To begin with, there is first a heavy loss of fuel incurred in melting the cold pig iron charged into the puddling furnace. There would doubtless be difficulties in running off the iron direct from the blast furnace in all cases, but there are many places where the proper mixture of pig iron might be made in the blast furnace, and where such regularity of working might be insured as would allow of the molten cast iron being charged direct into the puddling furnace, or at all events, the pig iron might be economically melted down in large quantities and supplied to the puddlers in a fluid state. But this suggests a more radical change in manufacturing operations than need be discussed at present. However sound such a proposal may be theoretically, it has not yet had any extensive application, though it has been practised in several ironworks.

But, taking the ordinary puddling operations, it is evident that a great waste of fuel occurs here. Large quantities of carbon are driven off in an unconsumed form in dense clouds of smoke, whilst another mass of partially consumed coal goes away as ashes and cinders. The same kind of waste is also characteristic of the various heating furnaces. The precise amount of fuel used in producing a ton of puddled iron differs in almost every ironworks, but it may be safely asserted that 25cwt. of fuel to the ton of puddled iron is under the average taking the country through. The question arises, whether it is practicable to so modify the construction of the existing puddling furnaces as will ensure more economical results, and at the same time afford proper facilities to the workmen. It is possible, in fact, to make the whole of the fuel used effective in producing heat in the furnace, because, if this can be accomplished, the quantity of coal required in the puddling process will be very considerably reduced. This problem has more recently occupied the attention of many minds, for numerous patents have been taken out dealing with it in one way or another, and it has now been to a great extent solved in a satisfactory manner, so that we appear to be getting near a means of using fuel as economically in the puddling as is already done in the blast furnace.

The Wilson modification of the fire-grate, as perfected by Messrs. W. Whitwell and Co., of Stockton, has received a good deal of attention amongst iron manufacturers, and it is gradually being adapted to the peculiarities of fuel in the various districts, and its construction is being reduced to its simplest elements. This furnace may be described in a few words, the principle having to be modified a little according to special circumstances. The fuel in this furnace is made to burn on a sloping solid fire-brick bottom, the coal being introduced at the top, and made to pass gradually down to the part where there is an incandescent mass; the hydro-carbons, which in ordinary furnaces form smoke, and thus pass off without doing any economical work, are turned into an intense flame in the furnace, and no smoke is made when a sufficient quantity of atmospheric air is admitted. Underneath the combustion chamber is a closed ash-pit, into which a blast of air is forced by means of a steam jet three-sixteenths of an inch in diameter. The air causes a reduction of the cinders and clinkers usually formed in ordinary furnaces; and at the same time the steam passing through the red-hot cinders is decomposed, carbonic oxide and hydrogen being produced. The air for combustion is mainly introduced by means of a pipe which passes through the flue bridge, round the furnace back, through the flame bridge, into an upper chamber above the sloping generator, whence it descends in thin streams through the perforated bricks into the furnace. The air is thus supplied in a highly heated condition. This furnace gives off no smoke, and the materials are perfectly consumed, the formation of ashes and cinders being also prevented. Without going into details, it has been practically demonstrated from results obtained by working these furnaces a considerable length of time, that the quantity of fuel required per ton of puddled iron is from 20 per cent. to 25 per cent. less than in the ordinary furnace, the consumption of coal ranging between 17cwt. and 18cwt. The principle of the Wilson furnace is the complete combustion of the fuel before it comes to the furnace chamber, but a certain amount of heat is assumed to pass from the furnaces without being utilized, though this can be as easily made available for generating steam as can the waste heat from puddling furnaces of ordinary construction. The subject, however, admits of being approached in another way, by devoting increased attention to the utilization of the heat, and by making the waste heat available again in the furnace. The Newport furnace, patented by Jones, Howson, and Gjers, and in operation at the Newport Ironworks, Middlesborough, is constructed on this principle. A chamber is built in the ordinary chimney stack, and in this are placed two cast iron upright pipes, with a partition reaching nearly to the top of each. The waste gases from the furnace are diverted into the chamber by means of a damper, and raise the temperature of the iron pipes to a high degree. Through these pipes the air required for combustion of the fuel is drawn by means of a steam jet; the mixed air and steam being conveyed to the furnace bridge, and delivered there by a series of tuyeres; also a portion of the air is sent in lower down, underneath the bars of the grate, the ashpit being closed so that no air can reach the furnace, except that which has been heated to a temperature of about 500 deg. by the waste gases. By this means a regenerative action is set up, and it is found in practice that the combustion of the fuel is nearly complete, the only smoke produced being at the time when heavy firing is going on. The actual results arrived at by the use of these appliances are the saving of from 25 per cent. to 30 per cent. of fuel as compared with the operation of the furnaces of ordinary construction. In the working of several of these furnaces with gray forge iron, six heats per day, the quantity of coal used in producing a ton of puddled iron has been reduced to 16cwt., and less; ordinary furnaces, working under similar conditions, using from 22cwt. to 23cwt. to produce similar results. In proportion as refined iron or lower qualities of pig iron are introduced, the proportion of fuel required decreases considerably.

The structural modifications required in adapting existing puddling furnaces to the more economical types here alluded to, are so slight, compared with the saving to be effected, that the whole outlay would quickly recoup itself; for, assuming even that each furnace would cost £50 in alterations, and would thus be made to save 25 per cent. in fuel, each furnace would more than clear itself in a single year. The modifications, also, are such that in each case the workmen would require no special training to enable them to use the new furnaces.

Though prominence is here given to only two varieties of improved puddling furnaces, I am aware that other modifications exist, each of which has its special advantages, but in this notice I wish to disregard any particular allusion to plans that would involve a large expenditure before they could be got into successful operation, and where a more highly-trained class of workmen than is yet available would be required in order to ensure success. The above remarks are, however, made without prejudice to other methods proposed to effect the economical use of fuel in the manufacture of finished iron. But I wish to insist upon the fact demonstrated from the working of the two types of furnace alluded to, that with proper care and an average amount of skill on the part of the workman, a saving of at least 25 per cent. in the fuel commonly used in puddling may be made without in any degree injuring the quality of the iron produced, and without the expenditure of a large sum of money in altering existing arrangements. Now what does this mean in the aggregate? We have previously assumed that 6,000,000 tons of coals are annually consumed in the production of the whole quantity of finished iron which this country could make—that is, allowing 9,000,000 tons of coal for the production of pig iron. A saving of 25 per cent. upon this represents exactly 1,500,000 tons of coal. If, then, it be possible to effect an economy of this marked character by means so comparatively simple, this subject undoubtedly becomes one of vast importance to the iron trade of the country, and, indeed, is entitled to rank as a national question.

If the results indicated in the above remarks could be secured for the whole iron trade of the country, this industry would be at once placed in a much more favourable position with respect to foreign competition, about which so much has been written of late. We are asked, however, to go a step further than this. We are invited to relinquish certain prejudices which most practical iron-makers and engineers have, as to the proper mode of manufacturing iron rails, plates, or bars—a mode that has been in existence for a very long period. In following up the process for making, say an ordinary railway bar or plate, we soon arrive at a complicated series of operations. The puddled iron has to be rolled into rough bars, which, after being straightened and weighed, and allowed to get quite cold, are cut up in short lengths, made into piles, conveyed to heating furnaces, heated and hammered or rolled down, are then a second time heated, and finally rolled off into finished bars. Even when the second heating is not required the ordinary process of manufacture contains several objectionable features. The iron is allowed to cool down in the intermediate stage of puddled bars. The piles can never be made perfectly homogeneous, lines of lamination remain in the finished iron, and these cause serious defects when the material is exposed to heavy wear, as in common rails. Now, theoretically, it would seem a more rational plan to carry on the various stages in the manufacturing process more rapidly, and without the many complications which now encumber it. In what is termed the Radcliffe process an attempt is made to carry out this principle, the puddled iron being passed through the necessary stages so rapidly that it reaches the point of finished iron in little more than half an hour after leaving the puddling furnace. This plan is described in a few words. There is no peculiarity about the iron used, the puddling, or the fettling employed. Good workmen are required, and the best fettling is allowed. The puddled iron is brought out "young," and the furnaces are made to work in such a manner that five or a greater number of balls may be brought out practically at the same time. These are treated under a heavy steam hammer, having a quick action; and by the aid of mechanical appliances a large bloom is easily formed, according to the size of the plate or rail to be manufactured. The bloom is passed through a heating furnace, to recover the heat lost in the shingling process; and, after being exposed to a mellow flame for a short time, it is at once rolled into the finished article.

In this system we find the various stages reduced to the simplest form, whilst the quantity of iron produced by this method speaks for itself. A perfect homogeneous structure is secured, no lamination occurring under this mode of treatment. This process has been extensively practised, especially in the production of plates at the Consett Ironworks; and therefore its value has been fully tested. It has the further merit of requiring very little modification in existing ironworks to enable the plan to be put into operation, an immense advantage in these days, when even more direct means of producing finished iron are thought to be not far distant improvements, and when plans requiring an extensive outlay have comparatively a poor chance of being adopted.

The method here sketched out leads to a great economy in labour, fuel, puddled iron, stores, repairs, and in many other ways, and, besides, the productive power of the machinery is so far increased, that the dead charges—a very important item in the cost of making iron—are distributed over a greatly increased make of finished iron. On the face of it, it must be evident that this process far more nearly fulfils the conditions required in a scientific plan for manufacturing iron than does the cumberous one generally adopted. If new works had to be constructed to carry out the system, still more satisfactory results would doubtless be obtained, just as has been the case with the modern improvements in blast furnaces. There is, it must be admitted, much prejudice to be removed from the minds of managers, and even higher authorities; there are mechanical and other difficulties to be overcome before complete success can be ensured, under the various circumstances characteristic of the finished iron trade. But what I wish to dwell upon is, that the principle of the proposed method of manufacture is theoretically correct, is calculated to effect a great reduction in the cost of producing iron, and promises to enable iron manufacturers to make the most of our national resources, by allowing of the production of the finished iron with the least possible expenditure of fuel and of labour.

Taken in connection with the first consideration, that of effecting greater economy in the use of fuel, it would seem that there is a possibility of saving, say 20 per cent. of coal, even upon the ordinary mode of working, and also of dispensing with processes that at present use from 10cwt. to 15cwt. of fuel. In other words, this subject, looked at in a national point of view, means a possible saving of about 3,000,000 tons of coal per annum, including the two principles of economy mentioned in this paper, besides which, there are other equally tangible points where a material saving could be effected, but which do not admit of being expressed in common terms, as in the case with the fuel.

It may be mentioned, however, that the rapidity of the process prevents the waste by oxidation of the iron under treatment, and, under ordinary circumstances, we are informed there is a saving of from 3½cwt. to 4cwt. of puddled iron in every ton of finished rails or plates produced. This iron is simply lost in the usual mode of procedure. If this heavy loss could be even partially prevented, a vast saving would be made, and no extra expense would be incurred in obtaining such a result.

The metallurgy of iron is such a wide subject, there are now so many workers in it, and the whole subject is of so much national importance, that I venture to think the points to which I invite attention are deserving of general notice by all who are practically interested in the iron manufacture, or in the use of iron for engineering purposes. It is high time that the manufacture of iron were placed upon a more truly scientific basis. Our mineral treasures have been so readily available, and we have, until quite recently, enjoyed such an extensive monopoly in the iron trade, that our position seemed unassailable. We have found, however, that the application of science has enabled our continental neighbours to overcome natural disadvantages, and to place themselves on a level with ourselves as far as cheapness of production is concerned. It is for us to apply to our manufacturing operations those principles which have proved successful in their case, and there is no doubt we may be able to effect such a sweeping economy in our cost of manufacture, that we shall soon obtain the full benefit which we ought to derive from our abundant supplies of coal and the vast quantities of ironstone lying within reach of the fuel required to smelt it.

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## ON THE NECESSITY FOR FURTHER EXPERIMENTAL KNOWLEDGE RESPECTING THE PROPULSION OF SHIPS.

By Charles W. Merrifield, F.R.S., Principal of the Royal School of Naval Architecture and Marine Engineering, and Honorary Secretary of the Institution of Naval Architects.

I address the Association on this occasion for the first time, and I trust that I shall be pardoned if, instead of throwing light on any one of the various branches of knowledge which pass before it, as it were in review, at its annual assemblies, I appeal to the Association for its aid in my own professional pursuits, and to its members for help in my individual necessities.

The theory of the circumstances attending the motion of bodies in a resisting medium may be described as one in which we have a very great deal of reasoning, founded upon a very small basis of experience. I am about to solicit the aid of the Association in the way both of advice and of practical assistance, in placing our knowledge on a different basis, as far as regards the exact character of some of the leading phenomena relating to propulsion.

Up to the beginning of this century, all that can be said to have been generally received on this subject was embraced in the following laws:

1. That, other things being alike, the resistance varied as the square of the velocity.

2. That the resistance of inclined surfaces varied as the sine squared of the inclination.

It is clear from Euler's writings that he was quite aware of the elements of uncertainty in the latter of these two laws. But he was wholly unable to supply the deficiency, and with regard to the power, it appears not to have had its accuracy seriously questioned, until quite modern times. Indeed, it has quite come by surprise on most men that the law of atmospheric resistance to projectiles has recently (since 1864) been shown to be more truly represented by the cube than by the square of the velocity. It would not be fair to say, however, that the law of the squares had always been considered as exact, even for the resistance of water. As regards atmospheric resistance Hutton had shown that it varied at a higher power than the square, but it was supposed to be a little above the power of $\frac{15}{7}$ of the velocity. The experiments of Bossuet, Condorcet, and D'Alembert, at the close of the last century, had shown that while the square seemed to be the leading term in the formulæ, there was reason to doubt its being the only term. The experiments of Colonel Mark Beaufoy in England, and of Sir John McNeill and Mr. Scott Russell in Scotland, had shown that there were limitations to this law, due to the character of the wave motion always accompanying a ship. I believe I am justly summarising all we at present know on the subject in the rough general statement, that, in giving increased velocity to a ship, we must, under the most favourable circumstances, expect to find the resistance increased *at least* in the ratio of the square of the velocity. That implies that a steamer consumes at least four times the quantity of coal per *knot*, and at least eight times the quantity of coal per hour, that she would do if driven at half the speed, supposing her performance to be equally good in each case. But it is well known that a short ship cannot be driven at high speed without a higher expenditure than this. Professor Rankine adds terms depending on the theory of waves, and of stream lines. M. Dupuy de Lôme uses a formula involving the square of the velocity, associated with other terms, one involving the cube, with a somewhat lower coefficient, and another involving a fractional power of the velocity. M. Dupuy de Lôme's formula is avowedly tentative—empirical in its form. Professor Rankine's are, in his own opinion, subject to great and imperfectly known limitations.

Almost all the published experiments which have any pretensions to exactness, and at the same minuteness of detail, have been performed upon small models. Now it unfortunately happens that no trustworthy comparison can be drawn from small to large models. There is reason to believe that the best comparison would be by giving to different models velocities varying as the square roots of their linear dimensions; this being the law of the accompanying wave lengths. We have enough experience to be certain that this is not accurate, and I believe that that is really all we know on the subject.

Such is the *résumé* of our experience on the mere power required to drive a vessel through the water, a question which at first sight one might imagine would be settled easily by a dynamometer.

Let us now go a little more into detail, and look to the circumstances affecting screw propulsion and steerage. We must first consider how a vessel stirs the water in which the screw and the rudder are to act.

If a vessel be propelled by any power acting in a manner wholly extraneous to the water in which she turns, as by wind on her sails, or by warping, it is clear that the whole of the work thus applied must be expended in giving equivalent motion to certain particles of water which she disturbs—a motion whose creation or modification must in its agregate absorb the whole of the work applied to the ship. A large portion of the motion so impressed on the water will be an actual towing of the particles in the direction of the ship's motion. But some of it will be expended in the creation of waves, and also of lateral currents and eddies. Of these the following leading divisions are easily recognised:

1. The water actually displaced by the vessel's entrance.

2. The water dragged along by the friction along the vessel's surface and communicated to adjoining particles.

3. The water which flows in to fill up the vacuity which would otherwise be left in wake of the vessel.

None of these, however, are simple phenomena. Liquids press equally in all directions, and the water tends to flow away from a high level in all directions, and fills a hollow from all directions. The negative pressure in the wake of a ship is met by water pressed in from the sides of the channel which she would otherwise leave, more still by water pressed up from the bottom, and again by various waves and eddies, which are due in part to the meeting of these currents and in part to the form of the vessel. It is evident that before we can calculate the effect of a rudder or a screw propeller we must measure these currents, in quantity, in direction, and in speed.

This has not yet been done. I wish the Association to get it done. I want to have it done carefully and accurately, and upon a large scale, not upon models.

We have had many theories on the subject. I do not say this as sneering at theory, for my own knowledge of these subjects consists of a moderate portion of theory with very litle practice. Moreover, the illustrious authors of the theories express themselves as thoroughly dissatisfied with the bases on which they rest. No one has studied the subject of waves on the surface of water more profoundly and successfully than Professor Rankine. It is with his express concurrence that I address you on the deficiency of our experimental knowledge.

We do not know at the present moment at what rate and in what manner the water which follows an ordinary ship is travelling. Still less do we know the details of what takes place when that following water is taken hold of and driven backwards by a screw propeller, or diverted by a rudder. I do not think it is too much to say that the science of propulsion will henceforth be at a standstill until we shall have learnt this.

I propose at the proper time and place, to ask for a committee to advise on the best means of bringing about this object. At the same time I feel it is incumbent upon me, in mooting this subject, to propose something definite, both to the Association to sanction and to the committee to settle.

The subject is obviously a very wide one. It will not do to attempt too much, and it is evidently better to make good a moderate portion of ground than to cover a great deal imperfectly.

What seems to me the first thing is this, to take a vessel of considerable, although manageable, size, to have her carefully measured in every possible detail, and then to have her drawn through the water in some such way as shall not disturb the water otherwise than by her own passage through it, as by warping a screw corvette with her screw lifted. I wish to have the accurate measures of the statical strain on the tow-rope—if that be the motive power—and a complete history of the power expended both in getting up and maintaining a given speed. I then wish to measure with accuracy the velocity and direction of the currents of water at every point in the neighbourhood in which it may appear useful to observe them. How this is to be done, is a matter on which I have some crude ideas—notions upon which I should not desire to recommend action without the advice and amendments of a select committee.

Well, this done, I propose to drive the vessel by her own screw, to take most careful indicator diagrams, and a full account of the work of the engine, with a self-recording dynamometer attached to the thrust collars of the screw shaft. The direction and velocity of the currents to be now again measured as before.

If your committee should agree with my views, I should be disposed to suggest that the Association should memorialise the Government, stating their opinion as to the value of such experiments, and as to the proper mode of carrying them out. It is obvious that no private body can carry out such experiments except at a ruinous cost in chartering vessels, while a Government, maintaining a fleet in time of peace, may not unfrequently be able to detail both suitable ships and scientific officers for experimental objects, instead of simply cruising for exercise.

I need hardly say that I have not thought proper to forestall the action of the Association by any proceedings of my own. I should not have thought it becoming in me to make any suggestions of this sort to our Government, even if I had not myself wanted advice as to what exactly should be done.

Very few public or private bodies have been more liberal in the matter of experiment, and especially in the publication of their experiments, than the British Government, and especially the Admiralty. If I may be permitted to find a little fault where so much is good, I would say that, as a nation, we have been a little too much afraid of incurring expense for abstract results. Possibly our Legislature, to whom any Government would have to render account, is still more timid or sceptical on this score than our administrators. Yet it is clear—I think you would take it as an axiom rather than ask me to prove it—that the accurate settlement of mechanical principles must always be a paying speculation to a mechanical country. However this may be, it is not likely that a department that has behaved with such splendid liberality in all that is connected with nautical astronomy, would be unwilling to assist us in finding out, to their own as well as the public advantage, the actual data of propulsion so soon as they could be satisfied, on your authority, that these data are both useful and attainable.

I now address myself to the means of making the observations. It will, of course, be understood that I offer only a crude basis for the subsequent amendment of the committee for which I am going to ask.

I propose that a corvette, with a lifting screw of about 2000 tons, should be both towed and driven by her own screw (at separate times) in smooth and deep water at various rates, 1, 2, 3 knots, &c., an hour, up to the highest attainable speed.

That dynamometers should be used to ascertain both the strain on the tow-rope and the thrust of the propeller.

That self-recording logs should be towed overboard in all imaginable directions in order to ascertain the velocity of the currents in the neighbourhood of the ship, and, if possible, their directions.

That the waves and other phenomena attending the motion of the ship should be observed with as great accuracy as possible.

That the results of this preliminary experiment should be referred back to to be fully discussed and reported to you either finally or as a guide for further experiment, as may seem advisable.

I foresee some difficulties which I shall now proceed to discuss. It is especially on these points that I want the aid and advice of the Association.

There does not seem much difficulty in towing a corvette; but the propeller of the towing vessel may send currents aft which may interfere with the following ship. This will require accurate testing; but there seems reason to expect that this disturbance may be eliminated, at least with great approximation, by judicious arrangement followed by suitable calculation.

It is not apprehended that there will be any difficulty in ascertaining the velocity of the currents at any point. It will not be quite so easy to ascertain their direction.

With regard to velocity, all that is necessary is to put some self-recording log at the place where the velocity is to be ascertained. But a good deal is to be said about the choice of the particular kind of log. The best for this purpose which I have seen is one that was exhibited by M. Anfonso at the Paris Exhibition of 1867, and again at Havre this year. It is an electrical log founded on Massey's, but in which the turning of the screw in the water simply breaks contact, and records itself by a common telegraph dial, instead of having to do the work of twisting a rope. It begins to record almost from the moment the water acts upon it, and there is very little friction to be overcome, so that the correction due to slip is very small indeed.

For work of this kind, Massey's log has the disadvantage that it does not begin to record until the tow-line has got its whole twist, and then there is a considerable correction to be made for slip. In Walker's log, where one part turns on the other, the friction of the counting machinery must have some tendency to turn the log as a whole, notwithstanding the guide plate on flange. This is no consequence for ordinary reckoning, because these are errors which can be ascertained and rated; but it is a drawback to them for a service in which all corrections are sources of inaccuracy, and where even the two ends of the log may not be in the same current. It seems to me that either Anfonso's electrical log, or some modification of it, is what is needed.

I feel much greater difficulty about the observation of the direction of currents—currents not to be observed solely or even generally at the surface. That is a point on which I solicit advice and assistance. At present I can suggest nothing better than direct observation by the eye.

I produce two instruments which have been devised for getting rid of the puzzling reflections and refractions at the surface of rippling water. One is a very old invention—the water telescope. It consists of a tube with a plain plate of glass at the bottom, which is actually dipped into the water. There is thus a smooth surface always perpendicular to the line of sight. The one exhibited is made for boat use. In clear water and in daylight, minute objects can be seen in four fathoms, when the surface is for all practical purposes opaque from ripple. I have seen an instrument of this kind nearly 20ft. long. With my own instrument I have found only one difficulty; that when the boat was under way, bubbles were driven past the surface of the glass so rapidly and in such quantities as to obstruct all useful vision. It is just possible that this might be remedied by altering the construction so as to dispense with the flange which in my instrument projects beyond the plate-glass, and forms a regular bubble-trap.

The other instrument is Arago's scopeloscope, of which I also produce a specimen. It consists simply of a common opera-glass, with a polarising prism inside it. The idea is to direct or weaken the reflected ray to polarisation, so as to leave the direct ray undisturbed. This very beautiful idea works quite satisfactory when a smooth reflecting surface is concerned. By its help you can see into a window on which otherwise you would only catch the glitter of the sunshine. But when I tried it on a rippling sea, I found that turning the glass merely altered the play of the light, but that the water was still practically opaque, for its not setting right the refractions. But I have not had as much opportunity as I could wish for trying either instrument.

It will be seen how very defective are the means, so far as they are known to me, of observing the horizontal directions of the logs. I do not know that there is any means at all of observing their deviation from the horizontal plane.

I noticed at Havre an invention for finding the errors of compasses. It has occurred to me that the principle might possibly be used for my object, and therefore I will describe it shortly. A mariner's compass is placed in a little log boat, and is towed astern of the ship, so far it may be supposed that the action of the iron or magnetism of the ship is practically nullified. A sharp pull then jerks out a stop, which lifts the cards off its bearing. It is then pulled in and the compass reading compared with that on board the ship, and it is thus made to give the error. Unfortunately the steadiness of the card can hardly be relied upon. But this would not necessarily effect it for our purpose of ascertaining the direction of the currents about a ship. A much more serious drawback to it might be the magnetic influence of the vessel. But might not this influence at any given point be ascertained at leasure, and a correction made?

I have very little doubt that the section will agree with me in the necessity of knowing what actually takes place about a ship, before we can pretend to calculate the effect of a rudder or of a screw propeller. Whether they will also be able to come to the conclusion that the experiments which I have suggested in the above sketch, afford any prospect of our getting accurate data on this subject is a very different question. I confess myself not altogether so satisfied with my own proposal as to desire its adoption without those improvements, both of detail and principle, which may be expected from the aid of a committee of this association.

It may possibly be asked of me why, being secretary to the Institution of Naval Archtiects, I have not brought this question before that body instead of the British Association. My answer is this. It is primarily a theoretical question. It is therefore right in the first instance, to confer with theoretical men as to the deficiencies in the experimental bases on which accurate deductions are to be founded. I hope your council will deem it right to communicate officialy your decision to the Institution of Naval Architects, and I think I can venture to promise you, on their behalf, the co-operation of their practical aid in settling the bases of our theoretical requirements.

The Institution of Naval Architects meets shortly before Easter in each year. I wish to secure the co-operation of the two societies, and also to allow time for the actual performance of the experiments in the fine months of next year To consult them first would would be to throw the experiments over until 1870 at earliest.

## ON CENTRIFUGAL PUMPS.

By John and Henry Gwynne.

At this special time when works of irrigation, reclamation, and surface condensing are respectively attracting a degree of public attention never before accorded them, we think a few remarks on our improved centrifugal pumps and centifugal pumping engines (machines which from their form are now generally recognised as the best adapted for raising water), may prove interesting to this Section. It is not our purpose to enter into any dry disquisitions, or to give any abstruse calculations concerning centrifugal force or the laws that govern it; this has been done over and over again; theory, however, has not been found to be practically correct; nor do we wish to offer any adverse criticism on the various types of centrifugal pumps made by other engineers. Having devoted a great deal of attention to the manufacture of centrifugal pumps for the last twelve years, we early began to perceive that there were many defects in the various types of those pumps. There are some points essential to the construction of a good pump, whether it is reciprocating or rotary. The first grand rule is, avoid all contractions or enlargements in the pipes or water passages, the importance of this is shown in the following experiments by M. Bossuct.

With a head of water of 32in., 4 cubic feet were discharged when the pipe was straight, in 109 seconds. With one enlargement it required 147 seconds to discharge 4 cubic feet, with three enlarged parts 192 seconds were occupied, and with five enlargements 240 seconds. As a rule, pump makers seem to think that sudden contractions only are to be avoided, large passages been considered an advantage, but in reality both contractions and enlargements are equally bad.

The second point to be observed is this:—All curves should be as gradual as possible, so that all sudden change in the direction of the water may be avoided. This is particularly necessary in centrifugal pumps, as the flow of the water is so very rapid and the friction in the bends increases as the square of the velocity, or nearly so.

The third point to be attended to is the shape of the pipes. The circle offers less surface for its area than any other figure, so round passages should always be chosen, as of course the less surface there is the less friction of the water there will be. There are many other general rules to be considered in especial relation to centrifugal pumps, upon which we will not dwell at present, but proceed at once to describe our improved centrifugal pump.

Diagram No. 1, Fig. 1, shows a cross section, and Fig. 2 a sectional elevation, of these pumps; a sectional model is also on the table. The pump itself consists of a wheel or disc, A, with from three to six arms; these arms are cast in one piece with the centre boss. A centre plate springs from the boss, gradually decreasing in thickness, till at the termination of the radial portion of the arms the plate finishes with a knife edge. The object of this plate is to bring the separated currents of water into each side of the disc without producing an eddy or reflux. The arms are radial for two-thirds of their length, curving off towards the periphery in an opposite direction from the line of rotation. The arms are bent *from* the line of rotation in order to direct the water into the sweep of the case, and prevent it rushing against the outer side of the discharge passages. This would result unless some such means were taken to prevent it, as all particles of matter flying off from a body in rotation do so in straight lines. The curve in the blades also tends to utilise the *vis-viva* which remains in the water after leaving the disc. The area of the disc should be equal to the area of the inlet and outlet pipes, at all points; thus the area of the opening at the periphery of the arm, or at the middle of the arms, should be precisely the same: this is accomplished by tapering the blades towards the outer edge, thus diminishing their breadth as the circumference increases. Two rings, one at each side of the arms, form the bearing surface. The wheel is keyed to a steel spindle by steel keys. The whole of the disc, with the arms and side rings, are one casting of steel. The metal casing consists of two pieces of such a shape as to form a profile of the arms of the disc, and recessed for the bearing rings.

FIG. 1.

FIG. 2.

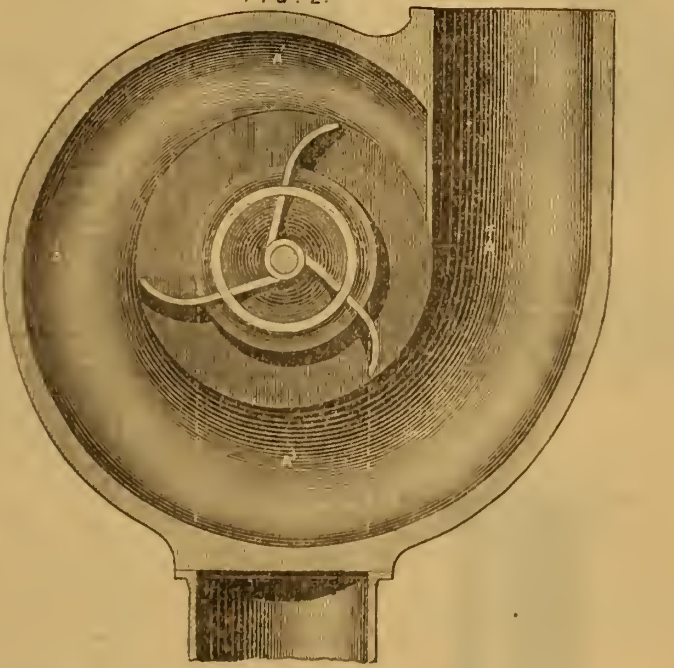


Fig. 1. B B shows an elevation and cross section of the case with the disc in position; C C are the suction passages which branch off from the suction pipe, E, at the point, D.

To prevent any obstruction to the flow of the water, the bottom part of casing for the disc B¹ dies off to a knife edge, and a space is left between the passage and the case to carry the suction pipe, C C, over the enlargement of the discharge passage in a straight line to the openings in the centre of the disc, at which point they curve into the top of the opening.

The discharge passages are sprung from the periphery of the disc in the form of a helix or volute, commencing at the top of the case, A¹, and increasing to the full size of the pipe at the point, A⁴. We have found, from carefully conducted experiments, then when the pumps are working at their best speed, the cubical contents of the disc are discharged three times in every revolution; thus, if the cubical contents of the disc are equal to one gallon of water, three gallons will be discharged per revolution; if making 500 revolutions per minute 1,500 gallons per minute will be discharged. We, therefore, make the discharge passage from the point A¹ to the point A⁴, three times the cubical capacity of the disc. When the pump is at work the water is constantly thrown off at all points from the periphery of a disc in a continuous stream, consequently, by forming the outlet pipe in the form of a helix, increasing to the point of discharge, the water travels round the case at about the same speed as the periphery of the arms, and the case is emptied once in every revolution of the disc. In all other centrifugal pumps that we have seen, the disc works in an oblong or square case, in which a very large surface is exposed to the friction of the water, with a consequently retarding effect. In the case under notice the water only once changes its form, and this when passing through the disc.

We believe a great point has been gained in doing away with the side plates of the disc. With the ordinary form of pump-cases, these plates were almost a necessity; but in our improvements the case acts as the side plates, the water being confined and subject to the impelling force of the arms. There are four friction surfaces on the ordinary disc, two on the inside of plates and two on outside. The disc is accurately faced on its spindle; and the bearing surface for the rings, as well as the sides of the case, are carefully turned, so that the arms fit, but without actual contact. The spindle passes through two stuffing boxes, cast on the cases, and to which are fitted gun-metal glands, with our improved cat's-claw lubricator. The pump is bolted to a rigid cast-iron bed-plate, to which a standard block and connecting piece for the suction is cast, so that the pump can be removed, if required for repairs, without disturbing the suction pipe. A driving pulley is attached to the end of spindle. The actions of these pumps is simple and effective. A valve is placed at the bottom of the suction pipe to retain the water when the pump is not at work. But if the pump is below the water, as is the case in breweries, where the liquor from the backs has to be raised to a higher level no valve is necessary. Many persons are under the impression that centrifugal pumps are able to produce a vacuum, and thus act as suction pumps; this is an erroneous idea, the fact being that the disc and suction pipes must be full of water before starting, or not one drop of water will be discharged.

Immediately the wheel begins to revolve at sufficient speed, the arms on the disc drive the water into the discharge passage with a force equal to the square of the velocity, the water from the suction pipe rushes in to fill up the vacuum, and thus a constant stream of water is discharged. The great advantage of centrifugal pumps lies in the fact that the water is kept in constant motion from the time it enters into the suction pipe till its exit from the discharge. In reciprocating pumps the water is stopped at the end of each stroke, consequently the *vis-viva* that remains in the water is destroyed, and a large waste of power is the result. We have just completed on this principle two of the largest pumps in the world. They are capable of throwing 250 tons of water per minute, and are to be employed for reclaiming a large surface of land from the sea in Denmark.

We shall now proceed to consider the improved centrifugal pump in combination with engines and surface condensers. The quick speeds at which centrifugal pumps require to be driven for high lifts necessarily prevented their adoption in many cases where the speeds of existing machinery was very slow, the power absorbed in getting up the required speed by countershafts being often greater than that required to drive the pump, and the pumps were often condemned in consequence. To remedy this defect we turned our attention to the manufacture of a steam engine in combination with a pump that would run at a high rate of speed without getting out of order. We succeeded in this beyond our expectations. The pump and engine are bolted on one deep bedplate; the cylinder is 6in. diameter, and 1½in. stroke. The piston and piston rod is of forged steel in one piece. The crosshead and connecting rods are also of steel. The crank shaft is forged out of one solid piece of steel, together with the crank and crank pin. We claim no particular originality in the construction of these engines; and if there is any merit attached to the design, it is solely on account of our combining many well tried principles. Attached to the crank is a most ingenious contrivance for lubricating the cran pin. We believe the idea came from France, but we are not aware that it has been applied in this country by any firm save ourselves. The diagrams (see Figs 3 and 4) explain the apparatus. A hollow brass cup with a small hole in the top is attached to a flat piece of brass plate, the length of the plate being the same as the throw of the crank, the end of the plate is screwed to the end of the crank pin, and a hole sufficiently large to admit the oil is drilled from the cup to the centre of crank pin, with a recess to admit the oil to the bearing. As the crank revolves, the centre of the cup being on the centre line of rotation remains on one spot, and no matter how quick the engine goes, the hole in the cup never alters its position, so that oil can always be put into the cup which the centrifugal action instantly forces up the hole into the plate. As the cup is sufficiently large to contain a supply of oil, the crank pin is kept properly lubricated, a most important disideratum in quick speed engines, as all practical engineers well know.

FIG. 3.

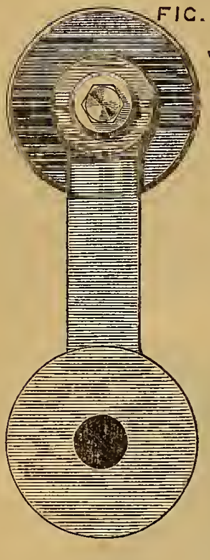


FIG. 4.

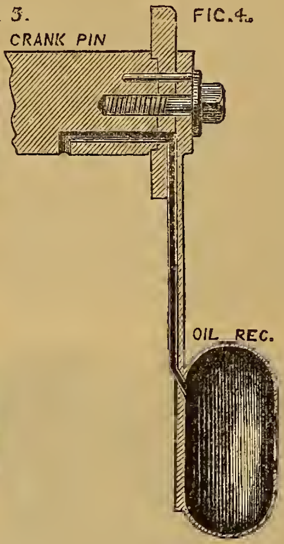
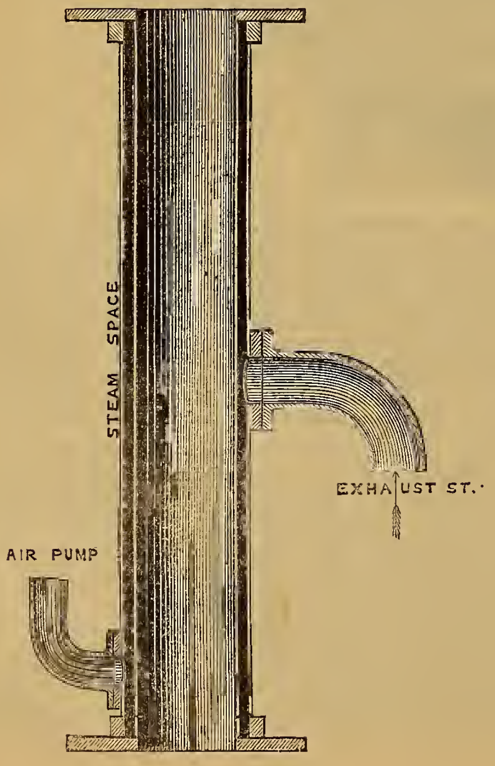


FIG. 5.



To give an instance of the extraordinary velocity at which it is possible to drive a steam engine, we may state that with a boiler pressure of 60lb. we ran this engine to 1,400 revolutions or over 1,000ft. of piston per minute with a 4½ inch stroke. Of course this was for a very short time, and when the pump was not throwing water. A mechanical counter registered the speed by making a pencil mark on a revolving cylinder covered with paper, each mark registering 100 revolutions. With 500 revolutions per minute of engine, and a boiler pressure of 60lb., the pump discharged 600 gallons of water 55ft. high in a constant stream. The size of engine pump and bed plate does not exceed one square yard. To render the engine and pump as economical in the consumption of fuel as possible, we looked for some means of doing this without a complication of parts, as it is perfectly impossible to make a good quick speed engine complicated; and we have no hesitation in saying that the plan we adopted is both simple and efficient. We form the suction or discharge pipe for a portion of its length immediately above or below the pump of copper; outside of this we put another pipe, so much larger than the inner one as to leave a steam space between. The pipes are connected together, so as to form a steam-tight chamber. The exhaust pipe from the engine communicates with this chamber and a small force pump working from the crank shaft is connected by means of a pipe to the bottom of the condenser. The principle will easily be understood by the following explanations, and by referring to Fig 5. When the engine is started the exhaust steam blows into the copper chamber, where it is instantly condensed. The large body of cold water passing through the pipe at a high velocity, keeping the condenser case quite cold, and almost without any perciptible increase in its temperature. The small pump draws the condensed water away from the condenser, and pumps the water back into the boiler, thus keeping up a supply of pure water. It is obvious that a great saving of fuel must result from this mode of condensing as a surface of 3ft. square is sufficient to condense the steam for every nominal horse power. In many cases for manufacturers' use it would be of considerable service to have the water slightly warmed, and by this means it can be done without any expense. A condenser pipe can also be attached to a centifugal pump, worked by an ordinary high pressure engine, and the exhaust pipe be carried into the steam chamber; the power of the engine will be thus increased for a small sum. For use on board ship in supplying water to the surface condensers, the combined engine and pump is beginning to take a prominent position. Till very recently, reciprocating, or awkwardly made centrifugal pumps, were driven from the screw or paddle wheel shaft to force the water through the condensers. But this is a great mistake, especially in regard to the latter machines, and for the following reasons: In the first place, a certain speed must be attained before a centrifugal pump can throw a drop of water, consequently, if the driving gear on the marine engines is arranged to work the pump at the proper speed when the engines are going at full power, no water would be thrown if the engines are going half speed. If, on the other hand, the pump is arranged to work when the engines are going half-speed, an enormous amount of power will be wasted when the ship is at full speed. In the second place, when the engines are first started no water will be thrown into the condensers at all, or when a ship is struck by a sea the same fault will exist. At present, in marine engines fitted with surface condensers, Her Majesty's Government insists upon having an auxiliary jet injector at a great increase in price. By having a separate combined engine and pump, these objections are obviated, as a large body of water can be passed into the condenser, and an instant vacuum be produced, even on the first stroke of the large engines; in fact, the pump can be regulated to throw a very large or a very small quantity of water as may be required. Many marine engineers put diaphragms into their condensers, which retard the flow of the water. The reason given for this is that it does not take so much power to drive the pumps. Our experience has taught us that this is a great mistake; it takes much less power to drive a large body of cold water through the condensers than is wasted by an insufficient vacuum being obtained, as is necessarily the case where the water does not circulate rapidly in the condensers. The pumping engine can also be arranged to pump from the bilge into the sea, from the sea on to the decks in case of fire, or for washing, and also for supplying the water to the boilers, and doing away with the donkey engine. In the latter case a force pump is worked from an eccentric on the crank shaft. We have now given you a short account of our improved centrifugal pumps, and a few of their applications, and hope it may have proved of some interest.

We much regret that owing to the very short time we have had to prepare this paper, we have not been able to give the subject the attention it deserves, nor have we had time to put together a mass of evidence as to the value of these inventions, which we could have readily procured had the time for preparation not been so limited.

At the conclusion of the paper, Professor Rankine made some satisfactory remarks, in which he was understood to say that the pump under notice was remarkable as being the application of known correct principles in hydraulics in an ingenious and mechanical manner.

A discussion then followed between Mr. Thorold, of Norwich, and another engineer, upon the respective merits of this pump and Appold's pump, Mr. Thorold advocating the Gwynne pump; after which the

Vice-President made some concluding remarks, in which he intimated that whatever differences of opinion there might be as to various principles, there could be no doubt that there were evidences of great mechanical skill and scheming in these machines, especially the combined pump and engine.

Mr. Wm. Smith, C.E., also bore testimony to the efficiency in combination with the engine, and spoke generally of the efficiency of Messrs. Gwynne's invention.

## ON THOMPSON'S ROAD STEAMER.

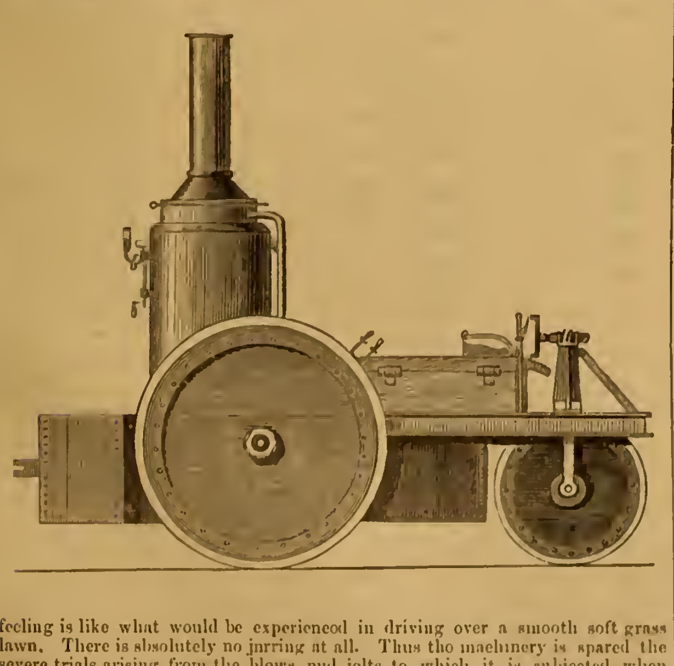
By Professor Archer.

This road steamer has wheels made of a material which at first sight does not look a very likely substance to stand the heavy work they are subjected to. The tires are made of bands of vulcanised india-rubber about 12in. wide and 5in. thick. Incredible as it may appear, this soft and elastic substance not only carries the great weight of the road steamer without injury, but they pass over newly broken road metal, broken flints, and all kinds of sharp things, without even leaving a mark on the india-rubber. They do not sink into the road in the least degree. They pass over stones lying on the surface without crushing them. Those soft and elastic tires resemble in some degree the feet of an elephant. Both the camel and elephant have very large soft cushions in hard hoofs, and no other animal can stand so much walking over hard roads as they can accomplish.

The power required to propel the road steamer is very much less than what would be required if the tires were hard and rigid. They do not crush nor sink into the roadway. The machine, as it were, floats along the india-rubber, and all the power used in crushing and grinding the stones under rigid tires is entirely saved. It might at first sight be supposed that it would take a great deal of power to propel a heavy carriage on soft tires; but if the tires are elastic as well as soft, the power used in compressing the tire in front of the wheel is nearly all given back as the elastic tire expands behind the wheel.

The india-rubber tires require scarcely any more power to propel them over soft bad roads or over loose gravel roads than on the best paved streets. The reason of this is quite obvious: they do not sink into roads, and do not grind down the stones in the least degree.

Trials have been made at Leith by running the road steamer across a soft grass field, in which an ordinary steam carriage would certainly have sunk. The way it ran through the grass, without even leaving a track, was very remarkable; but when it made for a part of the field which had just been covered with loose earth to the depth of one or two feet, and ran straight across, and then back through the deep soft soil, the surprise of those present was great indeed. The weight of the road steamer is between four and five tons; and yet the wheels in passing over the loose earth compressed it so little that a walking stick could easily be pushed down in the track of the wheels without any exertion. It is quite clear that one of the great difficulties farmers have had to contend with in using steam engines for ploughing is now removed, for the road steamer will run through any field, even when newly ploughed, without any difficulty. After various evolutions, showing the ability of the road steamer to run about where there were no roads, it passed out into the street, and, taking a large omnibus full of passengers in tow, it proceeded up the Bonnington-road to Messrs. Gibson and Walker's mills, where it took a large wagon, weighing with its load of flour about ten tons,* up a steep lane full of holes and ruts, and rising with a gradient of 1 in 20. It was obvious that the road steamer was able to do a great deal more than it had to do in this trial. The bite on the road is something marvellous, and the easy way in which it floated along on its soft and elastic tires was very curious. When riding on the road steamer the feeling is like what would be experienced in driving over a smooth soft grass lawn. There is absolutely no jarring at all. Thus the machinery is spared the severe trials arising from the blows and jolts to which it is subjected when mounted on common wheels. There is, incredible as it may appear, no appearance of wear on the india-rubber tires. The original surface which the rubber had when it left the manufactory is still visible.



The steamer which was the subject of the experiments had another specialty besides the wheels. It was fitted with a vertical boiler, which is one of the most economical steam generators yet produced. Externally the boiler looks very much like others of vertical construction; but internally it is entirely different. Its powers may be illustrated by giving the result of a series of trials made in contrast with a common locomotive boiler and an upright boiler of the ordinary kind. The latter evaporated 3·66lbs. of water for each pound of inferior Scotch coal burned; the locomotive boiler 4·13lbs. of water for each pound of coal; and the new boiler 4·68lbs. of water for a like expenditure of fuel. In contrasting the heating surface the new boiler had a still greater superiority. With 63ft. of heating surface it evaporated 15½ cubic feet of water per hour. The common vertical boiler, with 72ft. of surface, evaporated 14 cubic feet of water per hour; and the locomotive boiler, with 137ft. of heating surface, evaporated 15ft. of water per hour. This shows the new boiler to possess a very decided advantage.

The tractive powers of the machine have surpassed all expectation. It was constructed to drag an omnibus, weighing, with its load of say thirty passengers, about four tons, on a level road, but its powers are so greatly in excess of this task, that no load yet placed behind it has fully tested its power. An opportunity was offered which was confidently expected would show the limits of its capabilities. A huge steam boiler, weighing with its truck between twelve and thirteen tons, had to be dragged up a hill rising 1 in 12. The little road steamer was chained to the truck, and steadily drew the great boiler to the top of the hill, the india-rubber wheels biting the ground in the most perfect manner; there was not the least sign of slipping. The boiler was drawn from the works of Messrs. Hawthorn and Company along the Junction-road, and then up the hilly Bonnington-road, to the flour mills of Messrs. Gibson and Walker. In its progress the road steamer had to draw its great load over all kinds of road. Nothing seemed to affect the bite of the india-rubber tires. The road was so slippery from the frost that horses had the greatest difficulty in keeping on their legs, but no difficulty was found in going over the glazed surface with the india-rubber wheels. India-rubber does not slip even on ice, as may be easily ascertained by trying to slide in a pair of india-rubber goloshes.

A number of trials have just been completed with a powerful road steamer which has been constructed for hauling wagons loaded with coffee over the hilly roads in the island of Ceylon. This road steamer has two cylinders, each 7½in. diameter by 10in. stroke. and a vertical "pot" boiler 3ft. diameter by 7½ft. high. The engine is arranged by means of spur gearing to make either six or fifteen revolutions, as may be desired, for each revolution of the driving wheels. This road steamer weighs, with water and coal for two hours' work, about 8½ tons. It was intended to haul twelve tons gross weight up gradients of 1 in 16. It was found on trial that it was capable of doing a great deal more than the stipulated amount of work. It was first tested by going up a very crooked and steep street in Edinburgh, viz., Cockburn-street, with a wagon in tow weighing 2¾ tons. This street rises with a gradient in some places of 1 in 8, but the road steamer went up with the greatest ease.

The next trial was of a very severe kind. Four heavy wagons, constructed to carry 5¼ tons of coals each, were attached to the road steamer. Each wagon weighed when empty 2¾ tons. With this train in tow the road steamer ran from Leith to New Battle collieries, a distance of about eleven miles. The wagons were then loaded with 5¼ tons of coals each, and the road steamer drew the whole four from New Battle to Leith over roads with gradients rising 1 in 16 in several places. The total weight of coals was twenty-one tons, if to this the weight of the four wagons is added it makes a gross weight of thirty-two tons, and including the weight of the road steamer the weight of the whole train was upwards of forty tons. With this train of 90ft. long no difficulty was found in passing through the most crowded streets of Edinburgh and Leith in the middle of the day and in the midst of a great stream of ordinary traffic. The india-rubber tires are durable beyond all conception, and they are not in the least affected by either heat, cold, or moisture.

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## CORONERS' INQUESTS AND BOILER EXPLOSIONS.

By Lavington E. Fletcher, C.E.

The most casual reader of the public newspapers cannot fail to be struck with the frequency of steam boiler explosions and the great amount of life sacrificed by them. Sometimes as many as ten, and even twenty, lives have been sacrificed by a single explosion. On referring to the records of the association for the prevention of steam boiler explosions, in operation at Manchester, under the presidency of William Fairbairn, Esq., C.E., F.R.S., L.L.D., &c., it appears that since the commencement of 1855, up to the 31st of July last, there occurred in different parts of the kingdom as many as 464 explosions, by which 789 persons were killed and 924 injured. This, however, is by no means the total number of lives sacrificed. In the earlier years of the association's operations, such complete records were not kept of all the explosions occurring throughout the United Kingdom, as has been the case more recently; added to which there can be little question that some have always escaped its vigilance, so that the whole number occurring from year to year has never been fully reported. The list just given, however, of the lives sacrificed is a sufficiently serious one to excite attention, while it may be stated, in round numbers, that about fifty steam boiler explosions occur on an average every year, resulting in the loss of seventy lives.

Explosions have too frequently been attributed to unaccountable and mysterious causes, so that they have been regarded by some as catastrophes which science could not grapple with, or caution prevent. The experience of the association already named, proves, however, that this view is totally incorrect, and that explosions arise from the simplest causes, and are perfectly within the grasp of common knowledge and common care to prevent. Many explosions

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* This appears to be a rather unusually heavy wagon.—Ed. Artizan.

arise from the use of old worn-out boilers, which have been allowed to be so eaten away either by external or internal corrosion, that the plates have become reduced to the thickness of a sheet of brown paper, when explosion has taken place at the ordinary steam pressure, simply from the dilapidated condition of the boiler. Others arise from collapse of the furnace tubes, through the neglect of the simple precaution of strengthening them with encircling hoops, flanged seams, or other suitable provision. Others, again, are due to weak manholes, or defective fittings, while some occur through the carelessness of the attendants in holding down the safety-valves, or neglecting the water supply. Whatever may be the precise circumstances of each case, the cause of every one may be given in one word, viz., *neglect*, while the simple preventive is *care*.

At the inquiries conducted by coroners as to the cause of explosions, the public naturally look for all the facts of the case to be brought out, so that they may not only be informed that so many poor fellows have been blown to death, and so much property damaged, but also instructed as to the true cause of the catastrophe, so that a recurrence may be avoided. These hopes are, however, as a rule grievously disappointed. The public are misguided rather than instructed, and instead of any practical suggestions being given for the prevention of similar disasters, they are generally stated to be perfectly unaccountable and accidental that no one is to blame, and that nothing could have prevented the catastrophe. The evidence admitted is of the most absurd and frivolous character. In many cases, too numerous to refer to in detail on the present occasion, witnesses are adduced to prove that the exploded boiler which had just been rent in fragments was a thoroughly sound one—indeed the best of the series—and perfectly safe at the pressure at which it was worked, or at twice or three times as high; so that the explosion was perfectly mysterious. On one occasion a witness attributed the explosion of a weak and malconstructed boiler to wind in the pipes, produced by lifting the safety-valves; on another occasion one of the witnesses attributed the explosion to the formation of an explosive gas within the boiler which, he thought, had become ignited by a flame from the furnace leaping through a crack in the plates. In another case an explosion was attributed to the steam of one boiler mixing with that of another at a different pressure, which, it was imagined, would form an explosive compound. Another explosion was attributed to the water being allowed to rise 2 or 3in. above its ordinary level, the witness stating that "water was very turbulent, and would burst a boiler much quicker than steam;" adding that, as the boiler was but partially clothed, he thought that atmospheric influences, "had a good deal to do with the explosion in consequence of the boiler being but half clad on a cold frosty morning." Many other similar cases might be given, but these will suffice to show the character of evidence too frequently given at coroners' inquests as to the cause of boiler explosions.

With such investigations it must be clear no progress can be made, and fatal boiler explosions recur with sad constancy.

There are, however, a few, though very few, exceptions to this rule; one of which occurred in the city in which this meeting of the association for the advancement of science is now held. The explosion in question happened about two years since, killing seven persons, and laying the premises in which it occurred in ruins. The cause of this sad disaster was simply that the boiler was a bad one, though new and made under special contract. This the jury plainly stated in their verdict; and the maker of the boiler had to pay heavy damages, to the amount, I believe, of £2,000. A few such verdicts would shortly rid the country of boiler explosions, and it is in behalf of such plain and out-spoken verdicts that this paper is written.

This paper does not by any means profess to follow out to the full the interesting and important subject of the cause of boiler explosions; but to call attention to the inadequacy of the investigations with regard to them usually made by coroners, and to advocate these being more searching and complete. To accomplish this the following plan is proposed:—

Let every coroner be empowered and instructed, when holding an inquiry on a boiler explosion, to call in two competent and perfectly independent scientific engineers to investigate the cause of the explosion, and report to the jury thereon; these engineers to visit the scene of the explosion, and examine the fragments of the boiler, to attend the inquest, hear the evidence given by parties concerned in the charge of the boiler, and aid the coroner in conducting the inquiry; while, in addition, they should report to him either jointly or severally on the cause of the explosion, and accompany their report with suitable scaled drawings of the exploded boiler, showing its original construction, and the lines of fracture, as well as the flight of the parts, as far as they can be ascertained. The inquest to be open to the public, under the control of the coroner, and also to the press, both scientific and general, so that the entire proceedings may have as wide a circulation as possible. A full account of the inquiry, including the engineers' reports, accompanied with the scaled drawings, to be printed and deposited at the "patent office," and to be accessible both to the purchase and inspection of the public, as is at present the case with the specifications of patents. Also a report of each inquiry to be sent to the members of both Houses of Parliament as issued.

Such a course, it is thought, would stimulate coroners to make searching and full investigations; and if at the outset incompetent engineers were selected by the coroner, the publicity given to their proceedings as recommended above would bring them under the criticism of the press and general engineering public, which, it is thought, might be relied on, as a corrective. If full investigations were brought to bear upon boiler explosions; and those steam-users, who produce them by working on old worn-out boilers, were fairly brought to the bar of public opinion, and compelled, when necessary, to compensate the widow and orphan for the results of their negligence, the mystery of boiler explosions would soon be dispelled, and their occurrence put a stop to.

The frequency and fatality of steam boiler explosions has frequently been used as a plea for a Government system of compulsory inspection, and juries have frequently coupled with their verdicts a recommendation to this effect. There are, however, serious objections to this course. Such a system of inspection must necessarily be carried on by rule, and, however wisely such code of rules might be framed, and however liberally carried out, it would be impossible to prevent its proving a harass to the individual steam-user, and an impediment to progress; so that it should only be adopted as a last resort. These objections would be avoided by confining Government action to investigations carried out by means of coroners' juries consequent on fatal explosions. Under this system, the steam-user would be left perfectly free as regards the management of his boilers; but would be held responsible for results, and the Government would not interfere until a fatal explosion had occurred, when they would then make a faithful investigation, and freely report the facts. It is firmly believed that faithful investigations and plain speaking would do much to put down explosions in the course of a single year, and, therefore, the plan suggested for rendering coroners' inquests with regard to boiler explosions of greater efficiency is commended to the consideration of this section of the British Association for the Advancement of Science, believing that it would prove a practical step towards the prevention of the present loss of life through the constant recurrence of steam boiler explosions, and render a system of compulsory Government inspection unnecessary.

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## ON THE RECENT PROGRESS OF STEEL MANUFACTURE.

By Frederic Kohn, C.E.

The following are the tables referred to in Mr. Kohn's paper given in The Artizan of last month:—

### NEWPORT STEEL WORKS.

No. Furnace. Monday night, July 20th, 1868.

| Times of Charging. | Charges. | | | | Make. | |
|---|---|---|---|---|---|---|
| | Swed. Pig Iron. | K. and J. Pud. Bars. | Hematite Iron-stone. | Spiegel Eisen. | Ingot Steel. | Scrap Steel. |
| O'clock. | lb. | lb. | lb. | lb. | lb. | lb. |
| 8·0 | 6180 | | | | | |
| 9·40 | ... | 224 | | | | |
| 10·0 | ... | 224 | | | | |
| 10.30 | ... | 224 | | | | |
| 11.0 | ... | 224 | | | | |
| 11.45 | ... | 224 | 15 | | | |
| 12.30 | ... | 224 | 15 | | | |
| 1 0 | ... | 224 | 15 | | | |
| 1.40 | ... | 224 | 15 | | | |
| 2.40 | ... | 224 | | | | |
| 3.20 | ... | 224 | | | | |
| 4.0 | ... | 224 | 15 | | | |
| 4.40 | ... | 224 | | | | |
| 5.30 | ... | 224 | 15 | | | |
| 6.10 | ... | 224 | | | | |
| 7.15 | ... | ... | ... | 224 | | |
| 8.5 | ... | ... | ... | 112 | | |
| 8.45 | ... | ... | ... | 224 | | |
| 9.0 | ... | ... | Soft | steel... | 4962 | 116 |
| 5466 lb. | 1660 | 3136 | 90 | 560 | 4962 | 116 |
| cwt. lb. oz. | cwt. | cwt. | lb. oz. | cwt. | cwt. lb. oz. | cwt. lb. oz. |
| 48 3 6 | 15 | 28 | 3 6 | 5 | 44 1 6 | 1 0 4 |

Loss.................................. 7·10 per cent.

No. Furnace. Thursday, July 30th, 1868

| Times of Charging. | Charges. | | | | | Make. |
|---|---|---|---|---|---|---|
| | Cleveland Grey Pig Iron. | K & J Pud. Bars. | K & J Patent Slag. | Ilmenite. | Spiegel-Eisen. | Scrap Steel. |
| O'clock. | lb. | lb. | lb. | lb. | lb. | lb. |
| 5.0 | 2240 | | | | | |
| 6.30 | ... | ... | 280 | | | |
| 7.5 | ... | ... | 280 | | | |
| 8.5 | ... | 224 | | | | |
| 8.35 | ... | 224 | | | | |
| 9.5 | ... | 224 | | | | |
| 9.30 | ... | 224 | | | | |
| 10.0 | ... | 224 | | | | |
| 10.30 | ... | 224 | | | | |
| 11.5 | ... | 224 | | | | |
| 11.45 | ... | 224 | | | | |
| 12·20 | ... | 224 | | | | |
| 12.55 | ... | 224 | | | | |
| 1·30 | ... | 224 | | | | |
| 2.0 | ... | 224 | ... | 35 | | |
| 2.30 | ... | 224 | ... | 35 | | |
| 3.0 | ... | 224 | ... | 35 | | |
| 3.30 | ... | ... | ... | 35 | | |
| 4.0 | ... | ... | ... | 35 | | |
| 4.25 | ... | ... | ... | 35 | | |
| 6.15 | ... | ... | ... | ... | 448 | |
| 7.0 | ... | ... | ... | .. | ... | 5446 |
| 6594 lb. | 2240 | 3136 | 560 | 210 | 448 | 5446 |
| cwt. lb. oz. | cwt. | cwt. | cwt. | cwt. lb. oz. | cwt. | cwt. lb. oz. |
| 58 3 14 | 20 | 28 | 5 | 1 3 14 | 4 | 48 2 14 |

Remarks :—Cold short, brittle (not to be smelted in steel furnace).
Loss, 17·41 per cent.

No. 1 Furnace. Wednesday night August 5th, 1867.

| Times of Charging. | Charges. | | | | | Make. | |
|---|---|---|---|---|---|---|---|
| | Swed. Pig Iron. | K & J Pud. Bars. | Scrap Steel. | Hematite Iron-stone. | Spiegel-Eisen. | Ingot Steel. | Scrap Steel. |
| O'clock. | lb. | lb. | lb. | lb. | lb. | lb. | lb. |
| 12. | 1680 | ... | .. | ... | 560 | | |
| 1.35 | ... | ... | 224 | | | | |
| 2. | ... | 448 | 224 | | | | |
| 2.30 | ... | 448 | | | | | |
| 3.5 | ... | 448 | | | | | |
| 3.10 | ... | 448 | | | | | |
| 4.15 | ... | 448 | | | | | |
| 4.50 | ... | 448 | | | | | |
| 5.25 | ... | 448 | | | | | |
| 6.5 | ... | 448 | | | | | |
| 6.45 | ... | 448 | | | | | |
| 7.30 | ... | 448 | | | | | |
| 8.30 | ... | 448 | ... | 28 | | | |
| 9.25 | ... | 448 | ... | 28 | | | |
| 10.45 | ... | 224 | | | | | |
| 11.15 | ... | ... | ... | ... | 224 | | |
| 12.0 | ... | ... | ... | Soft | steel ... | 6972 | 448 |

Remarks: Very soft. Loss : 12·32 per cent.

No. Furnace. Tuesday, Aug, 4, 1868.

| Times of Charging. | Charges. | | | | | Make. | |
|---|---|---|---|---|---|---|---|
| | Millom Hematite Grey Pig Iron. | K & J Billets Pud. Bars. | Hematite Iron-Stone. | Ilmenite. | Spiegel-Eisen. | Ingot Steel. | Scrap Steel. |
| O'clock. | lb. | lb. | lb. | lb. | lb. | lb. | lb. |
| 9.5 | 1344 | ... | ... | ... | 248 | | |
| 10.15 | ... | 224 | | | | | |
| 11. | ... | 224 | ... | 56 | | | |
| 11.30 | ... | 224 | | | | | |
| 11.50 | ... | 224 | ... | 56 | | | |
| 12.15 | ... | 224 | | | | | |
| 1. | ... | 224 | | | | | |
| 1.45 | ... | 224 | | | | | |
| 2.15 | ... | 224 | | | | | |
| 3.20 | ... | 224 | 56 | | | | |
| 4.45 | ... | 224 | 56 | | | | |
| 6. | ... | 224 | | | | | |
| 6.45 | ... | 224 | | | | | |
| 7.20 | ... | 224 | | | | | |
| 7.45 | ... | ... | ... | ... | 224 | | |
| 8.20 | ... | ... | ... | ... | 244 | | |
| 9. | ... | ... | ... | ... | ... | 4536 | 124 |
| 5376lb. | 1344 | 2912 | 112 | 112 | 896 | 4536 | 124 |
| 48cwt. | 12cwt. | 26cwt. | 1cwt. | 1 cwt. | 8 cwt. | 40c. 2lb. | 1c. 12lb. |

Remarks : Rails. Loss : 17·02 per cent.

No. Furnace. Wednesday, August 5th, 1868.

| Times of Charging. | Charges. | | | | Make. | |
|---|---|---|---|---|---|---|
| | Swed. Pig Iron. | K & J Scrap Pud. Bars. | Hematite Iron-Stone. | Spiegel-Eisen. | Ingot Steel. | Scrap Steel. |
| O'clock. | lb. | lb. | lb. | lb. | lb. | lb. |
| 5.15 | 1680 | | ... | 1008 | | |
| 7.10 | ... | 448 | | | | |
| 7.50 | ... | 448 | | | | |
| 8.30 | ... | 448 | | | | |
| 9.50 | ... | 448 | | | | |
| 10.35 | ... | 448 | | | | |
| 11.15 | ... | 448 | | | | |
| 12.5 | ... | 448 | | | | |
| 12.55 | ... | 448 | | | | |
| 1.55 | ... | 448 | | | | |
| 2.30 | ... | 448 | | | | |
| 3.20 | ... | 448 | | | | |
| 4.10 | ... | 224 | 28 | | | |
| 4.40 | ... | 224 | 28 | | | |
| 5.15 | ... | 244 | 28 | | | |
| 5.50 | ... | 224 | 28 | | | |
| 6.35 | ... | 224 | | | | |
| 7.10 | ... | 244 | | 244 | | |
| 7.50 | | | | | | |
| 8.30 | ... | ... | Soft | steel ......... | 8624 | 304 |
| 9764lb. | 1680 | 6720 | 112 | 1252 | 8624 | 304 |
| cwt. lb. oz. | cwt. | cwt. | cwt. | cwt. lb. oz. | cwt. | cwt. lb. oz. |
| 87 0 20 | 15 | 60 | 1 | 11 0 20 | 77 | 2 2 24 |

Remarks : Very soft. Loss : 8.50 per cent.

## NAVAL MAL-ADMINISTRATION.

(*Concluded from page* 206).

Class 7.—*Above* £2000 *and under* £4000.—*Twelve ships, the net amount realised for each varying from* £2,005 2*s.* 10*d. to* £3,775 15*s.* 10*d.*

| | Tons. | Gross Amount of Money obtained for each Ship. | Amount paid to each Purchaser by the Admiralty, in re-purchasing Stores bearing "Broad Arrow." | Net Amount of Money obtained for each Ship. | Estimated Value of Hull and Machinery, as reported by Dockyard Officers. |
|---|---|---|---|---|---|
| | | £ s. d. | £ s. d. | £ s. d. | £ s. d. |
| *ampson*, paddle frigate | 1299 | 4574 0 0 | 2568 17 2 | 2005 2 10 | 4586 0 0 |
| *Vixen*, paddle sloop | 1054 | 3740 0 0 | 1693 19 11 | 2046 0 1 | 13670 0 0 |
| *Impérieuse*, screw frigate | 2358 | 6925 0 0 | 4719 0 9 | 2205 19 3 | 6450 0 0 |
| *Sidon*, paddle frigate | 1316 | 5100 0 0 | 2886 9 7 | 2213 10 5 | 5035 0 0 |
| *Vulture*, paddle frigate | 1191 | 4010 0 0 | 1737 8 10 | 2272 11 2 | 4900 0 0 |
| *Majestic*, screw line-of-battle ship | 2566 | 7160 0 0 | 4749 12 3 | 2410 7 9 | 11511 0 0 |
| *Plover*, screw gun-vessel | 426 | 2600 0 0 | 295 19 3 | 2304 0 9 | *3257 0 0 |
| *Penelope*, paddle frigate | 1616 | 5750 0 0 | 3444 1 0 | 2305 19 0 | 6039 3 0 |
| *Leander*, screw frigate | 2760 | 7350 0 0 | 4427 6 8 | 2922 13 4 | 14995 0 0 |
| *Leopard*, paddle frigate | 1406 | 6005 0 0 | 2986 11 2 | 3018 8 10 | 6253 0 0 |
| *Andromeda*, sailing, 5th rate | 1215 | 4500 0 0 | 744 4 2 | 3755 15 10 | 5000 0 0 |
| | 17207 | 57714 0 0 | 30253 10 9 | 27460 9 3 | 81696 0 0 |

* Including spare gear.

Class 8.—*Four ships, the net amount realised for each varying from* £4342 16*s.* 9*d. to* £8929 12*s.* 6*d.*

| | Tons. | Gross Amount of Money obtained for each Ship. | Amount paid to each Purchaser by the Admiralty in re-purchasing Stores bearing "Broad Arrow." | Net Amount of Money obtained for each Ship. | Estimated Value of Hull and Machinery as reported by Dockyard Officers. |
|---|---|---|---|---|---|
| | | £ s. d. | £ s. d. | £ s. d. | £ s. d. |
| *Victor*, screw gun vessel | 859 | 9375 0 0 | 445 7 6 | 8929 12 6 | 8830 0 0 |
| *Orion*, screw, line-of-battle-ship | 3281 | 8650 0 0 | 3769 5 6 | 4880 14 6 | 17104 0 0 |
| *Euryalus*, screw frgate | 2371 | 6450 0 0 | 1096 13 4 | 5353 6 8 | 6600 0 0 |
| *Termagant*, screw frigate | 1547 | 5400 0 0 | 1057 3 3 | 4342 16 9 | 4200 0 0 |
| | 8058 | 29875 0 0 | 6368 9 7 | 23506 10 5 | 36734 0 0 |

Class 9.—*Vessels sold abroad. None of these ships have any estimated value affixed to them, nor are there any deductions for stores re-purchased consequently the gross and net amounts are the same.*

| | Tons. | Amount obtained for each ship. | | Tons. | Amount obtained for each ship. |
|---|---|---|---|---|---|
| | | £ s. d. | | | £ s. d. |
| *Brune*, late steamer | 267 | 25 0 0 | *Alligator*, sailing, 6th rate | 500 | 1258 5 6 |
| *Netley*, sailing cutter | 122 | 70 8 4 | *Sheldrake*, screw gun boat | 234 | 2750 0 0 |
| *Africa*, sailing, 5th rate | 946 | 337 6 8 | *Coromandel*, paddle tender | 303 | 3163 18 4 |
| *Columbia*, late steam vessel | 361 | 500 0 0 | *Hercules*, sailing, 3rd rate | 1750 | 3781 10 10 |
| *Saracen*, sailing surveying vessel | 75 | 594 7 3 | *Minden*, sailing, 3rd rate | 1721 | 3995 0 0 |
| *Spy*, sailing sloop | 320 | 619 14 2 | *Waterman*, paddle, distilling vessel | 141 | 4132 1 4 |
| *Sapphire*, sailing, 6th rate | 606 | 710 0 0 | *Beagle*, screw gun vessel | 477 | 5500 0 0 |
| *Kestrel*, screw gun boat | 238 | 743 15 0 | *Cowper*, paddle tender | 342 | 10218 9 4 |
| *Staunch*, screw gun boat | 235 | 1000 0 0 | | | |
| *Bittern*, sailing sloop | 484 | 1000 5 2 | | | |
| *Isis*, sailing, 5th rate | 1321 | 1098 7 0 | | 10543 | 41498 8 11 |

Class 10.—*Under £100. No deductions for Stores re-purchased. Estimated value given in only four instances.*

| | Tons. | Gross Amount of Money obtained for each Ship. | Estimated Value of Hull as reported by Dockyard Officers. |
|---|---|---|---|
| | | £ s. d. | |
| *Pelter*, sailing brig | 184 | 32 0 0 | £74 0 0* |
| *Forester*, sailing lighter | 80 | 93 0 0 | From £12 to £65† |
| *Gulnare*, sailing surveying vessel ... | 31 | 76 13 0 | 77 0 0 Hull Fixtures and Stores. |
| *Busy* | | 52 5 6 | |
| *Beresford*, watch vessel | 180 | 90 0 0 | |
| *Good Portent* | | 40 14 9 | |
| *Princess Augusta*, watch vessel | 71 | 62 0 0 | |
| *Chance*, cutter | 58 | 70 0 0 | £50 to £55 |
| *Deptford*, lighter | 105 | 10 15 0 | |
| *Shark* | | 71 9 2 | |
| *Bantry*, cutter | 27 | 70 0 0 | |
| *Vega*, brig | 304 | 86 7 4 | |
| *Dove*, watch vessel | | 85 0 0 | |
| *Betsey* | | 23 16 0 | |
| *Lady Flora*, cutter | 21 | 76 13 7 | |
| *Neptune*, cutter | | 40 5 9 | |
| *Ann*, watch vessel | 24 | 76 13 8 | |
| | | 1057 13 9 | |

* Valued by an Auctioneer for Comptroller General of Coast Guard.
† Valued by Tradesmen for ditto.

Class 11.—*Above £100 and under £200. No deductions for stores re-purchased. Estimated value given in one instance only.*

| | Tons. | Gross Amount of Money obtained for each Ship. | Estimated value of Hull as reported by Dockyard Officers. |
|---|---|---|---|
| | | £ s. d. | £ s. d. |
| *Rose*, cutter | | 103 5 0 | |
| *Kite*, watch vessel | 156 | 110 0 0 | |
| *Scout*, cutter | 24 | 115 0 0 | |
| *King George*, cutter | 36 | 115 0 0 | |
| *Wellington*, cuttor | 143 | 120 0 0 | |
| *Princess Royal*, cutter | | 125 4 6 | |
| *Squirrel* | | 127 17 10 | |
| *Amphitrite*, cutter | 60 | 129 13 9 | |
| *Hamilton*, cutter | 59 | 136 15 0 | |
| *Lady of the Lake*, cutter | 22 | 136 15 0 | |
| *Captain Cook* | | 1[illegible]0 0 8 | |
| *Ann*, lighter | 67 | 161 0 0 | 110 0 0 |
| An old watch vessel at Barking .. | | 167 0 0 | |
| *Despatch*, cutter | 39 | 169 5 3 | |
| *Onyx*, cutter | 36 | 169 5 3 | |
| Two Junks | | 191 5 0 | |
| | | 2237 6 7 | |

Class 12.—*Above £200. No deduction for stores re-purchased.*

| | Tons. | Gross Amount of Money obtained for each Ship. | Estimated Value of Hull and Machinery as reported by Dockyard Officers. |
|---|---|---|---|
| | | £ s. d. | £ s. d. |
| *Amphion*, screw frigate | 1474 | 6600 0 0 | 6600 0 0 |
| *Wye*, screw store ship | 700 | 5070 0 0 | 4550 0 0 |
| *Collingwood*, screw line-of-battle ship | 2611 | 8531 0 0 | 17000 0 0 |
| *Sans Pareil*, screw line-of-battle ship | 2339 | 6620 0 0 | 12170 0 0 |
| *Woodlark*, sailing surveying vessel | 80 | 225 0 0 | |
| *Gertrude*, cutter | 37 | 229 12 3 | |
| *Sylvia*, sailing cutter | 70 | 253 8 0 | |
| *Desmond* | | 302 10 0 | |
| *Swift*, watch vessel | 164 | 330 1 6 | |
| *Cameleon*, cutter | 89 | 356 4 9 | |
| *Chance* | | 500 0 0 | |
| *Neptune* | | 1100 0 0 | |
| *Naiad*, sailing, 5th rate | 1020 | 1992 0 0 | |
| *Africaine*, sailing, 5th rate | 1173 | 2050 0 0 | 2050 0 0 |
| *Madagascar*, sailing, 5th rate | 1167 | 2551 19 0 | |
| *Arrogant*, steam frigate | 1872 | 6360 0 0 | 5130 0 0 |
| *Pelican*, screw sloop | 952 | 3500 0 0 | 3000 0 0 |
| *Vulcan*, screw troop ship | 1764 | 5500 0 0 | 5500 0 0 |
| | | 52071 15 6 | |

Class 13.—*Sold to the Chinese Government.*

| | Tons | Gross Amount of Money obtained for each Ship. | Net Amount of Money obtained for each Ship. | Estimated Value of Hull and Machinery as reported by Dockyd. Officers. |
|---|---|---|---|---|
| | | £ s. d. | £ s. d. | £ s. d. |
| *Africa*, screw sloop | 669 | 23800 0 0 | 23800 0 0 | 23800 0 0 |
| *Mohawk*, screw gun-vessel | 679 | 17150 0 0 and 2178 19 7 for stores left on board | 17150 0 0 | 17150 0 0 and stores 3000 0 0 |
| *Jasper*, screw gun-vessel | 301 | 8000 0 0 | 8000 0 0 | 8000 0 0 |
| | | 49250 0 0 | 49250 0 0 | 49250 0 0 |

Class 11.—*Sold to the Prussian Government.*

| | Tons | Gross Amount of Money obtained for each Ship. | Net Amount of Money obtained for each Ship. | Estimated value of Hull and Machinery as reported by Dockyd. Officers. |
|---|---|---|---|---|
| | | £ s. d. | £ s. d. | £ s. d. |
| *Niobe*, sailing, 6th rate ... | 1052 | 10520 0 0 and 5371 18 11 for stores left on board. | 10520 0 0 | 11520 0 0 hull & fixtures, and stores. |
| *Mosquito*, sailing sloop .. | 551 | 8102 0 0 and 3126 14 10 for stores left on board. | 8102 0 0 | 8102 0 0 |
| *Rover*, ditto | 551 | 8265 0 0 and 3198 15 10 for stores left on board. | 8265 0 0 | 8265 0 0 |
| | | 27187 0 0 | 27187 0 0 | 31187 0 0 |

* Includes stores—supposed £4,000 in valuation, but sold for £5,371 18s. 11d.

## ROYAL INSTITUTION OF GREAT BRITAIN.

### ON THE SOURCE OF LIGHT IN LUMINOUS FLAMES.

By Professor Frankland, F.R.S.

The most prolific source of error amongst mankind is the unquestioning acceptation of authoritative opinion. However much we may pride ourselves upon the sifting of the explanations of things by our own enlightened judgments it cannot be denied that the *ipse dixit* mode of settlement is still wonderfully frequent amongst us. Not only is this the case with the public in general, but even the cultivators of science are not entirely innocent of the same weakness.

The essential difference between a fact and a theory is not always appreciated with sufficient vividness. The statement that "16 parts by weight of oxygen unite with 2 parts of hydrogen to form water," is considered by many, for instance, as perfectly synonymous with the assertion that "1 atom of oxygen unites with 2 atoms of hydrogen to form water."

The existence of an imponderably ethereal medium filling all space is often regarded as equally certain with the presence of a gaseous envelope surrounding our globe.

The atomic theory and the hypothesis of an ethereal medium are, at present, absolutely necessary, the one to the progress of chemistry, the other to the further development of physics; but neither this circumstance nor the splendid discoveries made by their aid can establish their truth. A mathematician starting from false data is sure to arrive at a false result; but it is far otherwise with theory, for false theories can, and constantly do, conduct to true facts. Thus Columbus's counterpoise theory of the earth led to the discovery of America, although that theory was nevertheless essentially false.

The most sober worker in science cannot progress without the assistance of theory to co-ordinate his facts, and to lead him on to further research. It is here that even a false theory is invaluable, and it is only when the theory continues to be held after it has become opposed to facts, that it exercises a prejudicial influence upon the progress of science. Then it hinders rather than expedites the advance of the experimenter, and ought to be at once abandoned.

In pursuing the investigation forming the subject of this discourse, the speaker had been compelled thus to abandon a theory of the source of light in luminous flames, which he, in common with others, had derived from Davy's classical researches on flame.

Our text-books answer the question, *What is the source of light in a luminous gas or candle flame?* in the most positive and unanimous manner.

Selecting from some of the most celebrated, the following quotations may be made:—

"All our artificial lights depend upon the ignition of solid matter, in the intense heat developed by the chemical changes attendant on combustion."—*W. A. Miller.*

"Whenever hydrocarbons are imperfectly burnt, there is a deposition of carbon, and this temporary deposition of carbon is an *essential* condition for the production of the white light required in an ordinary flame."—*Williamson.*

"The illuminating power of the gas flame is therefore due to these *carbon particles*, which are afterwards burned nearer the border of the flame."—*Balfour Stewart.*

"The brightness or illuminating power of flame depends not only on the degree of heat, but likewise on the presence or absence of solid particles which may act as radiant points. A flame containing no such particles emits but a feeble light, even if its temperature is the highest possible."—*Watts.*

The speaker then proceeded to investigate a number of different flames: he showed that there are many flames possessing a high degree of luminosity, which cannot possibly contain solid particles. Thus the flame of metallic arsenic burning in oxygen emits a remarkably intense white light; and as metallic arsenic volatilizes at 180° C., and its product of combustion, arsenious anhydride, at 218° C., whilst the temperature of incandescence in solids is at least 500° C., it is obviously impossible here to assume the presence of ignited solid particles in the flame. Again, if carbonic disulphide vapour be made to burn in oxygen, or oxygen in carbonic disulphide vapour an almost insupportably brilliant light is the result; now fuliginous matter is never present in any part of this flame, and the boiling point of sulphur (440° C.) is below the temperature of incandescence, so that the assumption of solid particles in the flame is here also inadmissible. If the last experiment be varied by the substitution of nitric oxide gas for oxygen, the result is still the same; and the dazzling light produced by the combustion of these compounds is also so rich in the more refrangible rays, that it has been employed in taking instantaneous photographs, and for exhibiting the phenomena of fluorescence. Lastly, amongst the chemical reactions celebrated for the production of dazzling light, there are few which surpass the active combustion of phosphorus in oxygen. Now phosphoric anhydride, the product of this combustion, is volatile at a red heat,* and it is therefore manifestly impossible that this substance should exist in the solid form at the temperature of the phosphorus flame, which far transcends the melting point of platinum.

For these reasons, and for others which the speaker had stated in a course of lectures on Coal-Gas, delivered in March, 1867, and printed in the 'Journal of Gas Lighting,' he considered that incandescent particles of carbon are not the source of light in gas and candle flames, but that the luminosity of these flames is due to radiations from dense, but transparent hydrocarbon vapours. As a further generalization from the above-mentioned experiments, he was led to the conclusion that dense gases and vapours become luminous at much lower temperatures than aeriform fluids of comparatively low specific gravity; and that this result is to a great extent, if not altogether, independent of the nature of the gas or vapour, inasmuch as he found that gases of low density, which are not luminous at a given temperature when burnt under common atmospheric pressure, become so when they are simultaneously compressed. Thus mixtures of hydrogen and carbonic oxide with oxygen emit but little light when they are burnt or exploded in free air; but exhibit intense luminosity when exploded in closed glass vessels, so as to prevent their expansion at the moment of combustion.

In a communication just made to the Royal Society the speaker had described the extension of these experiments to the combustion of jets of hydrogen and carbonic oxide in oxygen under a pressure gradually increasing to twenty atmospheres. These experiments, which were conducted in the laboratory of the Royal Institution, were made in a strong wrought-iron vessel furnished with a thick glass plate of sufficient size to permit of the optical examination of the flame. The appearance of a jet of hydrogen burning in oxygen under the ordinary atmospheric pressure was exhibited. On increasing the pressure to two atmospheres, the previously feeble luminosity was shown to be very markedly augmented, whilst at ten atmospheres' pressure the light emitted by a jet about one inch long was amply sufficient to enable the observer to read a newspaper at a distance of two feet from the flame, and this without any reflecting surface behind the flame. Examined by the spectroscope, the spectrum of this flame is bright and perfectly continuous from red to violet.

With a higher initial luminosity the flame of carbonic oxide in oxygen becomes much more luminous at a pressure of ten atmospheres than a flame of hydrogen of the same size and burning under the same pressure. The spectrum of carbonic oxide burning in oxygen under a pressure of fourteen atmospheres is very brilliant and perfectly continuous.

If it be true that dense gases emit more light than rare ones when ignited, the passage of the electric spark through different gases ought to produce an amount of light varying with the density of the gas; and the speaker showed that electric sparks passed as nearly as possible, under similar conditions, through hydrogen, oxygen, chlorine, and sulphurous anhydride, emit light, the intensity of which is very slight in the case of hydrogen, considerable in that of oxygen, and very great in the case of chlorine and sulphurous anhydride. On passing a stream of induction sparks through the gas standing over liquefied sulphurous anhydride in a strong tube at the ordinary temperature, when a pressure of about three atmospheres was exerted by the gas, a very brilliant light was obtained. A stream of induction sparks was passed through air confined in a glass tube connected with a condensing syringe, and the pressure of the air being then augmented to two or three atmospheres, a very marked increase in the luminosity of the sparks was observed, whilst on allowing the condensed air to escape, the same phenomena were observed in the reverse order.

Way's mercurial light was also exhibited as an instance of intense light produced by the ignition of the heavy vapour of mercury.

The gases and vapours just mentioned have the following relative densities:—

| | |
|---|---|
| Hydrogen | 1 |
| Air | 14·5 |
| Oxygen | 16 |
| Sulphurous anhydride | 32 |
| Chlorine | 35·5 |
| Mercury | 100 |
| Phosphoric anhydride | 71 or 142 |

The feeble light emitted by phosphorus when burning in chlorine seems, at first sight, to be an exception to the law just indicated, for the density of the product of combustion (phosphorous trichloride) 68·7 would lead us to anticipate the evolution of considerable light. But it must be borne in mind that the luminosity of a flame depends also on its temperature, and it can be shown that the temperature in this case is probably greatly inferior to that produced by the combustion of phosphorus in oxygen. We have not all the necessary data for calculating the temperature of these flames, but, according to Andrews, phosphorus burnt in oxygen gives 5747 heat units, which, divided by the weight of the product from one grain of phosphorus, gives 2500 units. When phosphorus burns in chlorine, it gives only, according to the same authority, 2085 heat units, which, divided as before by the weight of the product, gives 470 units. It is therefore evident that the temperature in the latter case must be greatly below that produced in the former, unless the specific heat of phosphoric anhydride be enormously higher than that of phosphorous trichloride. The speaker had, in fact, found that if the temperature of the flame of phosphorus, burning in chlorine, be raised about 500° C. by previously heating both elements to that extent, the flame emitted a brilliant white light.

To return to ordinary luminous flames, the argument of the necessity of solid particles to explain their luminosity obviously falls to the ground; and a closer examination into the evidence of the existence of these particles reveals its extreme weakness. Soot from a gas flame is not elementary carbon, it always contains hydrogen. The perfect transparency of the luminous portion of flame also tends to negative the idea of the presence in it of solid particles. The continuous spectrum of gas and gandle flames does not require, as is commonly supposed, the assumption of solid particles. The spectra of the flames of carbonic oxide in air, of carbonic disulphide, arsenic, and phosphorus in oxygen, are continuous, and so, as we have seen, is that of hydrogen burning in oxygen under a pressure of ten atmospheres. It is to the behaviour of hydrocarbons under the influence of heat that we must look for the source of

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* Davy mentions this fact in connection with his view of the source of luminosity in flames, and endeavours to explain the, to him, anomalous phenomenon. He says:—"Since this paper has been written, I have found that phosphoric acid volatilizes slowly at a strong red heat, but under moderate pressure it bears a white heat: and in a flame so intense as that of phosphorus, the elastic force must produce the effect of compression."—*Davy's Works*, vol. vi., p. 48.

luminosity in a gas flame. These gradually lose hydrogen, whilst their carbon atoms coalesce to form compounds of greater complexity, and consequently of greater vapour density. Thus marsh-gas ($CH_4$) becomes acetylene ($C_2H_2$), and the density increases from 8 to 13. Again, olefiant gas ($C_2H_4$) forms naphthaline ($C_{10}H_8$), when the vapour density augments from 14 to 64. These are some of the dense hydrocarbons which are known to exist in a gas flame, but there are doubtless others still more dense; pitch, for instance, must consist of the condensed vapours of such heavy hydrocarbons, for it distils over from the retorts in the process of gas-making. Candle flames are similarly constituted. The direct dependence of the luminosity of gas and candle flames upon atmospheric pressure, also strongly confirms the view that the light of these flames is due to incandescent dense vapours.

This inquiry cannot be confined to terrestrial objects. Science seeks alike for law in the meanest and grandest objects of creation. From questioning a candle she addresses herself to suns, stars, nebulæ, and comets; the same considerations which have just been applied to gas and candle flames are equally pertinent to these great cosmical sources of light.

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## MANCHESTER ASSOCIATION FOR THE PREVENTION OF STEAM BOILER EXPLOSIONS.

The last ordinary monthly meeting of the Executive Committee of this Association was held at the offices, 41, Corporation-street, Manchester, on Tuesday, September 1st, 1868, William Fairbairn, Esq., C.E., F.R.S., LL.D. &c., &c., President, in the chair, when Mr. L. E. Fletcher, chief engineer, presented his report, of which the following is an abstract:—

During the past month 179 visits of inspection have been made, and 441 boilers examined, 249 externally, 10 internally, 9 in the flues, and 128 entirely, while in addition 3 have been tested by hydraulic pressure. In these boilers 124 defects were discovered, 1 of them being dangerous. Furnaces out of shape, 5; fractures, 20; blistered plates, 7; internal corrosion, 32—1 dangerous; external ditto, 12; internal grooving, 13; feed apparatus out of order, 2; water guages ditto, 2; blow-out apparatus ditto, 12; safety valves ditto, 2; pressure guages ditto, 14; without blow-out apparatus, 2; without feed-back pressure valves, 1.

### EXPLOSIONS.

"On the present occasion I have seven explosions to report, which were attended with the loss of twelve lives, as well as eight other cases of personal injury. Not one of the boilers in question was under the inspection of this Association.

TABULAR STATEMENT OF EXPLOSIONS, FROM JULY 25TH, 1868, TO AUGUST 21ST, 1868, INCLUSIVE.

| Progressive Number for 1868. | Date. | General Description of Boiler. | Persons Killed. | Persons Injured. | Total. |
|---|---|---|---|---|---|
| 27 | July 31 | Plain Cylindrical, egg-ended Externally-fired …… | 1 | 0 | 1 |
| 28 | July 31 | Plain Cylindrical, egg-ended horizontal furnace … | 0 | 0 | 0 |
| 29 | Aug. 8 | Portable Agricultural …… | 2 | 3 | 5 |
| 30 | Aug. 11. | Particulars not yet fully ascertained …………… | 0 | 0 | 0 |
| 31 | Aug. 16 | Particulars not yet fully ascertained …………… | 1 | 0 | 1 |
| 32 | Aug. 17 | Plain Cylindrical, egg-ended Externally-fired …… | 1 | 0 | 1 |
| 33 | Aug. 20 | Furnace Boiler, Vertical two-flued … | 7 | 5 | 12 |
| | | Total……………… | 12 | 8 | 20 |

"No. 27 Explosion, by which one man was killed, took place at ten minutes past two o'clock on the afternoon of Friday, July 31st, at a colliery, and is simply an additional illustration of the uncertainty and danger of plain cylindrical externally-fired boilers. This subject has been so frequently referred to in previous reports that it is impossible to say anything fresh with regard to it, though it is desirable to record the facts of this explosion as another warning of the danger of this class of boiler.

"The boiler, which was set with a flash flue, so that the flames from the furnace escaped direct to the chimney without passing round the boiler, measured 36ft. in length, by 5ft. in diameter, the thickness of the plates being from three-eighths to five-sixteenths of an inch, and the load on the safety-valve 50lb. per square inch.

"The boiler failed over the furnace at the fourth ring seam of rivets from the front end, the rupture beginning at the bottom, and then running completely round the boiler until it was divided into two sections, the hinder one of which was held in its place by a bank against which it was set, while the front was thrown to a distance of 250 yards, passing over an iron works in its course, and damaging the roof of one of the buildings about 30ft. high.

"With regard to the cause of the disaster—the boiler had been repeatedly repaired, and as recently as within a week of its explosion. Repairs frequently lead to the explosion of boilers of this class, and in this case the rent took place at the seam of rivets at which the new work met the old, and which appeared to have been fractured by the recent repairs just referred to. It may be added that the feed was injudiciously introduced a little behind the fire bridge by means of a vertical open-mouthed pipe which led the water down to the bottom of the boiler, and thus subjected it to unequal and severe contraction. The plates were thus exposed to the strain consequent on the introduction of the feed on one side, and the changes of temperature consequent on opening the doors and cleaning the fires on the other, and it was just as the attendant was in the act of raking out the fire that the boiler burst and scalded the poor man to death.

"In conclusion, I can only repeat the recommendation so frequently given on previous occasions, that these treacherous externally fired boilers should be exchanged for those of the more reliable internally fired class.

"Explosions Nos. 28 and 32 both occurred to boilers of the plain cylindrical externally-fired class through overheating of the plates, the first through a caking of salt deposited by the feed, and the other by the water supply being allowed to run short.

"No. 33 explosion, by which seven persons were killed and five others very seriously injured, occurred at six o'clock on the evening of Thursday, August 20th, at a steel and iron works.

"On a visit being made to the scene of the catastrophe by one of the officers of the Association the day after the explosion, some difficulty was experienced in obtaining permission to make any examination at all, and it was only accomplished ultimately at a disadvantage. In consequence of this the precise dimensions of the boiler cannot be given, but there is no question as to the cause of the explosion.

"The boiler, which was heated by the flames passing off from one or more of the iron furnaces, was of double-flued vertical chimney construction, cylindrical in the shell, with flat ends both at the top and bottom. Its approximate dimensions were—height 40ft., diameter 6ft. in the shell, and 2ft. 3in. in the flue tubes, with the exception of a length of 3ft. at the bottom, which expanded in the form of a bell mouth to 2ft. 6in., the thickness of the plates being seven-sixteenths to half an inch in the flat ends, and three-eighths to seven-sixteenths in the remainder, while the load on the safety valve was stated to be about 45lb. on the square inch.

"The boiler failed at the bottom, a portion of the flat-plate measuring about 5ft. in length by 2ft. at the widest part, being blown out, the primary rent running through the solid metal at the circumference of the circular end plate close to the attachment to the shell. The boiler was not moved many inches from its seat, but the rush of steam and hot water that ensued upon the rupture, blew up one of the adjoining iron furnaces, scattering the *debris*, and causing the most disastrous effects. A workman who was in the act of drawing the furnace was thrown to a distance of about 10 yards and dashed against a wall, when he was covered with the red hot bricks, and killed instantaneously. Six others were fatally injured and died shortly after, and the results of the scalding upon them are described as frightful in the extreme.

"The cause of the explosion was the defective condition of the boiler, caused by original malconstruction. The flat bottom, instead of being strengthened with good gussets tying it to the external shell, was stayed with diagonal rods connected to the flues, so that there was no tie between the bottom plate and the shell, except at the external ring of angle iron by which it was attached at the circumference. In consequence of this defective staying, a deep groove, about 5ft. long, was eaten in the bottom flat plate, near to the root of the angle iron, which reduced the thickness of the plate to about one-sixteenth of an inch when the boiler rent from sheer weakness. Competent inspection could not have failed to detect the groove in question.

"At the inquest the evidence sadly contrasted with the facts of the case, a scientific witness stating that there was nothing wrong in the construction of the boiler, and that he attributed the explosion to thinning of the plate by 'secret corrosion,' which might go on for years without being discovered. The jury returned the usual verdict of 'Accidental death,' and the coroner stated that he quite agreed that there was no want of care, skill, or caution; while the engineer, whose duty it was to examine the boilers on the works, was stated to be perfectly competent and unnecessarily particular in his attention to these matters. To those who have read a detailed account of the sufferings entailed by this explosion, and much more to those who witnessed them, it must appear a sad conclusion to arrive at that science is perfectly helpless in preventing such catastrophes, and consequently that those in attendance on boilers are at any moment liable to the same fate as the poor fellows who were scalded to death on this occasion. The experience of this Association shows that this view is totally false, and that steam boiler explosions are not accidental at all.

"This explosion clearly shows the importance of Independent Periodical Inspection, and also that it is high time that more searching investigation should be made, and the truth more plainly spoken than is at present the case at coroner's inquests on the occurrence of steam boiler explosions, in order to arrest the constant recurrence of these sad disasters by which about 75 lives are gratuitously sacrificed every year.

## THE ANGLO-DANISH TELEGRAPH.

The vessels, the *Archimedes* and *Chevy Chase*, which were chartered for the conveyance of this cable started from the Tyne on Monday, the 31st of August, and having steamed up by the coast for some distance made over for Denmark. They were compelled to betake themselves to Christiansand, in Norway, on account of the rough weather which prevailed, but on Friday, the 4th of September, they were enabled to continue their voyage, and arrived during the afternoon of the following day at Sondervig, in Denmark, from which point the paying out was to commence. The shore end having been made fast, and a splice between it and the mid-sea portion having been effected, the ships lay to during the night, and next morning proceeded on their way towards England: Everything went on satisfactorily until Monday evening, when 250 miles of cable had been out. On that evening a thunder-storm raged with such intensity, and the sea rose to such a height, that it was proposed to cut the wire lest the *Archimedes* should be dragged over with the shifting weight. The storm subsided, however, before the suggestion was acted upon, and the vessel proceded on her course. Still the weather was far from propitious, and every operation was performed with considerable difficulty. It was decided to cut the buoy as soon as land was sighted. The English coast was seen at an early hour on Tuesday; the vessels being ten or twelve miles distant from Newbiggin, the terminus of the cable on the British side. The cable was forthwith buoyed, and the ships of the expedition went towards shore for shelter, the weather continuing tempestuous.

The next morning, both vessels steamed out to sea with the object of recovering the buoyed cable, and completing the communication with the shore. They proceeded to the spot where they had left the wire on the previous night, but some difficulty was at first experienced in finding it. The buoy, either from the drifting of the cable or its settling down, had sunk below the surface, and was not for some time discovered. The cable was, however, at length caught by means of a grappling iron, and the work of splicing at once began. Some five or six hours were occupied in this process, but at length it was completed, and shortly before two o'clock the vessels began steaming towards the shore, and the paying out for the remaining ten or twelve miles required to complete the distance between England and Denmark recommenced. About four o'clock the vessels had come close ashore, and cast anchor just outside the rocks. A rope was then made fast to the end of the cable already laid and embedded in the earth on the sea banks at Newbiggin, and a length of cable sufficient to reach the shore was then put on board a small boat. Another boat was employed to assist, and by these means the remaining portion of the cable was laid to the shore, buoys, being employed to float it between the shore and the ship, so as to prevent too great a strain on the boats and thus avoid the danger of a capsize. Having reached the shore, the cable was carried up to the top of the bank, and there, as the dawn of the day fell, the junction of the two was safely effected. The greatest depth at which the cable is sunk in about 45 fathoms, but the average is not more than 25 or 30. The first part of the system—that from Hirtshall, in Denmark, to Arendal, in Norway—was laid so far back as the May of 1867. Since that time the main cable has been manufactured. The diameter for the shore end was fixed at an inch and a half, that for the deep water portion being much less. The weight is three tons a mile at mid-sea and six at the shore ends, and the insulation of the core has been effected by means of india-rubber. This was the first time that this substance has been applied to a wire of such great extent, and it was consequently an experiment, the result of which was watched with considerable interest. Three large tanks, 27ft. in diameter by 12ft. deep, were constructed in the hold of the *Archimedes*, as she lay at her moorings; and in the centre of each of these cylinders was a conically-shaped drum, eight-feet in diameter, tapering slightly towards the summit. Around these the cable was carefully coiled in layers, beginning at the outside cylinder and running towards the drum, and then outwards again from the centre. The cable was conducted in grooves to a revolving drum, six-feet in diameter, and onward to its allotted bed at the bottom of the sea. To this drum was attached a friction strap or break, in order to prevent the line running out too rapidly, while between it and the pulley on the vessel's stern was erected a dynamometer for indicating the strain upon the cable. The weight of cable placed on board the *Archimedes* was about 1,050 tons, consisting of the mid-ocean part; while the *Chevy Chase* carried 150 tons of the shore ends.

## OPENING OF THE METROPOLITAN EXTENSION RAILWAY.

On the 15th ult. another link in our now widely extended chain of metropolitan railways was inspected, preparatory to its formal opening on the 1st of this month. The new line, though not a long one, opens up a most important district, and leaves only a very short space—a little over 600 yards—to effect its junction with the line running from Brompton to Palace-yard, which will be opened for traffic at the end of the year. Nine-tenths of the great metropolitan inner circle will then be completed, and the passenger will be able to make the circuit of London without a break from Aldgate to Westminster Abbey. All that will then remain to complete the entire circle will be the narrow strip along the Thames Embankment, up Cannon-street, round Fenchurch Station, to Aldgate again. When this is completed the inner circle will be in communication with every railway entering London. It has been said of the Clapham Junction that the enterprising voyager may there book to Bombay or Belfast, Calcutta or Cremorne, so numerous are its junctions, so ubiquitous the lines which lead from them. The same may be said, though with greater truth, of the Metropolitan Railway and its extensions. This, however, is in a great measure only its auxiliary traffic. The main source of its income, and therefore of its strength, experience has shown will be chiefly derived from the local traffic of the district which it taps.

The line inspected on the 15th ult. extends from the junction with the main Metropolitan line, under Praed-street, to the Gloucester-road Station at Brompton, within a short distance of the site of the old Exhibition building of 1862. Its length is a little over 2½ miles—more than half of which is open cutting—the rest a series of very short tunnels. It was apprehended at the commencement of the work that considerable engineering difficulties might arise from the presence of water in the gravelly soil. This anticipation, however, proved to be unfounded. There was very little water met with, and what was encountered was very easily pumped out, and the other constructive difficulties overcome. The curves on the line are very slight, the greatest being at the junction at Praed-street. The gradients, too, are tolerably easy—the steepest of all being one in 70ft., which in these days of engineering may be considered as not a very steep incline. This slope is through a tunnel which passes beneath the high ground between Notting-hill and the station near Church-street, Kensington. After this the gradients are light, though on the whole the line has a continuous slope from Praed-street junction into Brompton of 75ft. in the 2½ miles. The deepest cutting is 42ft. deep, near Bedford-gardens. This, from its depth and narrowness, requires massive retaining walls to keep back the pressure of the earth. These walls are further set apart by cast-iron struts, which are strengthened by cross braces. Perhaps, however, the most curious specimen of wall shoring ever seen on a railway is to be found where the new line passes between the houses at Leinster-gardens. The railway had to take two of them, but left one on each side standing at a great height above the cutting. Structures so lofty and on the edge of a cutting required buttresses of no ordinary strength to retain them, and these they have got, with additional securities in the way of strong wrought-iron girders to keep them perpendicular. The average depth along the whole line is about 25ft. All the foundations of walls and tunnels are taken down to the London clay. In some cases this was easily reached; in others deep excavations had to be made before it was found. During the course of the excavations some Roman coins were discovered; and at the Brompton end, beneath the gravel, the bones and antlers of what is supposed to be the elk, and quantities of the bones and antlers of the Red deer were found. Singularly enough, in making the continuation of the Metropolitan District Railway which runs from Brompton into Palace-yard, and which, it is said, will at last be opened in January, a great quantity of the horns and antlers of red deer were found about 30ft. below the surface of the roadway, at the end of Victoria-street next to Westminster Abbey. Below the surface in front of Westminster Hospital they were also met with in great abundance.

On this new line there are five stations—one at Paddington, one at Bayswater, one at Notting-hill, one at Kensington, and one at the present terminus, Glocester-road, Brompton. The situations of all these are admirable. That at Paddington is in front of the Great Western Hotel and Station, with only the road between. Two spacious subways have been built under it which lead at once into the Great Western Station. Bayswater station opens out on the road a little below the Royal Oak, thus tapping one of the great main arteries of the western traffic. Notting-hill station faces the site of old Notting-hill gate, and the Kensington station comes out in the High-street just above the church. Of each of the three stations it is difficult to speak too highly in praise. The signals are worked on the block system—that is to say, the line is kept blocked at one station till the signal is sent that the train in front has safely passed the next station ahead. On this new line, however, the system is so managed as to admit of shorter blocks, so that trains can follow each other more quickly and with equal safety as at longer intervals. At present it is intended to run trains at five, seven, and eight minutes interval, which will average about 100 trains each way per day.

Chicago sent forward to the east last year, 48,000,000 bushels of grain, of which ninety-one per cent. went by water, and nine per cent. by rail. Of the millions of bushels of corn which were forwarded east from the same point, ninety-nine per cent. went by water. And all this in face of the four and one-half months of suspension of navigation during the season.

## THE ANGLO-MEDITERRANEAN TELEGRAPH.

In May last the prospectus of the Anglo-Mediterranean Telegraph Company was published, and arrangements and provisional contracts were made with the Telegraph Construction and Maintenance Company—firstly, for the purchase of their overland line in perfect order, from Susa on the French-Italian frontier to Modica, in Sicily; and, secondly, for the making, laying, and delivering to the company in perfect working order within four months of a deep sea telegraph cable, having an external covering suited to the known requirements of the Mediterranean bed from Malta to Alexandria. It was stipulated that the contractors should maintain the cable in an efficient condition for a period of twelve months.

In June the first portion of the contract was performed, by the submergence of a small cable, which was laid across the Straits of Messina, completing the communication between Susa and Modica, and the steamship *Chiltern*, chartered by the Telegraph Construction and Maintenance Company, arrived safely at Malta on the 16th ult., having on board the shore end and part of the mid-sea cable for the Malta and Alexandria line. The remainder of the cable is expected to be at Malta about the end of the month.

Up to the present year the direct course from Malta to Alexandria had never been surveyed, but at the beginning of July Her Majesty's ship *Newport* was despatched from Malta to survey the course and find the best route for the proposed cable. At the end of July the *Newport* returned, the result of the observations showing that, though the depth in certain places was great, a suitable cable might be successfully submerged. The distance from Malta to Alexandria direct is 816 miles, and on that route the soundings were principally made. From Malta the water gradually deepens to 50 fathoms, to which the shore end will extend. Thence it deepens to 270 fathoms at a distance of about 90 miles from the island—that is, at the end of the Malta bank. Here a great fall occurs, and the depth suddenly increases to something like 1,500 fathoms. At 150 miles from shore the depth is 1,000 fathoms, gradually increasing to 1,600, which is maintained for a considerable distance. At 440 miles it shallows to 800 fathoms, at what is the nearest point to the African coast of the route traversed, the cable then passing within a distance of 30 miles of Marsa Sousa—a place not very remote from the ancient Cyrene. From this stage the soundings gradually increase to 1,200 fathoms at 500 miles, and to 1,500 at 700 miles. The depth is reduced to 1,000 fathoms at 760, and then to 500 fathoms at 35 miles from Alexandria, and gradually shallows into the harbour. These figures indicate that the greater part of the cable will be laid in deep water, but the construction of the cable causes no apprehension of the failure of the expedition to be entertained.

In the contract it was stipulated that the Telegraph Construction and Maintenance Company should provide a cable capable of transmitting messages at a speed equal to the existing Atlantic cable. As the present line will be only half the length of the Atlantic, an insulated conductor of about half the weight has been provided. The conductor throughout the whole length consists of a strand of seven copper wires, weighing 150lbs. per nautical mile, which is covered with alternate coatings of Chatterton's compound and gutta percha, of the weight of 200lbs. per nautical mile, making the gross weight of the insulated conductor 350lbs., the weight of the conductor of the Atlantic line being 700lbs. for the same distance. The conductor thus insulated has been served in the ordinary manner with hemp, and has received an external sheathing of fifteen small galvanised homogeneous iron wires, further protected by a coating of bituminous compound over a serving of jute. The shore end of 20 miles differs from the mid-sea cable only in its size and sheathing, which consists of No. 1 galvanised iron wires. The length of line made is 950 miles, and, with the exception of the shore ends, the whole cable was manufactured at the works of the Telegraph Construction and Maintenance Company, at Greenwich.

## HILL'S NEW LETTER STAMPING MACHINE.

A small, ingenious, and simple machine, constructed to facilitate the stamping of letters, without involving more than a very little exertion on the part of the person performing the operation, has been invented by Mr. Pearson Hill, son of Sir Rowland, and consists of an upright polished bar to which is attached a frame-work, one-half of which consists of an elbow joint springing from a second upright circular bar. From a joint on the framing a lever rod extends, sustained to the upper frame-work by means of two elastic india-rubber bands. At the end of this lever is the stamp and a reservoir capable of containing ink sufficient to stamp twenty thousand letters. This reservoir supplies two rollers composed of circular wads of india-rubber strung together on steel axles that revolve beneath the faces of the date stamp and postage stamp obliterator. When raised, and when the stamps are pressed on a letter, the rollers go back for a further supply of ink. The mode adopted to give the required greater supply of ink to the face of the obliterator than to the date stamp is most ingenious, and is accomplished by the rollers being fixed in a sling cradle, and so arranged as to make the roller that rubs the face of the obliterator carry more ink than the other. Set round the stamp, which may be said to be at the end of a spring lever, are three rods which press down on the letters and secure a steady and even surface at the places required to be stamped. The machine is fixed in the back centre of a table, on the front portion of which an oblong square of vulcanised india-rubber about three feet long is let in. Over this elastic surface in every part the stamp can be made to traverse with the greatest ease, and without noise. The stampers use the machine with the greatest facility, and dispose of heaps of letters in one-third of the time which stamping by the old process would require. Each stamper can turn out, it is said, three hundred letters per minute, while according to the old process eighty letters per minute was reckoned good work. All the letters stamped by the machine were found to bear most clear impressions. The machine has been in effective use for some time past in the General Post Office, and in all the branch offices, as well as the Post Offices of all the principal cities and towns in England, and in many parts of the Colonies.

## A NEW SUBMARINE LAMP.

This plan of a submarine lamp which is the invention of M. C. Cretin is based upon the same physical principles as are involved in the ordinary operation of the diving-dress. Fresh air is supplied by one tube to the water-tight lamp, as to the water-tight dress of the diver; and by another tube are the products of combustion or of respiration, as the case may be, carried off into the atmosphere above. Indeed, so completely identical are the two processes, that the tubular system of this lamp provides for the removal of the contaminated air of the diver by the same escape tube as that of the lamp which the diver may at the same instant carry in his hand in his sub-aqueous explorations. The combustible for producing the light is coal gas, and gas condensed in strong iron cylinders and kept on a board a vessel would be the source of supply. Cretin's lamp consists of a strong glass cylinder placed vertically on a brass pedestal, from which, within the cylinder, projects a brass socket, terminating in an ordinary gas burner, to which the gas supply is led by a combination of india-rubber and brass tubing. The top of the glass cylinder is flanged with a stout ring of brass, which interiorly is about the same diameter as the cylinder, and projects beyond it all around about 1½in. Another brass ring of the same diameter applies to this first, and is secured to it by screws, making the connection gas tight. The second ring is convex in the centre, being made so by a moveable lid, which is hasped down on it quite securely. This lid gives access to the interior of the lamp, and it has on its top a stout handle by which the lamp may be carried. The under side of the first ring has a series of small brass tubes attached to it, which are disposed regularly all round the outside of the glass vessel, and made to curve down to its bottom. Through these metal tubes the air from an external supply tube of india-rubber is made to pass in below the point of illumination and diffuse itself into the glass cylinder, in order to form the atmosphere for the gas flame. On the top of the lamp, as on the helmet of the diver, there is the escape tube for the products of combustion. The escape of the contaminated air is facilitated by means of a small fan, put in action by spring clockwork. The flame is perfectly steady, and quite secure against the incursion of water. The water of combustion does not dew the interior of the glass cylinder; and the carbonic acid formed, judging by the clearness of the flame, is completely swept out. An exhaust pump may be substituted for the fan, and only very slight power is needed for the work. Diving to great depths, say to 30 or more fathoms, will necessitate attention to the tubes in order to keep them from collapsing, and but for this there does not appear any hindrance to this lamp being used at any depth, and as long as desired. The possible application of this method to the lighting of dangerous mines is suggested.

## CURRENTS OF THE ATLANTIC.

The *Moniteur* gives an account of certain interesting observations made by M. Savy on the density and saltness of sea water in the Atlantic, and the currents of that ocean. The first-named element varies regularly on the same meridian from pole to pole, the lightest occupying the site of the equator, and the maximum density lying between the parallels of 40 and 60 degs. N. lat. Between the latter and the pole the density diminishes again, and most probably the minimum exists at the pole itself. In the southern hemisphere no diminution of density has as yet been observed beyond 63 degs., but there is every reason to suppose that it does exist beyond that parallel. This distribution of density M. Savy attributes to the motion of the whole fluid mass; it immediately gives the idea of a circulation common both to the deep and superficial waters. Thus, at the equator, the aqueous stream possessing little density rises to the surface, and sends a wave to each pole. This supply of light water proceeds to the higher latitudes, where it covers over the heavier strata; but by this time it has lost its caloric and becomes heavy in its turn; so it sinks to the bottom, and is drawn towards the poles by the lightness of the water there, which contains less salt, because it dissolves the bottom of the icebergs, which contain none. Thence the same aqueous stream, having become heavy by concentration, returns by a submarine current to the equator, where it plays the same part over again. This circulation, according to our author, produces vertical and horizontal motions, the combination of which with the daily motion of the earth gives the explanation of all the great currents existing on the surface of the Atlantic—viz., 1, the great equatorial one, with its great intensity on the southern border of the light waters; 2, the current which is often observable on their northern border; 3, the current of the northern coast of Guinea; 4, the Gulf stream; 5, the cold-water currents from the poles; 6, those of the same temperature under the equator; 7, the cold water in the vicinity of the Cape Verd Islands: 8, their western current; 9, the cold streams on the coast of Guiana; 10, the *prororoca* on the same; besides explaining the low temperature of the deep waters under the equator, and the warmth of the polar regions.

## ON THE MANUFACTURE OF SUGAR FROM CANE JUICE.

By Mr. W. E. Gill.

According to Dr. Scoffern, quoted by Brande, in his lectures, there occurs "about one million tons of sugar per annum in the current of European commerce," and "another million tons produced in China, the Malay Archipelago, &c.," of which no certain statistics exist. Dr. Scoffern estimates the monetary value of this sugar at £15 per ton, on an average, at the place of extraction, and the total value of two million tons of raw sugar will be no less than thirty millions of pounds sterling per annum. Passing on to the amount lost in the process of extraction, we find here a subject of painful contemplation—the amount lost is enormous. There can be no question about this matter. All persons conversant with sugar are unanimous in this statement, that, at the lowest estimate, an equal amount is lost, owing to imperfect methods of conducting the operation. Dr. Scoffern has adduced evidence to prove that the loss is nearer two-thirds than one-half. "I am not prepared," says Brande, "to disprove this assertion—it may be true. So great a loss is altogether without a parellel in any other chemical art." If we accept Dr. Scoffern's evidence, then the value of the sugar saved is £30,000,000, and of the sugar lost is £60,000,000. So, also, if we recognise Professor Brande's *esprit du corps* in the reluctance with which he is "not prepared to disprove," when suggesting the loss to be no more sugar than is sold, we have the minimum loss £30,000,000 per annum, a loss which few can afford to look on with complacency, whatever may be their individual share. Experience confirms Dr. Scoffern's evidence, and we record the £60,000,000 in the interest of integrity, to denote the value of the annual loss of sugar, which, if saved, would reduce the price of sugar without commercial injury to any one, excepting the producers of beet-root sugar, whom it would annihilate. We are confidently assured that much can be done in this desirable direction, but men cannot be got out of the old groove to adopt another process. We have it on the same authority, that, much, if not the entire expense of animal charcoal may be saved in the sugar refinery, which must be another immense saving; for, it is the component parts of the juice other than sugar and water, which aggregate into impurity, to contaminate the sugar in every stage of its manufacture. If then this impurity retains its character and can be successfully arrested—and reliable evidence confirms the fact—it must be possible to arrest at any stage of the process. If this be done in the proximate stage we economise sugar; in the ultimate stage we economise only animal charcoal.

## NOTES AND NOVELTIES.

### MISCELLANEOUS.

**Setting Type by Electricity.**—Among the many wonderful evidences of the ingenuity of mankind is the machine for setting and distributing type. This is now so perfected that I have now before me a book containing 24,993 ems of solid matter, or 34,255 ems of leaded matter, the type of which was both "set" and "distributed" in six hours and thirty-nine minutes by the machine. By means of one of these machines, located in the large newspaper offices in the principal cities, and connected by telegraph with the capital, the reporter or operator can set type himself, the machine standing in New York or New Orleans, and he being in the capital. Or, instead of setting type, he may produced a matrix—by operating a series of arms and levers having type attached, and made to strike upon a suitably prepared and movable plastic surface—from which a stereotype may be cast ready for the press in a few minutes from the time the speech is delivered, or the action had happened, whatever it may be. Speeches would still have to be reported by shorthand, simply because no one could either write them out or set them up as fast as delivered. The compositor having the shorthand notes before him, could then set the type from them upon the machine at a distance, or, if required; the shorthand notes could be translated, as is now done for the telegraph operator, and then set up telegraphed. In the latter case, the same labour of the operator that now sends the message would put it into type ready for the press, thus dispensing with the time and labour now required to write out the message and set up the type. This seems to be the great step in the electrical progress of the age; and there is nothing to prevent its being done at once. It is simply a question of time and money—that's all.—*American Artisan.*

**Extraordinary Increase in the Passenger Traffic between Liverpool, Ireland, and Scotland.**—The passenger traffic between Liverpool, Scotland, and Ireland, and *vice versa*, has, during the week ending August 30th, undergone a most extraordinary and unprecedented increase. The trains arriving at and leaving Liverpool from the north have had their first-class passenger traffic greatly reduced, while all the steamers arriving in Liverpool from Scotland and Ireland are literally crammed both with saloon and deck passengers. The same fact is equally applicable to the steamers leaving the Mersey for Glasgow, Dublin, Belfast, and other Irish ports. As an instance in support of the above statement, we may state the Glasgow steamer *Penguin*, which arrived in Liverpool from Glasgow on Thursday last, brought no less than eighty saloon passengers—nearly treble the usual number—a large number of whom left the same evening for Ireland. The only reason that can be assigned for this unexampled increase is the late fearful catastrophe at Abergele; and it is presumed, in fact, some of the passengers by the *Penguin* said they preferred the inconveniences of a Channel trip to the dangers of a railway collision.

### SHIPBUILDING.

**Steam Shipbuilding on the Clyde.**—The *Headquarters*, screw, 860 tons burden, built by Messrs. Aitken and Mansell, and engined by Messrs. J. Aitken and Co., has run the lights between Cloch and Cumbrae, at an average speed of 11½ miles per hour. The *Headquarters*, which has been built for Mr. Laing, of Leith, has high and low pressure surface condensing engines of 100 horse-power nominal. She has been built for the carrying trade.—Messrs. L. Hill and Co., of Port Glasgow, have launched the *Flying Scud*, a small screw of 180 tons; she is intended for the South African coasting trade, and is to have her machinery fitted in by Messrs. Howden and Co.—Messrs. M'Nab and Co. have launched an iron screw of 360 tons burden, named the *Leon*. She will be supplied with engines of 55 horse-power, and will be fitted up with all the latest improvements. The *Kintyre*, screw, recently built by Messrs. Robertson and Co., of Greenock, for the Cambeltown and Glasgow Steampacket Company, has made an official trial trip, which was attended with favourable results. The *Kintyre* is a vessel of 300 tons burden, and she is propelled by a pair of direct-acting engines of 90 horse-power, nominal, supplied by Messrs. Blackwood and Gordon, of Port Glasgow. Messrs. J. and G. Thompson, of the Clyde Bank Foundry, have launched from their yard at Govan a gunboat of composite construction, built to the order of Her Majesty's Government, and intended for service in the China seas. She is named the *Hart*, and is of 500 tons burden; she has trunk horizontal engines of 120 horse-power. Messrs. Caird and Co., of Greenock, have launched the *Main*, a fine screw, of upwards of 3,000 tons burden, for the North German Lloyd. The *Main* is in every respect a similar vessel to the *Rhein*, recently launched by Messrs. Caird for the North German Lloyd, and she is intended to ply between Bremen and New York, *via* Southampton. The *Main* will be supplied by Messrs, Caird and Co., with engines of 700 horse-power. Another steamer, of about the same burden, will shortly be launched for the same company by Messrs. Caird and Co.

### STEAM SHIPPING.

**New Line of Mail Steamers.**—On the 10th inst. the largest of the steamers constructed for the new London, Belgium, Brazil, and River Plate Royal Mail Steamship Company was inaugurated at the Victoria Docks. More than ordinary interest attached to the occasion owing to the fact that the Belgian government has granted a subsidy to the line for the carriage of mails to the countries of South America. The vessel inspected for the first time yesterday is called the *City de Rio Janeiro*. She is 285ft. long 33ft. 6in. broad, and 26ft. deep. Her engines are 300-horse power, and her registered tonnage is 1,600 tons.

**Trial Trips.**—The *Westphalia* (s s), built by Messrs. Caird and Co. for the Hamburg-American Steam Navigation Company, left the Tail of the Bank in the Clyde recently, and averaged 14 knots an hour. A trial of the engines and machinery of the double-screw steam gunvessel *Seagull*, 3, was made at the measured mile outside Plymouth Sound recently. The weather was fine, sea smooth, and wind easterly, light pressure 2. Six runs under full boiler power gave a mean of 11·2 knots per hour, and fours runs at half-boiler speed produced a mean of 10 knots. These results were considered very satisfactory, the speed being, it is said, superior to that usually obtained by vessels of this class. There were no hot bearings. The masts of the *Seagull* are stepped, and she had in her bunks about 100 tons of coal; draught aft 9ft. 10in. forward 8ft. 1in. The double screw is on Mangin's principle.

### LAUNCHES.

On August 28th, Messrs. H. Murray and Co., launched, on the Clyde, a screw steamer named the *Villa Real*, of 467 tons, for Captain Sister, of Valencia, intended to trade between a Spanish port and the Mediterranean. She is a fine looking vessel, and was taken on to Glasgow, where engines of 60 horse-power will be put on board by Messrs. Howden.—A few days previously the same builders launched a screw steamer of 230 tons, for the Italian trade, named the *Nuovo Porto Maurizio*, the engines for which are being put on board by Messrs. Rankin and Blackmore, Eagle Foundry, Greenock.

A new iron steamer of 400 tons burden, built and engined by W. Simons and Co., was launched on August 29th, from the London Works, Renfrew. She is the property of the Clyde Trust, is intended for the improvement operations of the Clyde, and is the fifth steamer built for the trustees by this firm.

The screw steamship *Alice*, which was placed on Messrs. Harland and Wolff's patent slip, Queen's Island, Belfast, a few weeks ago, for the purpose of being lengthened 45ft. amidships, was launched on the 2nd inst. The *Alice* is owned by the Messrs. Harrison Brothers, of Liverpool, and is in the West Indian trade.

**Messrs. Walpole, Webb, and Bewley**, shipbuilders and engineers, Port of Dublin ship-yard, Dublin, launched on the 5th ult., an iron paddle steamer, called the *Countess of Erne*, for the London and North-Western Railway Company, to be employed in their passenger and cattle trade between Holyhead and North Wall, Dublin. The dimensions are as follows:—length over all, 247ft.; length on W.L., 240ft.; beam, 29ft.; builders' depth, 15ft. 9in.; depth in hold, 14ft. 6in.; tonnage, O.M., 996; Oscillating engines, 300 horse-power nominal, by Preston, Fawcett, and Co., of Liverpool. The boilers made by the builders in Dublin.

### RAILWAYS.

**New Overland Route to India.**—The announcement of the opening of the new line, of railway between Suez and Alexandria *via* Zagazig on September 8th. will be received with general satisfaction by all connected with India, since not only will passengers henceforth perform the journey between Alexandria and Suez in ten hours including stoppages, but, owing to the more favourable position of the line, the difficulty of maintaining it in efficient working order will be materially lessened. The length of the line from Zagazig to Suez is about 85 miles, and as the Cairo and Suez line is to be abandoned, the whole of the working stock will available for the new line, to which the rails and iron sleepers will likewise be transferred. Compared with the Cairo route the difference in speed by the Zagazig route will be considerable, owing to the heavy gradients on the old line being avoided, while even those passengers who desire to visit Cairo will lose but little time, since it will only involve a run of 28 miles from the Benha junction and back, which will be compensated for by the greater speed on the main line.

On the Bombay and Baroda Railway through communication has been interrupted and serious damage done to the works on the Nerbudda river, and also on other portions of the line by the heavy floods.

MOUNT WASHINGTON RAILWAY.—A railway to the summit of Mount Washington, New Hampshire, is now in course of construction. The station at the starting point is 2,700ft. above the level of the sea, and the road when complete will be 2 miles and 260 rods long, rising in that distance 3,600ft. to the Tip-Top-house, which is 6,300ft. above the level of the sea. The average grade of the track is 1,280ft. to the mile, but in some parts of the line the grade is increased to 1,760ft. to the mile, or 1ft. in every three. On this portion of the road the workmen, notwithstanding the sharp spikes in their shoes to prevent them from falling, could only build 25ft. per day. The track consists of three rails, the one in the middle being of wrought iron, with cogs or pins corresponding to cogs in the driving wheel. The train consists of the locomotive with a tender and one passenger car. The locomotive of 35 horse-power is built with its boiler suspended, so that is always level; it weighs 4 tons, and pushes the train up before it. The driving wheel is 15in. in diameter. There is a similar cog wheel on the tender, and another on the passenger car, each strong enough to hold the entire train. Friction rollers, running under the edges of the middle rail, hold the train down upon the track. The central rail projects about 2in. on each side beyond the beam on which it is laid. To the locomotive there are attached one steam break and one hand break, either of which can stop the train in a moment. In descending, the steam is shut off, and the engine is eased down by using compressed air. An experimental trip was recently made on the part of the road recently completed, and the locomotive is described as working with a steady motion. There was no jarring or rocking, but merely a slight trembling, like that of a steamer under the stroke of its engines. The ascent from the starting point to the second station, 5,300ft. above the level of the sea, was accomplished in one hour and twenty minutes, including two stoppages for water. The descent occupied 38 minutes. A passenger car holding 50 persons now runs up to the second station.

## NAVAL ENGINEERING.

THE ironclad turret-ship *Monarch* 7, 5,102 tons, 1,100-horse power nominal is fitting in Chatham harbour, with all possible dispatch, instructions from the Admiralty directing that every exertion is to be used in hastening her forward in readiness for her experimental trial cruises at sea. The chief work is concentrated on her turrets, in the completion of which a large number of mechanics and shipwrights are employed. Each of the turrets, which are 26ft. in diameter, with their foundation on the main deck, has had its teak backing and inner skin plating fixed ready for the reception of the armour-plating, which in the more exposed parts will be 10in. and in the other parts 8in. in thickness. The *Monarch* combines little of the turret principle in her construction beyond carrying a portion of her armament in two turrets, her turret guns will only be capable of being fired when the bulwarks are clear, to effect which the bulwarks, within the range of the guns, are made to fold outwards on hinges. The fire of the guns will be interfered with as little as possible by the number of shrouds to the lower masts being reduced, compensation for the loss of support thus entailed being at the same time made by increasing the dimensions of the iron masts. In each turret will be placed two 25-ton guns, the models of which, in wood, are now in the turrets to guide the mechanics in completing the internal arrangement of each. Owing to the erection of a forecastle on the upper deck—which is universally condemned as unnecessarily encumbering the forward deck of a turret-ship—the forward turret guns will be considerably restricted as to the range in which they can fire, the extreme angle to which they can be trained being that of 10 degrees with the keel, while they have a limiting angle of the same amount in their training aft. The after turret guns can be fired at an angle of 10 deg. with the keel towards the bow, and to within 6 deg. towards the stern. Two guns, each of 6½-tons, will be carried in the bow battery, and one similar gun in the stern battery, each having a training of 3 deg. within and 76 deg. from the line of the ship's keel.

NEW WAR SHIPS.—Messrs. Palmer, of Jarrow, have received an order from the Admiralty to build two vessels of war, of about 4,000 tons burden each, to be named the *Swiftsure* and the *Triumph*. They will be sheathed outside with wood planking, for the purpose of being coppered.

THE unarmoured composite-built gunboat *Cracker* (twinscrew), Commander H. Fawkes, recently commissioned at Portsmouth for foreign service, made the usual speed trial over the measured mile in Stokes Bay, near Portsmouth, on Saturday, previous to sailing for her destination. Noncondensing with her engines, out of six runs made over the measured mile she attained a mean rate of speed of 10·039 knots. With her engines condensing she attained a mean rate of 9·6 knots. Her tonnage is 467, her draught of water 8ft. forward and 9ft. aft, and her nominal power of engines combined, 120 horse. The *Cracker* is under orders to sail immediately for her station.

## DOCKS, HARBOURS, BRIDGES.

THE Chicago and North-Western Railroad bridge at Sterling, Ill., which was 300ft. in length, was destroyed by fire on Sunday night, the 23rd August.

A HOISTING and graving dock for repairing ships was launched in the Tagus on the 6th ult. The king and the court assisted at the ceremony.

## MINES, METALLURGY, &c.

THE production of mineral at the Lake Superior copper mines has increased from 6,075 tons in 1858 to 11,735 tons in 1867. For the last two years the Lake Superior mines have produced half the estimated consumption of copper within the United States. California, Vermont, Maryland, North Carolina, Virginia, and Tennessee together produce the other half. The imports from Canada, Cuba, Chili, &c., are counterbalanced by the export of domestic copper.

ADVICES from New Zealand, *via* Panama, state that the Auckland gold-fields continue to give surprising results. Week after week the story is heard of "good leaders" being struck, and splendid yields obtained. More than 2,000ozs. of gold have been just extracted from two tons of picked stone, and the *Daily Southern Cross* is of opinion that the Auckland fields will take rank among the richest in the world.

A RICH gold-field has been re-discovered in the neighbourhood of Chefoo, in the north of China. Large quantities of gold have been found within a few inches of the surface, and deeper digging reveals more abundant and purer veins of the same metal. During the Sung and Yuen dynasties (950-1368) these diggings were regularly but imperfectly worked; but since the latter date the authorities have, as in other parts of China, considered it necessary for the preservation of the peace in the district that the workings should be closed.

## APPLIED CHEMISTRY.

A NEW method has been devised by A. Mallet of preparing oxygen gas from atmospheric air. Subchloride of copper absorbs this gas from the air and is changed into an oxychloride, which, when heated to 400 deg. Cent. gives off its oxygen, and is reconverted into the subchloride. He places this copper salt in an horizontal retort, which can be rotated and mixed in sand or clay to prevent its melting together. A gentle heat is applied to the rotating vessel and the gas collected. One kilogramme of chloride furnishes twenty-eight to thirty litres of oxygen. A stream of air is then passed through the retort and in three hours its contents can again be heated.

## LATEST PRICES IN THE LONDON METAL MARKET.

| | From | | | To | | |
|---|---|---|---|---|---|---|
| | £ | s. | d. | £ | s. | d. |
| COPPER. | | | | | | |
| Best selected, per ton | 76 | 0 | 0 | 78 | 0 | 0 |
| Tough cake and tile do. | 74 | 0 | 0 | 76 | 0 | 0 |
| Sheathing and sheets do. | 78 | 0 | 0 | 79 | 0 | 0 |
| Bolts do. | 78 | 0 | 0 | ,, | ,, | ,, |
| Bottoms do. | 81 | 0 | 0 | 82 | 0 | 0 |
| Old (exchange) do. | 68 | 0 | 0 | 70 | 0 | 0 |
| Burra Burra do. | 80 | 0 | 0 | ,, | ,, | ,, |
| Wire, per lb. | 0 | 0 | 10½ | ,, | ,, | ,, |
| Tubes do. | 0 | 0 | 11½ | ,, | ,, | ,, |
| BRASS. | | | | | | |
| Sheets, per lb. | 0 | 0 | 7¾ | 0 | 0 | 8¼ |
| Wire do. | 0 | 0 | 8¼ | ,, | ,, | ,, |
| Tubes do. | 0 | 0 | 10¼ | ,, | ,, | ,, |
| Yellow metal sheath do. | 0 | 0 | 6¾ | 0 | 0 | 7¼ |
| Sheets do. | 0 | 0 | 6¾ | 0 | 0 | 7¼ |
| SPELTER. | | | | | | |
| Foreign on the spot, per ton | 20 | 5 | 0 | 20 | 10 | ,, |
| Do. to arrive | 20 | 10 | 0 | ,, | ,, | ,, |
| ZINC. | | | | | | |
| In sheets, per ton | 24 | 10 | 0 | 25 | 0 | 0 |
| TIN. | | | | | | |
| English blocks, per ton | 96 | 0 | 0 | ,, | ,, | ,, |
| Do. bars (in barrels) do. | 97 | 0 | 0 | ,, | ,, | ,, |
| Do. refined do. | 98 | 0 | 0 | ,, | ,, | ,, |
| Banca do. | 93 | 0 | 0 | ,, | ,, | ,, |
| Straits do. | 92 | 0 | 0 | 92 | 10 | ,, |
| TIN PLATES.* | | | | | | |
| IC. charcoal, 1st quality, per box | 1 | 5 | 6 | 1 | 8 | 6 |
| IX. do. 1st quality do. | 1 | 11 | 6 | 1 | 14 | 6 |
| IC. do. 2nd quality do. | 1 | 4 | 6 | 1 | 5 | 6 |
| IX. do. 2nd quality do. | 1 | 10 | 6 | 1 | 11 | 6 |
| IC. Coke do. | 1 | 1 | 6 | 1 | 2 | 0 |
| IX. do. do | 1 | 7 | 6 | 1 | 8 | 0 |
| Canada plates, per ton | 13 | 10 | 0 | ,, | ,, | ,, |
| Do. at works do. | 12 | 10 | 0 | ,, | ,, | ,, |
| IRON. | | | | | | |
| Bars, Welsh, in London, per ton | 6 | 10 | 0 | 6 | 12 | 6 |
| Do. to arrive do. | 6 | 10 | 0 | ,, | ,, | ,, |
| Nail rods do. | 6 | 15 | 0 | 7 | 0 | 0 |
| Stafford in London do. | 7 | 10 | 0 | 8 | 10 | 0 |
| Bars do. do. | 7 | 10 | 0 | 9 | 10 | 0 |
| Hoops do. do. | 8 | 2 | 6 | 9 | 15 | 0 |
| Sheets, single, do. | 9 | 2 | 6 | 11 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 6 | 0 | 0 | ,, | ,, | ,, |
| Do. mrch. Tyne or Tees do. | 6 | 10 | 0 | ,, | ,, | ,, |
| Do. railway, in Wales, do. | 6 | 0 | 0 | ,, | ,, | ,, |
| Do. Swedish in London do. | 9 | 17 | 6 | 10 | 0 | 0 |
| To arrive do. | 10 | 0 | 0 | 10 | 0 | 0 |
| Pig No. 1 in Clyde do. | 2 | 14 | 3 | 2 | 18 | 3 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | ,, | ,, | ,, |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 7 | 0 | 0 | 7 | 10 | 0 |
| STEEL. | | | | | | |
| Swedish in kegs (rolled), per ton | 14 | 5 | 0 | ,, | ,, | ,, |
| Do. (hammered) do. | 15 | 0 | 0 | 15 | 10 | 0 |
| Do. in faggots do. | 16 | 0 | 0 | ,, | ,, | ,, |
| English spring do. | 17 | 0 | 0 | 23 | 0 | 0 |
| QUICKSILVER, per bottle | 6 | 17 | 0 | ,, | ,, | ,, |
| LEAD. | | | | | | |
| English pig, common, per ton | 18 | 15 | 0 | ,, | ,, | ,, |
| Ditto. L.B. do. | 19 | 0 | 0 | ,, | ,, | ,, |
| Do. W.B. do. | 21 | 5 | 0 | ,, | ,, | ,, |
| Do. sheet, do. | 19 | 10 | 0 | 20 | 0 | 0 |
| Do. red lead do. | 21 | 0 | 0 | ,, | ,, | ,, |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 0 | 0 | 22 | 10 | 0 |
| Spanish do. | 18 | 5 | 0 | 18 | 10 | 0 |

* At the works 1s. to 1s. 6d. per box less.

## 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 August 21st, 1868.

2602 T. Haigh—Apparatus to be used in brewing
2603 J. Elliott—Cutting, dressing, and moulding stone
2604 E. J. E. Niepce—Safety blinkers
2605 J. H. Johnson—Manufacturing wheat into flour
2606 P. N. Hasluck—Hackney carriage mileage register
2607 F. J. Knewstub—Despatch boxes
2608 T. W. Rammell—Rotary or centrifugal machines
2609 J. L. Clark—Apparatus for communicating between the passengers, &c., of a railway train
2610 B. Walker and J. F. A. Pflaum—Rolling disc wheels
2611 D. Evans—Manufacture of metallic casks, cans, &c
2612 J. Tall—Apparatus to be employed in the construction of walls, &c.

### Dated August 22nd, 1868.

2613 T. Wrigley—Looms for weaving
2614 A. B. Childs—Machinery for dressing or cutting millstones
2615 W. J. Kesselmeyer and C. A. Kesselmeyer—Governors for steam and other motive power engines
2616 F. M. B. Bertram—Obtaining illuminated devices, &c.
2617 J. Watson—Blast furnaces
2618 R. D. Morgan—Facilitating swimming
2619 G. H. Barber—Preserving meat
2620 H. Thompson—Apparatus for roughing horses
2621 W. R. Lake—Uniting the ends of railway rails
2622 W. J. Sallity—Gravitating wheel machine or engine

### Dated August 24th 1868.

2623 W. Chorlton—Improvements in slashers, tape legs, &c.
2624 C. George—Artificial horizon used for taking altitudes
2625 G. Tidcombe—Removing dirt from the bottoms of boots
2626 A. F. Eckhardt—Preparing and manuring grain, &c
2627 A. Goodman—Furnaces
2628 W. R. Lake—Cartridges
2629 O. C. Setchell—Manufacture of bricks, &c.
2630 W. H. Tooth—Manufacture of bricks, &c.
2631 G. J. Colette—Holders or protectors for sewing needles
2632 G. S. Dracopulo—Raising water
2633 H. Ground—Bushing the bungholes of casks and similar vessels

### Dated August 25th, 1868.

2634 J. Jeavons and C. Martin—Iron for plating vessels
2635 R. Couchman—Dress fastenings
2636 R. Scholefield—Brick making machinery
2637 C. J. R. Jahns—Obtaining motive power
2638 W. C. Cambridge—Crushing, breaking, and reducing the soil
2639 B. J. Coben—Apparatus for receiving memoranda, &c.
2640 J. S. Adcock—Keeping accounts
2641 J. Barrans—Apparatus for flattening hackle pins, &c.
2642 J. J. Long—Reducing and cutting or dividing timber
2643 J. Gillot—Cutting coal
2644 J. H. Johnson—Condensing the vapour of water, &c.
2645 A. M. Clark—Breech loading firearms
2646 R. Harvey—Sewing machines
2647 A. E. Borgen—Direct decomposition of neutral fatty substances

### Dated August 26th, 1868.

2648 J. Dawson—Shaft tug
2649 S. Morris—Self acting mules
2650 J. Hamer—Looms
2651 W. Hall—Rotary engines to be worked by steam, &c.
2652 R. W. Morgan—Machine for mowing
2653 W. Houghton—Looms
2654 W. L. Williams—Motive power engine
2655 E. Zoepfel—Rendering certain portions of windows air and water tight
2656 S. R. Samuels and J. Birks—Manufacture of woven fabrics
2657 J. Hanson—Breech loading firearms

### Dated August 27th, 1868.

2558 A. Lupton—Boilers
2659 T. Wrigley—Furnaces applicable to boilers for generating steam
2660 W. M. Jackson—Roofs and roofing tiles
2661 E. Peyton—Metallic bedsteads
2662 L. P. Hebert, L. A. Moulin, J. P. Couinck, and E. Couinck—Improved press for stamping letters, books, &c.
2663 D. Smith—Smoke consuming apparatus

### Dated August 28th, 1868

2664 B. Burrows—Apparatus to facilitate the separation of skeins of silk, &c.
2665 N. J. Holmes—Electric telegraphs
2666 J. Tule—Arrangements and apparatus for dealing with sewage
2667 W. Strang—Arrangements for dealing with sewage
2668 G. Ker—Cleaning gloves, &c.
2669 T. Henderson—Sewing machines
2670 B. Corcoran and W. Dunbam—Apparatus for dressing millstones
2671 R. Saunders—Oscillating screen breakwater
2672 W. McGregor—Construction of telegraph and signal posts
2673 C. H. Gardner—Lithographic cylinder printing machines

### Dated August 29th, 1868.

2674 E. Richardson—Casings or coverings for bottles
2675 H. Potter—Bleaching cotton, &c.
2676 J. Martin—Extracting pitch from wool
2677 W. E. Gedge—Agglomerating coal dust in any shapes, &c.
2678 J. Tattersall, T. Tattersall, and T. Richmond—Grinding cards used in the preparation of cotton, wool, &c.
2679 E. Jackson and J. Ogden—Preparing cotton, &c.
2680 J. M. Hunter—Apparatus for effecting aerial propulsion
2681 E. L. Paraire—Working steam engines
2682 W. Naylor—Railway brakes
2683 C. F. Varley—Electric telegraphs

### Dated August 31st, 1868.

2684 W. S. Fletcher—Preventing draughts of air and the admission of rain through apertures under doors, &c
2685 S. Newton—Swing door hinge
2686 J. Greenwood—Looms
2687 T. Lester—Steam engines
2688 J. Fieldhouse—Improvements in the furnaces of steam boilers
2689 H. Walker—Putting up needles, pins, &c., for sale
2690 J. Wilkinson—Printing carpets
2691 W. R. Luke—Improved relieving coupling for wire rigging
2692 W. R. Lake—Projectiles for ordnance and firearms
2693 W. E. Gedge—Warding off leaves and other matters likely to clog the working of turbines
2604 N. Thompson—Cutting nippers
2695 L. F. A. P. Riviere—Cases for packing bottles containing wine

### Dated September 1st, 1868.

2696 J. C. Martin—Gelatine
2697 J. and W. Badger—Steam engines
2698 J. Ladley—Machinery for spinning and twisting wool
2699 F. Hudson—Improving dry gas or liquid meters
2700 W. C. Holmes—Apparatus used in the manufacture of gas
2701 T. Toms—Waterproof boots
2702 T. G. F. Dolby—Valves, &c.
2703 E. Jobson—Pianofortes
2794 W. R. Lake—Looms
2705 W. W. Macvay—Glass furnaces

### Dated September 2nd, 1868.

2706 H. A. Bonneville—Regenerating certain alimentary substances
2707 J. H. Greener—Construction of insulators for telegraph wires
2708 J. Adams and H. Barrett—Improved stopper for bottles
2709 E. Cortazzi—Suspended iron roads or ways
2710 C. E. Brooman—Purifying wool
2711 H. Aitken—Improvements in treating grain, pulse, &c.
2712 J. F. C. Carle—Breech loading needle guns and cartridges
2713 J. Evans—Finishing and welding iron and steel tubes
2714 J. I. Campbell—Securing bales of cotton and other material
2715 T. Forster and J. Heartfield—Porous or spongy substances from india rubber

### Dated September 3rd, 1868.

2716 W. C. Green—Breech loading firearms
2717 J. Neumann—Puzzling fan
2718 F. Preston and R. C. Ross—Stop blocks for railways
2719 A. C. Kirk—Improvements in packing and storing ice
2720 J. Griffiths—Uprooting or deforesting trees, roots, &c.
2721 A. M. Clark—Portable bedstead
2722 E. L. Parker—Improvements in fastenings for braces

### Dated September 4th, 1868.

2723 T. Atherton and J. Atherton—Improvements in looms
2724 S. Grafton—Machinery for cutting cucumbers, &c.
2725 J. H. Johnson—Preparation of a blue colour from aniline
2726 G. White—Preventing incrustations on the sides of boilers
2727 T. Butterworth—Pump suitable for lubricating, &c.
2728 D. Jones—Stand or support for umbrellas and parasols
2729 A. M. A. Laforgue—Introducing powders into natural cavities in the human frame
2730 C. Travis, J. Chadwick, and J. Law—Condensers of carding engines
2731 W. G. Cooper and R. Harrison—Looms for weaving
2732 J. Sproul—Improved system of water power
2733 W. E. Newton—Thermometers
2734 J. Parker—Improvements for obtaining motive power
2735 S. Sharrock—Metallic standards for posts for electric telegraphs
2736 T. Perkins—Elevators to raise agricultural produce

### Dated September 5th, 1868.

2737 J. Pickering—Raising and lowering weights
2738 R. Banks—Floor dog
2739 T. Howcroft and A. McGregor—Agricultural implements
2740 I. L. Pulvermacher—Producing and applying electric currents
2741 J. Sloper—Perforating, &c, cardboard and other material
2742 W. H. Crispin—Manufacture of artificial fuel
2743 W. E. Newton—Improvements in mariners' compasses
2744 T. Wilson—Breech loading firearms
2745 W. Tatlock and C. N. Abelseth—Manufacturing gas

### Dated September 7th, 1868.

2746 H. Cowing—Steam land locomotive engine, &c.
2747 J. Wood—Frog plates for the intersections of railroad tracks
2748 C. E. Brooman—Feeding and burning mineral oils
2749 H. M. Lee—Cases employed to contain visiting cards
2750 U. A. Masselon—Kilns for burning bricks, lime, &c
2751 J. Joynson—Ladies wearing apparel called muffs
2752 G. Davies—Improved meter
2753 W. T. Carrington—Capstans
2754 V. Wanostrocht—Construction of powder mills
2755 A. V. Newton—Machinery to be used in knitting
2756 E. Stokes, E. B. Stokes, J. Stokes, and H. Stokes—Pearl ornament
2757 J. C. Walker—Improvements in coppers or boilers
2758 S. B. Tucker—Rotary engines
2759 C. Holland—Compositions for the production of artificial stones

### Dated September 8th, 1868.

2760 F. Andoe—Lowering apparatus to be used as a fire escape
2761 J. Jones—Arrangement and construction of furnaces
2762 J. Burdett—Construction of machinery for making bricks
2763 A. R. Stocker and J. A. Edgley—Improvements in caps
2764 A. J. Fraser—Locks
2765 G. Lowry—Construction of heckling and carding machines
2766 I. Aub—Advertising match boxes and spill holders
2767 P. I. Sculage—Indivisible pin to be used in fastenings of jewellery
2768 E. Cottam—Rolling and shaping iron or other metal
2769 J. Stewart and J. Nicholson—Continuous expansion engines
2770 T. E. Clarke—Improvements applicable to open fireplaces
2771 S. Benjamin—Improved blind for hansom cabs, &c.
2772 G. Warsop—Obtaining motive power by means of air, &c.
2773 E. Johnson—Muffs, &c.

### Dated September 9th, 1868.

2774 J. Millward—Steam boilers
2775 J. Adams and H. Barrett—Supplying the syrup in aerated beverages
2776 L. B. Covert—Extension ladders
2777 A. M. Clark—Metallic spring packings
2778 A. M. Clark—Opening envelopes
2779 E. Wood—Steam engines
2780 A. V. Newton—Pumps

### Dated September 10th, 1868.

2781 J. Shand—Steam boilers
2782 G. Davies—Stamping or embossing horn, leather, &c.
2783 T. Bennett—Manufacture of spoons, forks, and ladles
2784 A. A. Lejeune—Manufacture of certain colours employed in printing fabrics
2785 E. Padley—Anchors
2786 S. G. Archibald—Apparatus for reaping corn and other grain
2787 W. McNaught—Steam engines, steam boilers, &c.
2788 J. Maynes—Self acting arrangement for supplying weft
2789 A. B. Ibbotson—Improvements in railway fastenings
2790 C. H. J. Matton—Stockings, &c.
2791 S. Tragbeim—Mode of cleansing fibrous materials
2792 J. Challender and B. Kitchen—Securing fog signals
2793 J. Oliver and C. O. McAllum—Utilisation of alkaline salts, &c.
2794 A. Cruis—Improved press for the manufacture of cement tiles, &c.
2795 W. R. Lake—Improvements in condensing apparatus
2796 A. C. Henderson—Ornamentation of boot and shoe straps, &c.

### Dated September 11th, 1868.

2797 O. C. Evans—Constructing girders and other parts of bridges
2798 B. Dobson and W. Slater—Wood cutting machinery
2799 W. Thompson—Sifting, cutting, and mixing tea
2800 B. D. Godfrey—Securing soles upon boots and shoes
2801 I. Hudson—Self acting tilts for casks, barrels
2802 J. Bullough—Improvements in warping or beaming machines
2803 E. T. Hughes—Annealing gauze wire
2804 B. Gardiner and T. H. Faulkner—Umbrellas and parasols
2805 G. Bischof—Precipitation of copper from its solutions
2806 J. Roberts—Portable stove
2807 J. Roberts—Shoes for horses, &c.
2808 G. Bower and W. Hollinshead—Improvements in gas engines
2809 M. Henry—Apparatus for weighing

### Dated September 12th, 1868.

2810 H. B. Woodcock—Manufacture of metal for axles, &c.
2811 C. Turner—Furnaces
2812 A. W. Rodger—Improvements in caps, &c.
2813 F. Warner—Improvements in bore holes or wells
2814 E. Turner—Improvements in packing for pistons, &c.
2815 W. R. Lake—Machinery for manufacturing brushes

### Dated September 14th, 1868.

2816 J. C. Coombe and St. G. Gregg—Coating iron and steel, &c.
2817 J. Coppard—Machines for mincing meat and other substances
2818 W. R. Lake—Improved substitute for hair stuffing
2819 C. E. Brooman—Manufacture of metallic plates, &c
2820 F. Seebohm-Ultzen—Apparatus for generating carbonic acid
2821 C. E. Pommier—Size or compound for treating paper
2822 M. A. Soul—Improvements in spring pendulums
2823 J. D. Pinfold—Apparatus for grinding grain, &c.
2824 J. Hetherington—Machines for winding yarn or thread
2825 H. J. Turnbull—Preserving the bottoms of iron ships
2826 J. Fenwick—Construction of annealing ovens and kilns
2827 J. Hewes—Apparatus for day and night advertising
2828 A. M. Clark—Improvements in drawing off liquids

### Dated September 15th, 1868.

2829 E. Vickers—Hats and caps and other coverings for the head
2830 C. D. Abel—Securing buttons to articles of dress
2831 M. Benson—Steam pumping machinery or engines
2832 E. Sarjeant—Improvements in the manufacture of gaseliers, &c.
2833 H. Jewitt—A new toy representing game cocks, roosters, &c.
2834 C. De Bergue—Improvements in gas cooking stoves
2835 F. Brady—Improvements in sweeping machines, &c.
2836 J. H. Schucht—Pian fortes and other musical instruments
2837 W. Cannon and G. Hall—Washing or bleaching various articles
2838 J. Edmondson—Fastening metallic hoops used in securing bales
2839 G. Davies—Hulling and cleaning or polishing coffee, &c.
2840 R. Martin—Scraping and otherwise cleaning boots and shoes
2841 A. Rooker—Improvement in curtain rings
2842 W. R. Lake—Improved covering for walls, ceilings, &c.
2843 E. Henaser—Fastenings and locks for travelling bags
2844 W. Durham—Preserving from corrosion wire webs
2845 R. Hodson—Improved construction of punching machine

### Dated September 16th, 1868.

2846 C. Havard and M. X. Harmony—Preserving meat
2847 J. Orrin and T. Geer—Cutting the edges of hooks
2848 J. Horrocks—Improvements in looms for weaving
2849 F. F. Greenwood—Improvements in fastenings
2850 G. R. Samson—Improvements in the construction of pianofortes
2851 J. Walmsley—Communication between the guards and the drivers of railway trains
2852 H. Marrian—Weighing machines
2853 J. De Masy—Cases for holding railway tickets
2854 A. M. Clark—Electro magnets
2855 G. B. Sharpe—Improvements in the construction of fire grates
2856 J. B. Spence and R. E. Kelly—Improvements in pigments
2857 W. Betts—Improvements in machinery for capsuling bottles
2858 R. Dea—Pulverising plough
2858 W. R. Lake—Heads of dolls, &c.

### Dated September 17th, 1868.

2860 T. Beards—Steam plough
2861 J. Davey—Ploughs
2862 W. T. Watts—Annealing vessels
2863 W. E. Newton—Raising water
2864 A. F. Campbell—Construction of ships
2865 W. R. Lake—Explosive compounds
2866 H. Wilson—Engines worked by hydraulic fluid
2867 G. H. Barth—Administering gases, &c.
2868 T. Jones, J. Jones, J. Branwood, and J. Wren—Furnaces applicable to boilers
2869 J. H. Johnson—Combustion of liquid fuel
2870 J. H. Johnson—System of advertising
2871 R. Smith—Preventing the fouling of iron ships
2772 W. Clissold—Feeding wool to carding machines
2873 J. Head—Constructing wire fences

# SUEZ CANAL DREDGERS.

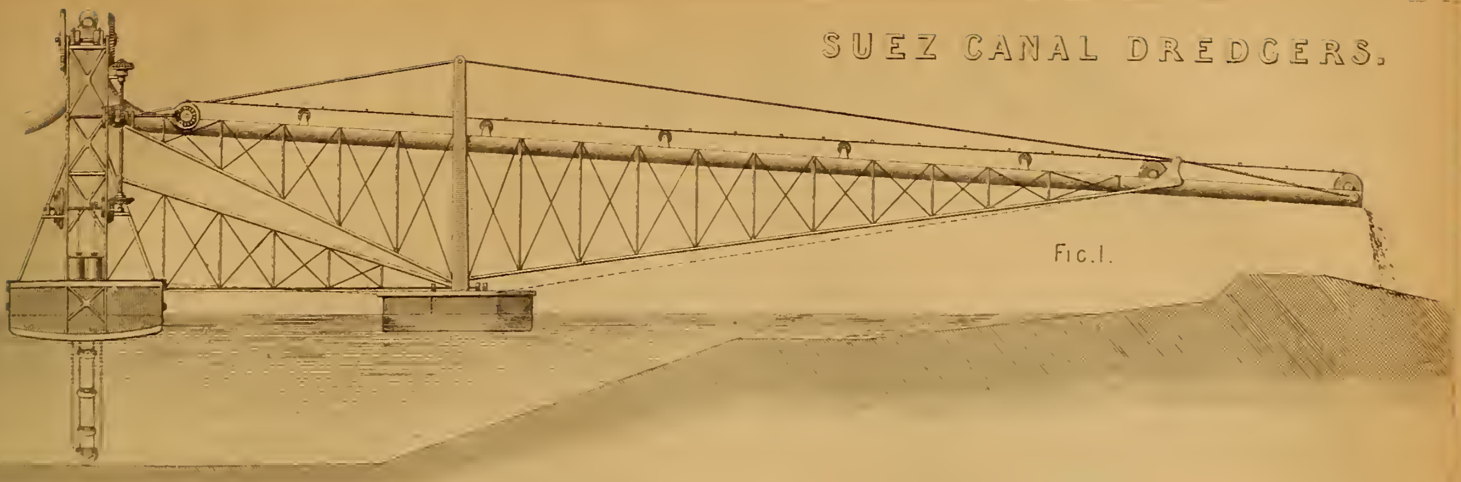

FIG.1.

SCALE TO FIGS 1 & 2.

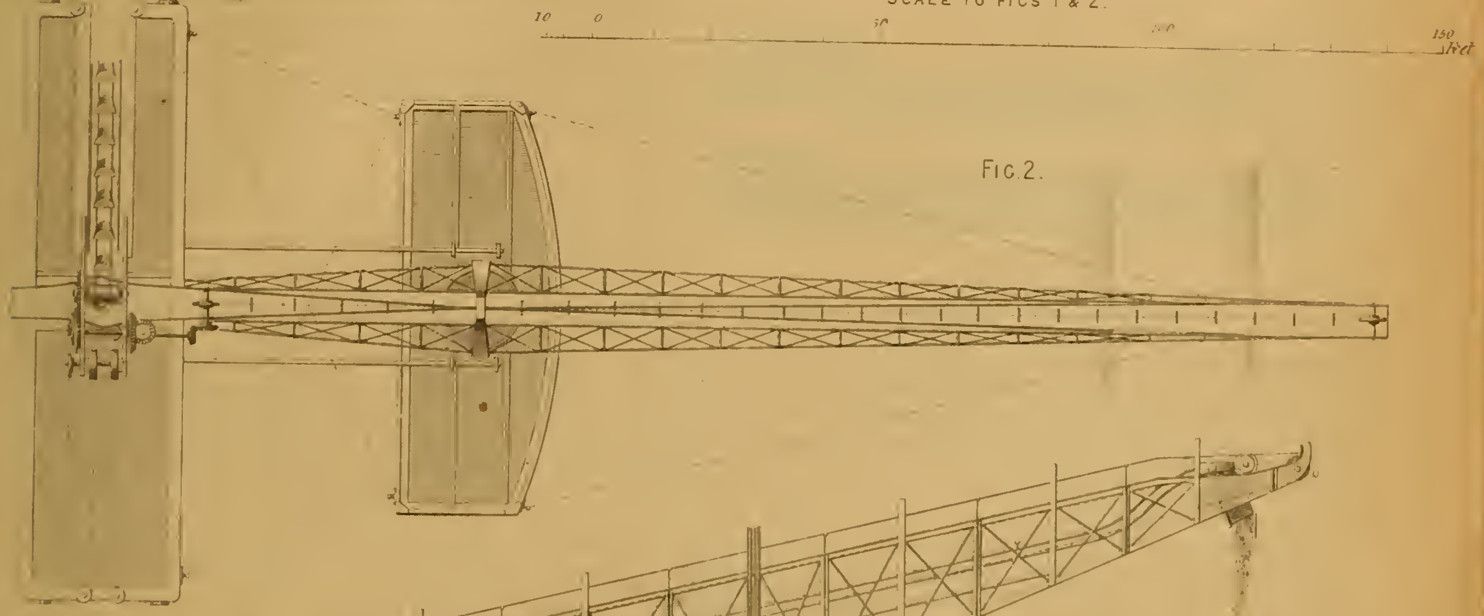

FIG.2.

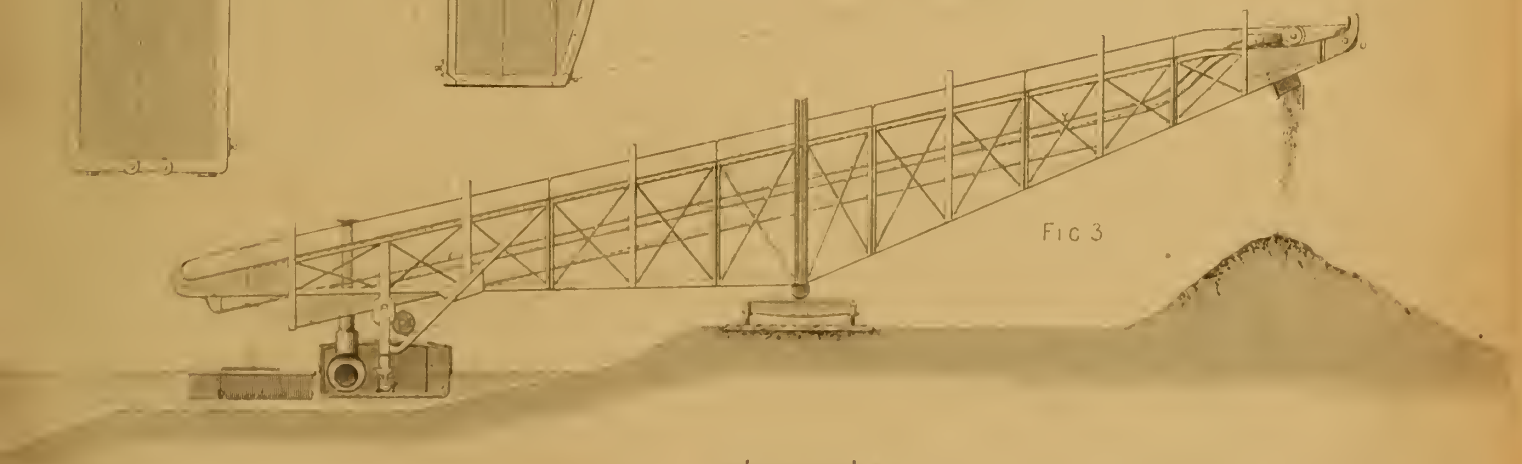

FIG 3

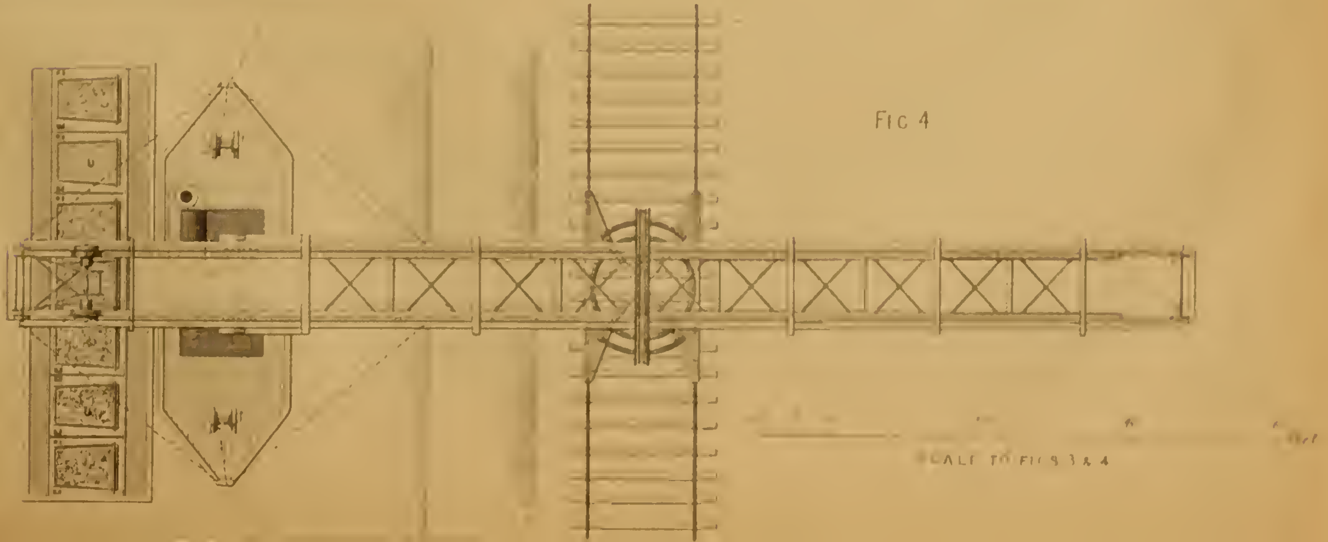

FIG 4

SCALE TO FIGS 3 & 4

# THE ARTIZAN.

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## THE STEAM DREDGERS EMPLOYED IN THE EXCAVATION OF THE ISTHMUS OF SUEZ CANAL.

(*Illustrated by Plate* 338).

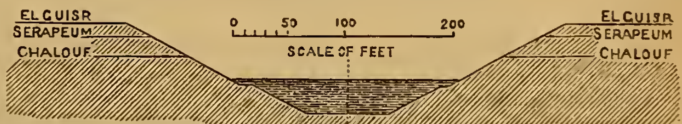
As the Suez Canal is an undertaking of such vast importance we trust we shall not be wearying our readers by the numerous articles which have appeared in The Artizan upon the subject, both when it was first suggested, and lately when it is fast becoming an accomplished fact. The following description of the steam dredgers, which may be considered as supplementary to those articles, is condensed from a very interesting paper contributed by M. Borel, and read before the Paris meeting of the Institution of Mechanical Engineers.

The excavation of the Suez Canal is not of the same character throughout, the general configuration of the Isthmus requiring at one part cuttings of considerable depth; but the greater portion of the length requires only the excavation of a channel through ground scarcely above the sea level, and a considerable portion lies below that level so as to require embanking on each side of the channel. The present distance from the Mediterranean to the Red Sea across the Isthmus of Suez is 100 miles; but at a comparatively recent date the waters of the Mediterranean reached up to the table-land of El Ferdane, and the Red Sea nearly to Chalouf. The land distance of 56 miles between these places was further reduced by Lake Timsah, which was formerly fed by the waters of the Nile, having a bottom 19ft. below the sea level; and also by the two Bitter Lakes, which are 12½ and 9 miles length, and 16 to 32ft. depth below the sea level, but are at the present time dry. The Mediterranean thus appears to have retreated about 37 miles, leaving behind it the shallow lakes or rather marshes of Lake Ballah and Lake Menzaleh, from the latter of which it is now separated by a narrow belt of sand of only 100 to 200 yards width. The Red Sea has also retreated about 9 miles, leaving a plain at nearly the level of high tide.

The first half of the entire length of the canal, extending from the Mediterranean to near the Bitter Lakes, passes mostly through fine sand more or less muddy, some portions passing through clay and mud of varying hardness and consistency, and some through agglomerated sand; but no portion offers serious difficulty to the dredger when excavating from underneath. There are also some beds of calcareous and gypseous formation more or less hard, but not very thick, and not expected to cause any great difficulty to a dredger with the ordinary buckets. Near the Bitter Lakes the soil changes entirely and becomes clayey, and a gypseous clay with a few alternations of sand forms the remainder of the distance to be traversed by the canal to the Red Sea; but this material is not expected to offer any remarkable difficulties to working by a dredger suitably constructed.

The canal starts from a point at Port Said on the Mediterranean coasts, where the water deepens most rapidly, in order to reduce the length of the jetties that have to be constructed. The line of the canal passes through the successive lakes, cuts through the elevated table-lands of El Guisr or El Ferdane and Serapeum, and the high ground at Chalouf, and crosses the Suez plain to the Red Sea at Suez. The section of the canal was originally intended to be made with 26ft. depth of water and 72ft. width at the bottom of the excavation, with slopes of 1 in 2, giving a width of water-way of 176 feet at the surface; but this width has been increased to 328ft. for the portions of the canal passing through the low ground and lakes, and the slopes below the water line have been left to take the natural slope of the soil. For the cuttings through the high ground at El Guisr, Serapeum, and Chalouf, the section of the canal is that shown in Fig. 5.

Fig. 5.—*Transverse Section of Canal, where passing through the high ground at El Guisr, Serapeum, and Chalouf.*



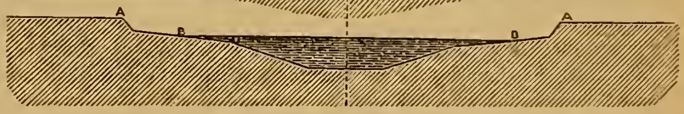


Fig. 6.—*Transverse Section of Canal, where passing through the low ground and lakes.*

The first operation consisted in cutting a freshwater canal, in prolongation of the old Ouady Canal from the Nile, for the purpose of obtaining a supply of fresh water for the men employed on the works; this prolongation was carried to Ismailia, where the head-quarters of the works are established near the middle point of the maritime canal. The line of the maritime canal through Lakes Menzaleh and Ballah was then commenced by excavating two side trenches, the spoil forming a continuous embankment along each side of the canal across the ground lying below the sea level; and the embankment on the African side was made strong enough to resist the action of the waves in the lake, and to carry the fresh water conduit on the top. A communication by water was then effected from the Mediterranean to the Red Sea by means of the freshwater canal, a branch of which was constructed from Ismailia to Suez, and the channel though shallow sufficed for supplying the works, as long as hand labour alone was used. When the fellahs previously employed were withdrawn by the Egyptian Government, mechanical means had to be resorted to for continuing the works, and steam dredgers were then adopted.

The dredgers used on the first 10 miles of the canal from Port Said are constructed entirely of iron, with one bucket frame, the foot of which is ahead of the hull, so as to be able to open the channel in advance of the vessel. The buckets hold 14 cubic feet each, and the shoots depositing the spoil on the sides of the canal are successively lengthened; the slope of the shoots being about 1 in 10, the wet mud and sand readily pass down them. All the movements for raising and lowering the bucket frame, for traversing across the canal, and for going ahead, &c., are performed by a condensing steam engine of 35 horse power with two cylinders.

On the next portion of the canal, extending to El Ferdane, the surface of the ground is somewhat higher than in the first portion, whereby not merely is the size of the spoil banks increased, but also the height at which the spoil has to be deposited; moreover the clay which here constitutes a portion of the spoil prevents it from spreading so far on falling from the shoot, and thereby further increases the height of the spoil bank. The mode of executing the work therefore on this portion of the canal was as follows:—Leaving the trench on the African side for the the boats bringing up supplies from the sea at Port Said the Asiatic trench, which as a rule was originally cut narrower and shallower than the other, was enlarged first. All the soil above the water level was taken out by hand labour, and carried beyond the distance at which the dredgers were to deliver, in order to allow as much slope as possible for the dredger shoots; but notwithstanding this precaution, the shoots had still to be lengthened and sloped more gently than before. The dredgers employed for excavating below the water level are worked by engines of 14 to 18 horse power at high pressure without condensers, having driving belts and cog wheels driving the tumblers. The hulls, which are of iron, are 72 and 82ft. long with 23ft. beam. In order to add to their stability with their long shoots, a wooden lighter 39ft. long by 10ft. beam was firmly lashed alongside. The buckets of these dredgers are from 3½ to 5½ cubic feet in capacity, and the delivery is at the rate of about 20 buckets per minute. The shoots are made of sheet iron; they are 4ft. wide, their cross section being a semi-ellipse with the long axis horizontal, and they are inclined from 1 in 12 to 1 in 16, their length being from 65 to 72ft. Sixteen of these dredgers have been used to make 18 miles of new channel, 59 to 65ft. wide and from 6ft. to 10ft. deep.

That portion of the spoil from the main channel of the canal which is not deposited upon the banks by the dredger shoots is delivered into ballast lighters fitted to go out to sea, which discharge the spoil in deep water in the Mediterranean. The English sea-going ballast lighters hold 217 cubic yards and have one screw driven by an engine of 50-horse power working with surface condensers; these are excellent boats, both in form and construction, and also from the simplicity of the whole arrangement. Others built in France carry 261 cubic yards, and work at high pressure without condensing. The speed in both cases is about 7 to 8 miles per hour.

In the course of working, it was remarked that by the passage of the vessels, and especially of the small steam tugs, the sides of the canal were worn down somewhat rapidly when dressed to a slope of 1 in 2, and it was therefore proposed that the slopes should be pitched; but before this could be accomplished, it was found that the action of the waves had formed a sort of gently shelving beach, on which their force was then spent without further injury to the slopes. This clearly showed that all that was necessary for the further protection of the slopes was to shift back the spoil banks A A to such a distance, as shown in Fig. 6, that not only might the slopes of the channel of the canal be made flatter without causing the sides and spoil banks themselves to give way, but also that there might be formed along the water line a sufficiently wide ledge B B to serve as a gently shelving shore for the waves to break upon. For this reason the width of the canal at the surface of the water was increased to 328ft., as in Fig. 6, and the inner crests of the spoil banks A A were made 394ft. apart, or 197ft. distance on each side from the centre line of the canal. This necessarily increased the quantity to be excavated, and means had to be devised for depositing on each bank 246 cubic yards of spoil per yard run; and a most successful solution of the difficulty was found in the adoption of extra long shoots. But it then became necessary to give the dredgers an unusual height and to make the shoots 230ft. long; and it was consequently impossible to retain the same arrangement of the parts as in the smaller dredgers. The new arrangement however presented the great advantage of doing away with cranes, ballast lighters, and especially wagons for removing the spoil, which, running over banks made of mud or wet clay broken up by the buckets, were constantly getting out of order. Moreover with the aid of a few torches the dredger could be worked by night as well as by day.

The dredgers with the extra long shoots are shown in Figs. 1 and 2, Plate 338, and are fitted with a single bucket-frame like the others, the foot of which is ahead of the hull; the hulls are 108ft. long and 27ft. beam, and the upper tumbler is 48ft. in height above the water. The shaft of the engine carries a drum working two centrifugal pumps, for supplying water to facilitate the discharge of the spoil through the shoots. The length of the shoot from the centre of the dredger is 230ft., and its section is a half ellipse 2½ft. deep and 5ft. wide; the width of the vertical well into which the buckets discharge the spoil being greater than that of the shoot, a tapering junction is made of as great a length as possible. The shoot is stiffened lengthwise by two lattice girders which rest on the bottom of an iron lighter placed at about one-third of their length from the dredger; the uprights supporting the shoot are not fixed to the bottom, but jointed to a large horizontal spindle placed lengthwise in the lighter, and passing along its centre of displacement. A horizontal hinge couples the shoot to the dredger, and allows of its inclination being altered; this joint is covered by a piece of leather protected by sheet iron, over which the spoil passes, the leather and iron being fixed to the dredger only. In order to allow of changing the inclination of the shoot the uprights resting on the lighter are made telescopic. The shoot is lifted by two small hydraulic presses worked by hand; blocks of a suitable thickness are then put into the slides of the uprights and the whole is bolted together.

For the purpose of facilitating the transport of the shoots, the framework supporting the shoot is cut in two horizontally above the slides just mentioned, so that when the shoot is detached from the dredger it can be turned on a sort of platform and brought into a position lengthwise with the lighter, the outer end being put upon a boat for that purpose. As it is necessary that the dredger in traversing across the canal from side to side should carry its shoot and lighter with it, the lighter is connected to the dredger transversely by a pair of chains, with horizontal struts at right angles to the two hulls to serve as distance pieces; and a second pair of chains run from the stern and bow of the dredger to the bow and stern of the lighter, whereby they are securely stayed together longitudinally. A pair of iron frames fixed to the dredger, and resting on the lighter and attached to it, make the two hulls like one piece in their vertical movements.

Many of these dredgers with long shoots are now at work satisfactorily, and fully realise what was expected of them; and twenty more are being constructed. It was feared that the swinging or traversing movement of the dredgers across the canal from side to side might be attended with some difficulty on account of their mass, and from the wind acting with so great a leverage: but these fears are found to be without foundation, as the dredgers are shifted just as easily as those discharging into ballast lighters. The swinging movement of the dredger is performed by means of chains from the four corners of the dredger to anchors with very broad and strong flukes. These chains pass through hawse holes, 3 to 5ft. below the water, leaving sufficient depth of water above them for the boats actually used on the canal to pass over the chains; the hawse holes are found to wear away very quickly.

Only one form of bucket is used, of elliptical section and very conical, and as this empties very easily it has not been considered necessary to try any other forms. It should be borne in mine that, beyond a certain size, the buckets empty very well, even when they work in sticky clays; because the adhering surface of the spoil is simply proportional to the square of the dimensions, whereas the volume and consequently the weight of the spoil is proportional to the cube of the same dimensions. Thus the weight increases more quickly than the adherence, and consequently the latter is always overcome beyond a certain limit of dimensions.

With these dredgers 48ft. high it will be easy, with the exception of certain short portions where the ground is too high, to complete the cut across the Mediterranean lakes and the Suez plain, which form the two ends of the canal, and also to excavate the approaches of the Bitter Lakes. the whole amounting to more than half the entire length of the canal, Before constructing the dredgers 48ft. high however, it was necessary to proceed cautiously in exceeding the dimensions of the first dredgers of only 26 to 30ft. height; and experience showed that it was necessary to devise some new method for getting rid of the spoil in the higher ground. The formation level of the canal is throughout at the same height, and consequently the cubic quantity of spoil increases very rapidly as the ground rises; and as the crest of the spoil bank deposited on this high ground must be at least so far below the extremity of the shoot that the largest lumps which the buckets bring up may easily be got rid of, the height of the shoot and consequently of the dredger increases much more rapidly than the depth to be excavated. This necessitates increasing the strength of all the framework, the length of the bucket frame, and the weight of the chain of buckets; but the pins and links of the bucket chains had already reached very considerable dimensions and weights in the original dredgers, which made them inconvenient to repair. The first trial was made with dredgers only 10ft. higher than the original ones, and their excellent working encouraged the making of others still 10ft. higher; but it was evidently impossible to go much beyond the last height of 48ft.

In order therefore to excavate the short lengths of the canal where the ground is too high for even the long-shoot dredgers of 48ft. height, an attempt was made to work with cranes carried on the canal banks, having 33ft. radius of swing, which were to take up the boxes filled by the dredgers and brought alongside in floats. The arm of the crane not being long enough to discharge more than a small quantity on the spoil bank, the remainder was to be run off in trucks in the ordinary way. The first thing necessary was that the canal banks and slopes should be sufficiently solid to carry the cranes and rails and loaded wagons, when sloped at the inclination of 1 in 2, which was necessary for allowing the floats to come alongside. After some months' trial on the most favourable portions of the canal, it was found that the action of the water on the slopes, and their general want of solidity under the weight put upon them, rendered this plan defective. The object then was to find some arrangement of mechanism which, whilst it should be capable of movement longitudinally, should be steady laterally, and should discharge at least one-half of the spoil direct on to the bank, without the use of wagons or any further handling.

These considerations led to the construction of an Elevator, which is shown in Figs. 3 and 4 Plate 338, and consists principally of two lattice iron girders, placed at right angles to the canal and resting half way on the bank; these support a pair of rails inclined about 1 in 4½, the lower end being about 10ft. above the water, and the upper end about 46ft. A truck running on the bank parallel to the centre line of the canal, 6ft. above the water, supports the girders in the middle, and the lower half towards the water rests on a lighter, the centre of which is 26ft. from the lower end of the girders; the upper half towards the shore is completely overhanging. The girders are tied together by vertical struts, and are strutted between their lower plates. The gussets at the middle are joined above the rails in an arch, and at their lower ends widen out and rest on truck. The two girders are thus supported at two points 13ft. apart which gives them sufficient stability transversely, but allows of vertical oscillation, so that the inclination can be suited to the level of the water. They are attached to the lighter by a cast-iron block fitted with two trunnions placed horizontally and at right angles to each other; to this piece are secured four uprights, in the shape of an inverted pyramid, which are riveted two and two to the girders, thus forming a universal joint.

On the inclined rails N of the girders runs a trolly R with external wheels, which is shown enlarged in Figs. 7 and 8; the pair of wheels at the lower end are fixed upon their axle, while the other pair are loose; and the axle of the latter carries two pairs of drums S S and T T of different diameters cast in one piece. On the smaller drum S is coiled a chain, to which the boxes U filled by the dredger buckets are to be hooked; on the larger drum T is coiled in the contrary direction an iron cable, which passing over a pulley O at the top end of the elevator runs down to a winding drum I fixed to the supports of the girders on the lighter. The winding drum I is worked by a two cylinder engine; the boiler is in the lighter, which contains also the water tanks and coal bunkers; and as the engine itself is fixed to the girders the steam pipe passes through the universal joint uniting the girders to the lighter. The elevator is worked in the following manner. Supposing the trolly R is at the lower end of the incline and consequently outside the lighter, a float is brought underneath, carrying boxes U U filled with spoil by the dredger, one of which is hooked on to the chain, and the engine set to work. The first effect is that the cable uncoils itself from the larger drum T on the axle of the trolly, Figs. 7 and 8, thereby winding up on the smaller drum S the chain hooked to the box U, which is thus lifted until the stop V touches the drum S; and as the chain cannot then be wound up any further, the cable drags the trolly up to the top of the incline, where the spoil is tipped by a self-acting movement. For tipping the spoil a pair of rollers X, Fig. 7, are placed at the back of the box U and on the lower side, which are caught between two pairs of guiding rails Y Y parallel to the incline of the elevator; and shortly before getting to the top of the incline these guides rise in a curvilinear line, as shown in Fig. 3, so as to tip the box into a nearly vertical position for emptying out the spoil. By reversing the engine the trolly is allowed to run down to the bottom of the incline, and the box is lowered back again into the float.

Fig. 7.

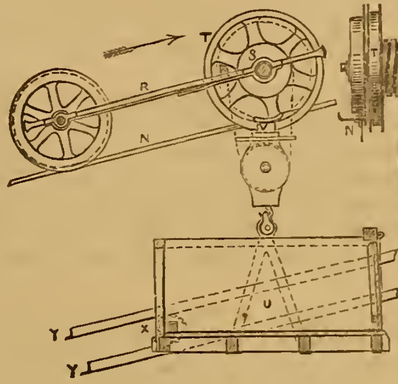
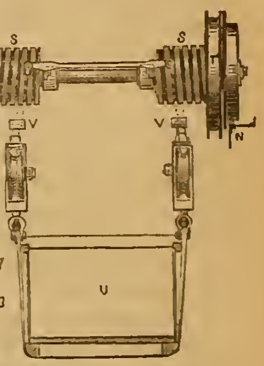


Fig. 8.



The boxes U hold 4 cubic yards each, and their shape is similar to that of tip wagons, as shown in Figs. 7 and 8; the bottom is lined with thin sheet iron, and they are made somewhat narrower at the back than in front. The flap door at the front end is hinged on the upper edge, Fig 7, and kept shut by a catch on each side, which is released by a self-acting chain at the moment of tipping the box. The floats carry seven boxes each; they are made of two long rectangular chambers of sheet iron, 57ft. long, 3½ft. wide, and 4ft. high; these are kept 10ft. apart by eight open-work partitions between which the boxes are put, and fully loaded they are almost entirely sunk in the water. Each dredger will ultimately have two elevators, one on each bank, and will get out a section of 300 to 450 yards length. If the final depth of the canal has to be excavated in three or four stages, the dredger will go up and down the length so many times, but the elevators will go only once.

In the Suez plain there was some difficulty about conveying the dredgers to the place where they were to commence work upon the line of the maritime canal, and it was impracticable to put them together on the spot. They are therefore put together and tried at Port Said, whence they are brought by water to Ismailia, and so passed into the freshwater canal by the two locks situated there; and they are then conveyed along the freshwater canal to a point about 5 miles from Suez. At this point has been excavated a sort of basin opening into the freshwater canal, and beyond is a second basin serving as a lock chamber; a communication is made between the two basins, and the dredgers with 82ft. shoots are floated into the second. They are then set to work and scoop out the bottom 6ft. deep below the sea level, and the communication between the two basins being stopped and the water allowed to escape from the second basin, the dredgers descend to their final level. They then cut their way to the line of the maritime canal and turn north and south, cutting a side trench right and left, along which the dredgers with 230ft. shoots can follow and complete the work.

In order not to be exposed to the rise and fall of the tide, the cut will not be made into the Red Sea until the works are sufficiently advanced for admitting the water into the smaller of the two Bitter Lakes, which will be temporarily shut off from the larger one by a small embankment constructed upon the ridge that forms the division between the two lakes. A weir will then be put up at the mouth of the cut at Suez, having its upper surface about at the level of mean water, and fitted with sluices, so as to be able to retain the water in the canal up to the required level. The fall of the tide would otherwise impede the working of the dredgers.

The modes of working already described are those employed for cutting the canal wherever the surface of the soil is less than 6ft. above the sea level, that is, over a section about 56 miles in length, and including about 50 million cubic yards of excavation. Of this work the different implements have the following shares respectively allotted to them: dredgers delivering into sea-going ballast lighters, 13 million cubic yards; dredgers with elevators, 6 million cubic yards; dredgers with long shoots, 31 million cubic yards.

The higher ground along the line of the canal comprises the elevated table-lands of El Guisr and Serapeum and the high ground at Chalouf For the excavation at El Guisr, a cut was originally opened by hand labour to a level somewhat below that of the sea, and this cut is now being completed to the full width in the ordinary way, with wagons loaded by hand and drawn by small contractors' locomotives; in some places excavators are used for loading the wagons. This portion of the canal will then be completed by dredgers coming up from Port Said, which will deliver their spoil into lighters with flap doors at the bottom, and these will empty in Lake Timsab.

The lighters with bottom doors are 108ft. long with 23ft. beam, carrying 160 cubic yards of spoil, and drawing 5ft. of water. They are fitted with twin screws and a pair of cylinders placed end to end; the engines work at high pressure without a condenser, with a tubular boiler at 120lbs. pressure, using only fresh water. Whether loaded or light they make good a speed of 3 to 3½ miles an hour, and although made especially for lake work they can put to sea. Their construction is simple and economical; and it is found that high pressure engines are preferable to those of a medium pressure, as being simpler, lighter, and easier to keep in working order, and consequently more to be relied on for continuous work.

For the Serapeum cutting, there is no means of bringing the dredgers and lighters in at the northern end direct from the Mediterranean, as at El Guisr; and they are therefore got upon the line of work by a similar plan to that already described in the case of the Suez plain, by cutting a channel from the freshwater canal to the line of the maritime canal. As the level of the freshwater canal is 20ft. above the sea level, it is not possible in this case for the ballast lighters to empty into Lake Timsah until the cutting has been excavated down to 6ft. below the sea level; and for depositing the spoil it was therefore decided to take advantage of three natural hollows which were found to extend transversely right and left of the line of the maritime canal, being formed by the undulations of the ground. By embanking these hollows at suitable points, and then filling them with water from the freshwater canal, shallow lakes are formed, of sufficient capacity to receive from the ballast lighters all the spoil excavated by the dredgers down to a depth of 26ft. below the freshwater canal or 6ft. below the sea level. When the bottom of the cutting has been lowered to this depth, the communication with the freshwater canal will be shut off, and the water allowed to run out into Lake Timsah, the dredgers will then begin again and work out the canal bed to its final level, the ballast lighters discharging in Lake Timsab.

For emptying the spoil in the shallow water of the temporary freshwater lakes, it became necessary to seek some new arrangement by which the ballast lighters could discharge in a very shallow depth; and the lighters constructed with flap doors at the sides are found fully to answer this purpose. The well is 65ft. long, and is divided into two portions by a longitudinal air chamber of a triangular section; the bottom of the boat, which is flat, forms the longest side of the triangle, and the vertex of the triangle is about level with the gunwales. The well is also divided across by five partitions into twelve compartments; the sides of the lighter are inclined slightly outward towards the top, and the flap doors of the compartments are hinged at the top; these doors are 4ft. high. The winches working the doors are inside the air chamber, which is entered from both ends of the boat. The engines and boilers, which are the same as those on the other lighters with flap doors at the bottom, are in a compartment at the stern. These lighters carry from 100 to 120 cubic yards and draw 4ft. of water.

The high ground at Chalouf, will be cut through dry, and the stuff removed with barrows and wagons; these latter are entirely of iron, and hold 2½ cubic yards each. This portion, when excavated sufficiently low to admit the water from the Red Sea, will be completed with dredgers in the same way as the other portions, the spoil being discharged in the smaller of the two Bitter Lakes by ballast lighters with bottom doors. The sand on the previous portion of the canal was found to be completely impermeable to water when a certain depth was wetted; but the same is not the case here, as in the Suez plain the soil is clayey, mixed with some beds and pockets of sand. It has therefore been necessary to put up centrifugal pumps to keep the water under in the cutting, as the leakage is considerable from the freshwater canal, which is here at only a very short distance from the maritime canal. This water is run back into the smaller of the two Bitter Lakes.

To keep the numerous dredgers and engines in working order there are large shops at Port Said, and ten small shops on the different sections. In reference to the repairs, it may be mentioned that, in the first dredgers used at Port Said, the pins of the bucket chain were made some of iron, others of soft steel; but when working in the sand a pin of 2in. thickness was found to be completely worn away after 16,000 to 20,000 cubic yards had been got out, and three or four days' stoppage was required to put in a new pin. The wages alone for the dredgers however amount to about £4 per day, with another £4 to £6 for the bargemen of the ballast boats, making a loss of about £8 to £10 per day, when they were stopped and 4,000 cubic yards would have been excavated during the three days. Pins 2¾in. diameter with triangular beads were then made of the hardest possible steel; the bead is fixed in the double link, so that the single link takes all the wear, the eye being bushed with the hardest steel. After a certain time the pins are turned round one-third, and 48,000 cubic yards can now be excavated without turning the pin.

The following observations have been made as to the manner in which the different sorts of spoil pass down the shoots of the dredgers. The fine sands, which are the only sands met with, pass easily down a shoot inclined 1 in 20 or 25, if mixed with a quantity of water equal to about half their own bulk. When the shoot has a less inclination than 1 in 25, the water separates from the sand, which is thus deposited all along the shoot in layers of continually increasing thickness; the addition of a larger quantity of water does not seem to have any effect, and it is necessary to stir it up with a shovel. When the sand contains any shells, they are deposited in the shoot even with an inclination of 1 in 20, notwithstanding their lightness; and create round them deposits of sand, which continually increase, and have to be got rid of with shovels, or better still by increasing the inclination of the shoot. Different degrees of fineness and muddiness in the sand, and different sections more or less flattened of the shoots, require different inclinations of shoot.

The top of the spoil bank has the same width as the extent of side motion of the dredger. The inner slope is more or less steep according to the means used to support it; the outer slope, if the top of the bank is high and the spoil has but little height to fall from the end of the shoot, varies from 1 in 16 to 1 in 25. The more muddy the sand is the gentler is the slope. When the top of the bank is low, and consequently the spoil falls from a greater height, the outer slope is gentler still. The sand when got out occupies only 2 or 3 per cent. more cubic space than in the solid.

Mud behaves very much like sand, if it is sufficiently soft to mix with water; and it will then pass down a shoot set with scarcely any perceptible inclination. The very softest mud, such as that got out of the old channels previously cut through the clay ground, does not require the addition of any water in the shoot. With clay it is quite different; the addition of water washes away only a very small quantity of the material, and hardly breaks up the lumps at all. If each lump of clay were to slide perfectly straight down the shoot, all would work well; most commonly however a lump winds about and soon stops, and the contents of the next bucket then drive it on 5 or 10ft., and the whole increases the block. Others come after and increase the stoppage, till the mass gets 12 to 16in. in thickness and reaches to the top end of the shoot, when the contents of the succeeding buckets seem to break it up, and the mass descends quietly and regularly in pieces of about 3 to 6 feet length. The shoots for clay are inclined from 1 in 12 to 1 in 16. With an inclination of 1 in 20 the lower end gets choked, which tilts that end of the shoot down and empties it, the work being thus carried on intermittently; with an inclination of 1 in 12 to 14 the work is more regular. When the clay is mixed with sand, the surface acts like a rasp, because the water washing away the clay makes the grains of sand more prominent and cutting, and thus seems to be rather detrimental. This is also the case when the buckets bring up hard clay and mud; the mud lubricates the clay and makes it run down more easily, whereas the water only washes the mud away.

In short, experience has shewn that whilst a considerable supply of water must be added to sand, it is not so for mud or clay, to which only just enough water must be added for moistening the mass. Jets of water, have not given good results; they merely wash down the points against which they are directed, and do not break up the lumps. The simplest and most convenient plan has been to put up a foot-way along the side of the shoot, and keep three or four men at work with scrapers to prevent its choking. In the long-shoot dredgers, with shoots of 230ft. length, an endless travelling chain is employed, as shewn in Fig 1, driven by the engine and furnished with a series of scrapers to carry the clay down the shoot. Generally the greatest difficulty with all kinds of spoil is in passing the first 40 or 50ft. length of the shoot; when once the material has passed this with any given inclination, it continues moving on down the some inclination without further difficulty.

## REGULATIONS AFFECTING THE SAFETY OF MERCHANT SHIPS AND THEIR PASSENGERS.

By Thomas Smith, Mem. Inst. Naval Architects.

I was much pleased to see in The Artizan of last month, an article under the above heading, and that an institution of such national importance as the British Association had taken the question of the safety of merchant ships in hand, as it is a matter most urgently required to be carried into practice. The same, or very similar suggestions, were proposed by me in the columns of The Artizan of July and September, 1857, but unfortunately without obtaining any practical results at that immediate period, beyond the foundation of the Institution of Naval Architects in 1860, which was also suggested by me at the same time. Treating the matter as it appears in the columns of The Artizan,—firstly, with regard to the depth to which a vessel should be immersed, 3in. freeboard is mentioned as being considered sufficient for every foot of immersion. This is perfectly correct for a vessel designed by a theoretical and practical naval architect, who has received the proper training and education to enable him to design and build vessels that will be sea-worthy. One of the greatest faults in our merchant navy, and one that is the cause of so many failures in required performances, is the fact that a large proportion of our vessels are built by inexperienced men who work entirely by the rule of thumb. Many shipowners even entrust their captains to make models for both their steam and sailing vessels, just to suit some whim or fancy of their own, without being able to give any intelligent reason for such a shape. These vessels are actually built by our shipbuilders according to the form of these blocks of wood, for they are nothing else, unless, as is frequently the case, the shipbuilder cuts a bit off the bow, and puts a bit on the stem, or *vice versa*, to suit some fancy of *his* own, but with no more idea of a correct theory than the captain who made the model. It is a fact, that many of our shipbuilders, even at the present time, are perfectly ignorant of any rules, either theoretical or practical, referring to the construction and form of vessels for various purposes and trades. It is such shipbuilders that usually turn out an un-seaworthy craft; she either is a vessel with too little stability, no bearings in the ends, draws some feet more water than was intended, is a knot under her required speed, or some other glaring bungle. The owner then finds fault with the builder, but why did he entrust the building of his vessel to such a man? At the meeting of the Institution of Naval Architects, April, 1868, the Earl of Hardwicke as chairman, at one of the afternoon meetings, said, referring to some experiments made by Mr. Mackrow on the Greek ironclad *King George*, that he trusted the time had now arrived when all *shipowners* would see that great advantage to themselves, and the safety of the public at large, would be attained by having their *vessels built only* by such shipbuilders as were both practical and theoretical naval architects, and not the common rule of thumb, and block-of-wood men. It is by building such vessels that so many accidents occur (*vide* my article in The Artizan of September, 1857, referring to the *Belgique*). Whatever amount of freeboard you may allow, a badly-constructed vessel with little or no floor, will ship successive seas, and in time some of her deck fittings must give way; the ship then fills and founders. As to the position and stowage of dead weight, this is a very important point in the safety of a sea-going vessel, and one referred to by me in The Artizan of September, 1857; still I fear we are no better off than we were then. This cannot be properly regulated until an act is passed or regulations made by the Underwriters, to have proper persons to superintend the stowage of cargo in vessels, with some regard to their centres of gravity, stability, and form.

The suggestion as to marking on every vessel her proper depth of immersion, both forward and aft, is a very good one, and would be a great security. In the event of the vessel being loaded beyond the allowed depth, the insurance company should not be held liable for any loss or accident that might occur, which would be the means of deterring unprincipled persons from overloading their vessels for the sake of extra gain. But the next question is, who is to decide to what draught vessels of various construction are to be immersed, for the draught must *in all cases* be ruled by the form of vessel. The Board of Trade have lately thought fit to dispense with their shipwright surveyors, and left the whole matter of supervision in the hands of the engineer's surveyor. This is a great mistake; an engineer may know *something* about the construction and putting together of the iron work of a vessel, but beyond that he is lost and entirely out of his element, although many men profess to have mastered both professions. They may, and do, no doubt, understand the general routine of naval construction, but as regards the scientific construction of vessels they are, for the most part, greatly in error. One of the commonest mistakes made by them, and one, I believe, still entertained and persisted in by the heads of the Board of Trade is, that a vessel is a girder. Now a ship is not a girder, neither can it in any one way be treated as such. In the case of any ordinary vessel the constant movement of the waves, and the different portions continually being subjected to various strains by the pitching and rolling of the vessel, must show that to look upon the structure in the form of a long girder is altogether wrong. This is one of the points that requires investigation, with a view of having proper supervision to insure the efficient and safe construction of our merchant navy.

As regards "deck loads," the Hull captain referred to is right, provided the cotton *was protected;* in the class of vessels he mentions, with a long flat floor, such a load would be quite safe. All shipowners are aware, that in steam vessels built for the Atlantic trade, and particularly for New Orleans, that it is necessary to build their vessels as deep as possible, so as to allow space for stowing a sufficient quantity of cotton; consequently many of these vessels are built with full poop and forecastle and deep bulwarks amidships, so as to allow room to stow on the homeward voyage, a large deck load of cotton, which is, of course, liable to get wet with the sea. Perhaps some will ask, why not cover in the space between poop and forecastle, with a light deck, if you desire to carry light bale goods? The answer to this is, that on account of Lloyds' or the Underwriters' classification adding so much to the tonnage of the ship, no matter for what purpose or trade the vessel is for, they require such a large additional thickness of iron and other extra weight that the ship is spoilt, that is, if the owner wants a class. I will mention one instance of a vessel built on this construction (without consulting the surveyor) and closed in from the forecastle to the poop with a light deck, and sides to protect her deck load. The vessel was built in every respect, as regards scantling, &c., to the highest classification at Lloyds, and under the *special survey* of their surveyors, but at the finishing of the vessel, when the builder commenced to close in from the poop to the forecastle, the surveyor opened his eyes, and asked—What are you going to do? The builder replied, "merely to make a covering to protect the deck load, and prevent the sea from going down the engine skylight and boiler hatch; in fact, to make the vessel safe for her intended trade." The surveyor immediately reported the same to the committee who decided that *the protecting of the deck load,* or say, the light deck from poop to forecastle, was an infringement of their rules, and therefore refused to class the vessel as originally intended, although her scantling was of the highest grade. Many sea captains, and would-be wise-acres, when this took place, came to look at the vessel on the stocks, and predicted she could never stand without ballast, and would be sure to capsize when launched, besides many similar remarks usual on such occasions. In fact, from this period till the time of the vessel being launched she got the name of the "Umbrella Ship,"* which soubriquet was, I believe, originated by some one connected with Lloyds, and who should have been a person of superior standing in his profession to have made such an error. To the utter amazement of these critics, when the vessel was launched without ballast, but with masts, topmasts, topgallant masts, and yards across, and nearly 100 men and boys on her top deck, the vessel, when she left the ways, never listed 6in. either to port or starboord. The owners who were delighted with their vessel, got what they desired, saw she would be a safe ship for the trade, and troubled themselves no more about the classification. The vessel is still running, and her captain reports she is an excellent sea boat and a large carrier. The foregoing is another illustration of the errors in judgment of those placed in authority, and the difficulties to be contended against, with respect to the safety and construction of our merchant navy.

Boats.—With the proposition as to the stowage of boats I agree, also as to the necessity of exercising the crew at boat duty; but there is one point grievously wrong with regard to the Board of Trade regulations for boats for passenger steamers. Suppose a steamer of 600 or 800 tons, requires a Board of Trade certificate for a foreign-going voyage, and has accommodation for, say, 10 passengers, she must have life and other boats of the same dimensions as if she had accommodation for 100 passengers. Looking an the matter in a different form; if the vessel is 1,000 tons register she requires as many boats, and of the same capacity, as for a vessel of 3,000 or 4,000 tons, no matter how many passengers she may be licensed to carry. In trades where only a few passengers are carried, the boats are a great inconvenience on deck, and add a large amount of unnecessary top weight.

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* Should any of the readers of The Artizan be curious to see what the "Umbrella Ship" is like, as I have in my possession the lines of the vessel, I will gladly forward a copy to the office of The Artizan for inspection.

## ON THE DYNAMICAL THEORY OF HEAT.

By Joseph Gill, Esq.

The first law of thermodynamics enounces that heat and mechanical energy are mutually convertible. The direct conversion of mechanical energy into heat seems sufficiently obvious from various known phenomena of friction and percussion; and the admirable experiments of Joule have shown, with an accuracy sufficient for all practical purposes, that in the process of friction mechanical energy is directly converted or transformed into heat in the proportion of 772 foot pounds for each British unit of heat. The direct conversion of heat into work is not so obvious, and satisfactory experimental proofs of the fact are still wanting.

Physically considered, the universe has been defined as matter and motion; and, as far as human means are concerned, it is allowed that matter and motion can neither be created nor destroyed. In all the wonderful transformations of matter revealed by chemistry, it is well known that the quantities of the substances acted on are absolutely constant; not an atom is destroyed or created; and physical science now demonstrates in a manner almost equally convincing that motion, or the free unbalanced action of force on matter, as well as force itself in a potential state, where it is counterbalanced by some equivalent resistance, is also absolutely constant in all the various transformations through which it may be caused to pass. The genius of Lavoisier established the truth of the conservation of matter; and many living authorities of the highest scientific standing have concurred in establishing the certainty of the conservation of force—a theory which appears to shed a fresh light upon almost every branch of physical inquiry, and to impart a new interest to subjects the study of which was already beginning to settle down into a quiet current of fixed opinions.

The grand simplicity of the idea of the conservation of force, together with the tendency to generalise which influences most inquirers in scientific matters, would naturally lead to the belief that if mechanical energy is directly convertible into heat, heat should be also directly convertible into mechanical energy, and, of course, in the same proportion. Hence it is assumed that when a hot perfect gas performs work by expansion in a cylinder supposed to be neutral to the thermometric effects of heat, and having a piston moving without friction, it must naturally lose as much heat in raising a weight of 772 pounds one foot as would raise the temperature of one pound of liquid water one degree of Fahrenheit's scale. By the same reasoning, steam, in performing work in vessels supposed to be equally neutral to heat, should lose exactly the same quantity of heat in doing the same quantity of work; and as perfect steam (neither super-heated nor containing water in suspension) cannot lose heat without undergoing a corresponding amount of condensation, it is assumed that in the working of the steam-engine as much steam is condensed (theoretically) as corresponds to the amount of work performed in the proportion of Joule's equivalent and consequently that the quantitative heat of the steam passing into the condenser is by so much less than the total heat of the steam furnished by the boiler to the engine.

More than thirty years ago Seguin, in his interesting work "On the Influence of Railways," endeavoured to trace the dynamical relation which he saw must exist between the heat applied to the boiler and the energy developed by the engine; and it is remarkable that, in many experiments made by him on the actual working of steam-engines, with the express purpose of proving the disappearance of quantitive heat which he thought must be converted into the work done, he could not detect the expected disappearance of heat.

Soon afterwards Mayer published some very interesting speculations on the mechanical equivalent heat; and, from theoretical considerations on the effect of heat in increasing the elastic pressure of air, he deduced a numerical value of the dynamical equivalent, which agrees very closely with the result of Dr. Joule's independent and highly philosophical experiments. These experiments proved indisputably that mechanical energy is directly convertible into heat; but so far no experiments seem to have proved with equal clearness that heat was directly convertible into mechanical work. More recently this part of the inquiry was taken up by the distinguished engineer M. Hirn of Colmar, who, like M. Seguin at an earlier period, instituted a series of experiments on the actual working of large steam-engines, to ascertain, if possible, the disappearance of heat equivalent to the work done as assumed by the dynamical theory; but he could not obtain satisfactory proof of the direct disappearance of quantitative heat from the working steam as an equivalent of the work done. These negative results led to a controversy, in which the correctness of the dynamical theory was ably sustained by Professor Clausius; and at his suggestion M. Hirn made a fresh series of experiments on the large scale as before, from which he still could detect no disappearance of the heat supposed to be changed into the work done. His apparent facts were again ably combated by the supporters of the dynamical theory; and finally, in 1862, M. Hirn published a work in which he admits that his former views were erroneous, and shows himself a convert to the dynamical theory, giving a fresh set of experiments on large engines, in which he shows that heat does disappear from steam in the act of performing mechanical work. He argues that it must be so, as work or heat would be produced from nothing unless we allow than an equivalent of heat has been actually transformed into the work done, or reproduced in the heat developed by friction—and consequently that, in all cases where work has been performed by a hot elastic fluid, the fluid must contain less heat after the work is done than it contained before, the heat which has disappeared being the equivalent of the work done, and in fact transformed into this work. Moreover, when a gas is compressed it becomes hotter; when it expands against a moderated resistance its temperature falls. In a simply dynamical point of view, this case is like the winding up and unwinding of a spring: force from some exterior source is transferred to the compressed fluid, which in expanding back against a moderated resistance to its initial tension, gives out the same amount of force. But how explain the heating and cooling of the gas? Formerly the explanation was easy, on the supposition that the specific heat of gases varied with the density, the capacity for heat increasing as the density decreased. Regnault's experiments showed that the capacity of gases for heat is constant, or nearly so; consequently the facts of the heating and cooling of a gas by compression and expansion are inexplicable, and really without a cause, unless we allow a direct relation between the work expended or produced and the heating and cooling of the gas.

It has been supposed that M. Hirn's more recent experiments, described in his *Exposition Analytique et Expérimentale*, prove an exact proportionality between the work performed by the engine and the excess of heat supposed to exist in the steam as it leaves the boiler above the quantity of heat which it contains as it leaves the cylinder, which latter quantity is found in the condenser—in other words, that the work performed is proportional to the heat which disappears from the steam in its passage through the engine After careful examination of the phenomena, I think it will be found that this statement, though on the whole undoubtedly true, is not yet clearly established by direct experimental proof.

The quantity of work performed was ascertained by a friction-brake; but in these experiments it was of comparatively small importance to ascertain the exact quantity of work performed in each case, the object being rather to effect a constant amount of work with a variable consumption of steam. The tension of the steam in the boiler, its degree of superheat, and the quantity and temperature of the water injected into the condenser being all maintained constant, the external work performed by the engine may be modified in two distinct ways.

(1) This work may be diminished or increased by opening more or less the steam admission-cock.

(2) This cock being kept full open, and consequently a free passage of steam through it, the amount of work may be increased or diminished by cutting off the steam earlier or later during the stroke. Therefore, reciprocally, the work may be maintained constant if, while the amount of cut-off is diminished, the steam-admission is also diminished by "wire-drawing."

By carefully clothing the cylinder, the loss of heat from exterior cooling may be reduced to a very small quantity. The proportion of work lost in friction and other resistances cannot be avoided to the same extent, nor is it easy to calculate it with even approximate exactness. But if the amount of work done by the engine is maintained constant while the consumption of steam is varied, as above mentioned, it may be supposed that the amount of work lost in friction &c. of the moving parts of the machine is also constant (or nearly so); so that the total quantity of external work performed by the steam may be supposed to be equal in each case. And as the consumption of steam to produce this constant amount of work may be caused to vary considerably (more than one-third in these experiments) by varying the mode of its admission to the cylinder, if still we find in each case that the *disappearance* of heat is the same in quantity, notwithstanding the variation in the quantity of steam consumed, it may be fairly deduced that the loss of heat in the steam is in all cases proportional to the amount of work performed.

To ascertain the amount of heat which disappears (or is changed into work) in each case, it is requisite, first, to know the quantity of heat given to the steam before its admission to the cylinder, and, secondly, the quantity of heat given out by the steam in the condenser; the difference should obviously be the heat consumed in performing the work.

The quantity of heat required to evaporate a given weight of water under given conditions is known by Regnault's formulæ. Its value is complex; but this consideration does not greatly affect the present inquiry, as we are certain that the steam would give out in condensing all the heat it had previously absorbed for its formation, provided none of it be lost by any intermediate process—such, for instance, as the performance of external work at its expense.

In these recent experimental researches of M. Hirn, the steam on leaving the boiler was always more or less superheated, without change of pressure. This condition is indispensable for obtaining correct results, because ordinary steam generally carries into the cylinder a certain quantity of water, necessarily variable in amount, and very difficult to measure or estimate; consequently it is impossible in these circumstances to value correctly the quantity of heat furnished by the boiler.

The additional amount of heat required to superheat the steam a given number of degrees is also ascertained by a corresponding formula. We can thus ascertain the number of thermal units in the steam furnished to the cylinder in a given time; and, theoretically, this same quantity of heat should be found in the condenser, provided that none of it were lost during its passage through the engine by being changed into the work done.

The quantity of heat passing out from the engine in a given time can be easily ascertained by noting the quantity of water heated a certain number of degrees in the condenser during the same time. The difference between this quantity of heat and the total heat of the steam as it leaves the boiler in the same time, should be the equivalent of the work done in that time.

In all these experiments the pressure in the boiler was maintained nearly constant, not varying more than one-tenth of an atmosphere; the temperature of the saturated steam was therefore known from the tables of tension. The temperature of the superheated steam was ascertained by a thermometer in the steam-pipe close to the cylinder, where the pressure was nearly the same as that in the boiler. The temperature of the condenser-water was taken every minute while the engine was in regular action, and was represented in each case by the mean of thirty observations.

To ascertain with accuracy the respective quantities of the steam and the injection-water employed in given times under the varying circumstances of the experiments was a task of great difficulty. The quantity of steam furnished to the engine per second with the throttle-valve full open, and consequently the maximum amount of cut-off to produce the given constant amount of work, was ascertained by keeping the engine in constant action during a whole day; and the number of strokes made by the engine during this period was taken by a counter. By dividing the whole quantity of water by the whole number of strokes of the engine, the weight of steam for each stroke was ascertained.

It was much more difficult to ascertain the quantity of steam furnished to the engine in a given time while working without cut-off, and regulated to the same constant rate of work by throttling or "wire-drawing" the steam. In this case the consumption of steam, and consequently the consumption of fuel, increased; the furnace adapted for the more limited rate of combustion which sufficed for the more economical mode of working was not sufficient for the larger consumption; and under these circumstances the difficulty of maintaining the conditions of the supply of steam constant during a whole day's work was so great as to render it almost impossible to ascertain accurately by the former method the quantity of steam supplied; consequently another method was adopted for the purpose. The quantity of cold water supplied to the condenser, and the tepid water discharged from the air-pump in a given time, were each accurately gauged, the respective temperatures being taken into account; and the excess of the latter quantity over the former, representing the steam passing through the engine, being divided by the number of strokes in the given time, showed the weight of steam used per stroke.

The first series of experiments described by M. Hirn were made with a large engine making twenty-seven strokes or revolutions per minute, and producing the constant work of 150 horse-power, as shown by a friction-brake. Under the most economical conditions of the action of the engine this work was produced from k. 0·31554 of steam per second, representing 228·16 French thermal units or calories; and under the least economical conditions the steam used was k. 0·46927 per second, equal to 286·38 calories. In the former case a disappearance of 40·34 calories was observed; and in the latter case heat equal to 38·08 calories disappeared.

A second set of experiments with the same engine, producing work equal to 116 horse-power, showed a consumption of k. 0·23548 of steam per second in one case, and k. 0·32307 in another—the observed loss of heat being 30·51 calories in the first case, and 32·13 calories in the second case.

Another set of experiments with a smaller engine, making ninety-three revolutions per minute, and producing the constant work of 90 horse-power, showed the steam used to be k. 0·1902 per second, in one case with an observed loss of heat equal to 21·5 calories; and in another case the consumption of steam was k. 0·229 per second, with a loss of heat equal to 22·58 calories.

In the most economical of the above experiments a constant amount of work equal to 116 horse-power was obtained from k. 0·23548 of steam per second, the steam, of five atmospheres' pressure, being superheated 93° C. (from 152° to 245°) and cut off early, so that the expansion was as 6 : 1. In another experiment, the steam being equally superheated and cut off near the end of the stroke, so that the expansion was only as 1·15 : 1, the rate of work being kept constant by throttling or wire-drawing the steam, the same 116 horse-power required the consumption of k. 0·32307 of steam per second, being 36 per cent. more than in the former case. Now, everything else being equal, the furnace must furnish in the second case one-third more heat than in the first case. If, therefore, reasons M. Hird, we find in the condenser-water also one-third more heat, we may fairly deduce that the amount of heat consumed in its passage through the engine depends entirely on the quantity of external work produced; for by this mode of experimenting, the quantity of work obtained being constantly 116 horse-power, the proportion of loss from friction, &c., should be the same in all cases, and therefore need not be calculated. Now the heat which disappeared was nearly equal in both experiments, being 30·51 colories in the first case, and 32·13 in the second; and the mean of all the experiments showed a still nearer approach to equality. It was therefore deduced that in all cases an exact proportionality exists between the work produced by the engine and the difference between the quantity of heat furnished before the steam enters the cylinder and the quantity of heat remaining in the steam as it leaves the cylinder.

As a result of my own experiments, and from what I have understood of the experimental investigations of Seguin and of Hirn on the working of steam-engines, I have for many years entertained the opinion that the *direct* change of heat into work has not been satisfactorily shown by experiment; and it still appears to me that when the heat employed in working the engine is supposed to be merely the heat of the steam as it enters the cylinder (whether saturated or superheated), and *when the steam works at full pressure throughout the whole stroke*, none of this heat should disappear theoretically in the production of work, as in this case all the heat of the steam which passes through the cylinder should be found in the condenser. Consequently, as regards tangible proof from direct experiment, M. Hirn's earlier opinion that heat did not disappear from the steam in the production of work may have been really in accordance with facts as far as they were perceived, though at variance with the whole truth; and I would submit that the conclusions arrived at from his more recent experiments, as above quoted, though in accordance with truth, may be questioned as to their satisfactory proof by experiment. In short, I now imagine that our investigations on the subject by experiments on the actual working of steam-engines have not been conducted on really correct grounds, and that the results have therefore been anomalous. It is no doubt true that the heat furnished by the fire is in all cases more than the heat which passes into the condenser; and if no heat were otherwise lost, this excess would correspond to Joule's equivalent; but when the engine works with the full boiler-pressure throughout the whole stroke, it seems evident that the whole work is in effect done in the boiler by the expansion of the water into steam, and is merely transmitted by the steam to the piston; so that the heat equivalent to the work done disappears from the boiler, and is locally made up by the fire directly without any indication of these phenomena being perceptible in the subsequent parts of the process of working the engine. If this view of the subject is correct, it is difficult to perceive how M. Hirn's deduction of an exact proportionality between heat lost and work done could be fairly proved from the experiments (though doubtless the law is true); for with a cut-off at one-sixth of the stroke, about two-thirds of the work would be done by the expansion of the isolated steam in the cylinder, with a corresponding disappearance of heat in the condenser, which should be very perceptible; while in proportion as the engine worked with steam approaching to full pressure, the proportion of work actually done by the steam in the cylinder would become less and less, until the disappearance of heat from the working steam might become inappreciable.

In order to maintain the work of the engine constant with a variable consumption of steam, throttling or wire-drawing was used more, as the expansion from cut-off became less; and as the process of wire-drawing increases the heat of the working steam *at the expense of the heat in the boiler*, the quantity of heat passing into the condenser would be affected also by this cause.

It is certain that the performance of work by the expansion of isolated steam drawing solely on its own self-contained sources of energy must cost to the steam a full equivalent of force in some shape; and as in this case no other form of force can be directly detected except heat (or molecular motion, as it is now defined), and it is mathematically demonstrated that heat should disappear in such cases and might be transformed into the work done, it may be freely admitted that the work performed by the expansion of isolated steam is accompanied by a corresponding disappearance of heat. This disappearance of heat, if the steam is saturated, should cause a corresponding condensation of part of the mass, or an equivalent amount of cooling if the steam is sufficiently superheated to bear abstraction of heat without condensing. If a reservoir of saturated steam be put in free communication with a cylinder and loaded piston, the piston's outward motion would be accompanied by an expansion of the whole mass of steam, and a condensation of steam-particles throughout the mass equivalent to the amount of work done by the piston. If, now (the communication with the working cylinder being closed), fresh steam from some other source be forced into the reservoir until its original pressure is recovered, the compression thus effected should re-evaporate the liquid particles of condensed steam, and the general mass of steam should become again dry, or merely saturated. If yet a further quantity of steam equal to a stroke of the working piston be injected into the reservoir, the mass of steam should become superheated; and the fall of temperature and pressure consequent on the succeeding stroke would now bring back the steam to its initial state of saturation. Thus it would seem that heat should equally disappear from an isolated mass of steam doing work by expansion, whether the steam be saturated or superheated; but in the case here imagined the disappearance of heat would be from the whole mass in the reservoir and cylinder together.

In the circumstances above imagined, the source of a continuance of work would be the injection of a continued supply of steam into the reservoir; and the operations of injecting and withdrawing steam being intermittent and occurring at alternating intervals, a corresponding fluctuation of density and temperature would occur in the whole mass, with periodic superheating or condensation, as the case might be, but without permanent disappearance of heat except in the cylinder, the contents of which formed part of the general mass during the working stroke, and participated in the general loss of heat assumed to be transformed into the work done. Thus, if the cylinder be $\frac{1}{10}$ of the volume of the reservoir, the disappearance of heat from the cylinder itself would be $\frac{1}{10}$ of the whole heat supposed to disappear; the remaining $\frac{9}{10}$ would be replaced in the reservoir by the succeeding stroke of the injection pump, while the contents of the cylinder would be discharged into the condenser in the state in which the fluid remained at the end of the working stroke.

If the steam supplied to the reservoir were injected at the same time and at the same rate as the steam is withdrawn in giving motion to the working piston, so that the density and pressure in the reservoir should remain constant, it would appear that the whole work would be done directly by the injecting piston, and merely transferred to the working piston by means of a moveable plug of steam at constant pressure and temperature. In this case no heat should disappear either from the reservoir or from the cylinder; and the contents of the cylinder at the end of the working stroke should be identical with an equal mass of steam of corresponding pressure and temperature from any common source.

The formation of steam from the water in a boiler may be considered equivalent to the injection of steam ready formed from some other source; and during the whole stroke, if at full pressure, or the full-pressure part of the stroke if working expansively, only a small fraction of the heat assumed to be converted into work would disappear from the cylinder itself, being in the proportion of the contents of the cylinder to the whole contents of the steam-space in the boiler, and smaller as the fluctuations of pressure in the boiler due to the intermittence of supply to the cylinder are bounded by narrower limits. On the other hand, all the loss of heat which corresponds to the work done by expansion in the cylinder after the cut-off should take place in the cylinder itself. Hence, in experimental researches on the assumed disappearance of heat from the steam in the act of doing external work, we should not expect to find tangible proof of this phenomenon by comparing the quantity of heat in the steam working at full pressure in the cylinder during the whole stroke with the amount of heat found in the condenser; for theoretically these quantities may be nearly equal, if, as supposed above, the work given out by the piston is virtually done in the boiler; and the steam which fills the cylinder at the end of a working stroke may differ but slightly from an equal weight of common saturated steam of the same pressure taken directly from a boiler. If such be the case, it were useless to search *in this part of the process* for a loss of heat equivalent to the work done; for the exhaust-steam dashing tumultuously into the vacuous condenser should produce there as much heat as there is cold produced in the cylinder by the expansion which drives out the steam—as in Joule's experiment of causing compressed air to expand into a vacuous receiver, by which process the total quantity of heat remains unaltered. This view of the case may help to account for the apparently anomalous results obtained by Seguin and by Hirn in their researches on this subject; and as in my own experiments sufficient account was not taken of the influence of expansion from cut-off, I think I can now detect sufficient cause why I could not discover the disappearance of heat which might be fairly attributable to a transformation into the work done by the engine.

On the other hand, if an isolated mass of steam, for example the steam which fills the full-pressure portion of the stroke at the moment of cut-off, be caused to produce work by its own expansion during the remainder of the stroke, it must lose something equivalent to this work—apparently a proportional quantity of its own heat; and as saturated steam cannot part with any of its heat without suffering a condensation of some of its particles, it should follow that the moderated expansion of steam in the act of doing work should be accompanied by the condensation of steam-particles throughout the mass, representing an aggregate amount of heat equivalent to the work done. Thus the steam working expansively in the cylinder isolated from exterior sources of heat or coal, should assume the condition of a mist from the formation of numerous minute water-particles throughout its mass; and as the heat which had previously maintained these particles in the state of vapour no longer exists in the cylinder, having, in fact, been transferred or transformed into the work done by the expansion, the remaining mass of expanded steam must contain so much less heat, and should accordingly show less in the condenser.

The grand principle of the Conservation of Energy indicated with indisputable certainty that the work done by a steam-engine must cost its full equivalent to the fire; but in the absence of any direct proof of the disappearance of this equivalent of heat from the steam in its passage through the engine, I was fain to suppose that the heat in passing into the boiler might undergo a transformation into some form of repulsion in the vapour-particles corresponding in intensity to the temperature and pressure of the steam—and that the work done might be attributed to an equivalent disappearance of this repulsion with a fall of temperature and tension in the steam, but without loss of its quantitative heat, considered simply as molecular motion. It will perhaps be allowed that this hypothesis was not altogether unreasonable so long as there was no satisfactory experimental proof of the direct disappearance of heat from the steam in its passage through the engine; and even if I had proved this disappearance of heat, I might still have remained in doubt as to the mode of the change of heat into work so long as I was uncertain whether this process might take place simply on mechanical principles applied to molecular action, as shown in Professor Rankine's hypothesis of molecular vortices. This uncertainty has been removed by the complete confirmation of the results of Regnault's experiments, showing a constant specific heat of air at different densities which I have recently obtained from a repetition of some of his experiments in a different shape; and I hope to be able soon to complete some experiments which should furnish additional proof of the actual disappearance of heat in the production of work in the steam-engine. The want of such direct proof is acknowledged; and its importance is evident when we consider how intimate is the connexion between a more extensive knowledge of this subject in a practical point of view and the improvements to be made in the wide field which still remains open for effecting economy of fuel in the working of our thermic prime movers.

## RUNCORN BRIDGE.

The estuary of the Mersey has always been a serious hindrance to anything like direct approach to the town of Liverpool from the south, whether by rail or road. A glance at a map will instantly convince one that the most eligible, if not indeed the only, spot at which the Mersey could be crossed by a bridge is at that narrow part of the river where it runs between Runcorn and Widnes. A railway bridge has now been thrown across the stream at that place; but it may not be generally known that, so far back as the second decade of this century, a plan had been matured for a road bridge, long before there was any anticipation of the greater work, the execution of which the necessity arising from the development of our railway system has enforced.

When Telford was engaged in surveying for the road from Newcastle-under-Lyme to Liverpool he found it necessary to take the road by way of Warrington. He says, in his autobiography, that he saw, if the estuary of the Mersey could be crossed at Runcorn, and a straight road made from thence to Liverpool, there would be some saving in distance. The scheme was not carried out, public enterprise as to roads at that time being different to what it was four or five years ago as to railways. Adopting the most direct line of road to Warrington, passing on the west side of that town, and improving the Prescot road, the saving was reduced to about four miles. The Mersey was "a well-frequented navigation," and the cost of a suspension bridge, which would not create any material inconvenience to the navigation, Telford roughly estimated at upwards of £100,000. He thought that the expenditure of such a sum was not to be justified for saving a distance of four miles.

The project, however, was entertained for some years. Telford eventually made a proposition for the construction of an iron suspension bridge at Runcorn Gap, and four years were occupied by him in making experiments with a view to such a bridge being erected there, if it had been found practicable. In narrating the circumstances which led to the construction of the Menai Bridge, Telford says:—"It so happened that, in the year 1814, I had been called upon to consider the best mode of crossing the river Mersey at Runcorn, in Cheshire, with a view of shortening the London road to Liverpool, and under all the circumstances of the case I recommended a bridge of wrought iron upon the suspension principle, to prove which I tried several hundred experiments upon malleable iron. * * and having thus obtained a knowledge of elementary facts, I constructed a model 50ft. in length, and ascertained its strength. Though the project which gave occasion for these experiments was abandoned, they had authorized me to recommend a bridge upon a similar principle over the Menai Strait." Mr. Fitchett, the solicitor and secretary to the Company for the proposed bridge to be constructed across the river Mersey at Runcorn, addressed a letter to Telford, stating it to be the wish of the Select Committee to have a report from him respecting the best means of accomplishing that communication. Telford made a report, dated the 13th of March, 1817, in which he says that his professional pursuits had afforded him opportunities of being well acquainted with the Mersey for more than 20 years; and early in 1814, his attention having been particularly called to the proposed communication at Runcorn, he was fully aware of its nature and importance. In that report Telford discusses two points. First, the practicability of constructing a bridge at the proposed site, and what kind of a bridge was (under all the circumstances connected with the place) the most eligible; and, secondly, the probable expense and time required to construct a bridge of the form recommended. In discussing the first point, Telford describes the place, which is still in the same condition. He says:—"The proposed site is in some respects favourable, it having on the Cheshire side a steep bank and a bold rock down to the water's edge; also a projecting point of land of considerable elevation, with a flat rocky shore down to low water mark on the Lancashire side; but under low water mark the channel (about 1,000ft.) is occupied by a mass of sand to a very considerable depth. This last circumstance would render the constructing of any pier or embankment at this place, if not impracticable, at least very hazardous and expensive; but there are, in my opinion, still more serious objections to introducing any obstruction to the tide-way." The scheme never was carried out. The coach road became deserted, as Telford's successors planned the several lines of railway which now traverse the district; but still the great engineer's ideas survived. Warrington has hitherto remained the pivot on which the Liverpool traffic turned; but an increasing traffic, and, more than that, hard-pressing competition, has led to the necessity of adopting a shorter route between Liverpool and Crewe.

For the purpose of avoiding what has for years been felt a long and circuitous route between those towns, Mr. W. Baker, the engineer to the London and North-Western Railway Company, has designed a bridge which has recently been erected at Runcorn Gap, and forms part of a new line which will be opened in the course of the coming winter. This line, which was commenced in 1863 and is intended to shorten the distance between Liverpool and Crewe by a distance of nine miles, leaves the Warrington and Garston railway near Ditton, proceeds on a curve across Ditton marsh, and a promontory called West Bank. The bridge that carries the railway across the Mersey is placed only a few yards to the west of the places which are now the ferry stations. After skirting the town of Runcorn, the line proceeds in a south-easterly direction, and is connected with the main line at Preston Brook. The length of the new line from end to end is about eight miles. On the Widnes side is a viaduct about three-quarters of a mile long, built in sections of ten arches. On the Cheshire side there is also a viaduct, not much of which is seen from the river. The few arches nearest to the bridge are built of white brick, and the remainder of blue Staffordshire brick.

The abutments on the river bank are handsome structures of Bramley Falls stone, and are castellated in style. In the stream are two stone piers, each being 30ft. thick at the foundation, and sloping gradually up to the girders, where the thickness is 25ft. On those piers are placed the signals which are necessary for the protection of the vessels navigating the river by night. The work of erecting those piers was very difficult, owing to the shifting nature of the sands in the river. The foundations were taken down to the rock, which lies many feet below the river bed. These abutments and piers carry the bridge, which is nearly 1,000ft. in length, and affords a headway of 75ft. above high water mark. The piers are placed at equal distances apart, and from the abutments, three openings being thus formed, over each of which there is a span of 305ft.

The bridge is built upon six girders, which extend from abutment to pier, or between the piers. Two are lattice girders, these being at the sides of the bridge, which is 25ft. wide within the girders; the other four run beneath the metals on which the trains travel. There are transverse girders placed 10ft. apart, to form the permanent way. The lattice girders at the sides of the bridge are also braced together at the top by smaller lattice girders. The ends of the six main girders are supported by rollers, which allow for the expansion and contraction of the bridge in varying states of the atmosphere.

On the Warrington face of the bridge is a foot-path 6ft. wide, supported on cantilevers. This will be for the use of the public, and when it is opened the ferry will probably be abolished. Even in the most adverse weather, the walk across the bridge will be preferable, and the toll ought not to be so much as the present charge for the ferry boat.

The cost of this work will be about £250,000. A tablet over the arch through which the trains pass, at each end of the bridge, records the names of those who have been engaged in this work:—Mr. William Baker, engineer; Mr. Francis Stevenson, assistant engineer; Mr. L. H. Wells, resident engineer; Messrs. Brassey and Ogilvie, contractors, and Mr. John Evans, agent; Messrs. Cochrane, Grove & Co., Woodside, contractors for the iron work, and Mr. J. P. Ashton, superintendent of that portion of the work. The construction of this line and bridge has occupied upwards of five years.

## REPORTS OF THE SCOTTISH MINE AND COLLIERY INSPECTORS.

### Eastern District.

Mr. Ralph Moore, in his report for this district, dated Glasgow, 29th February, 1868, says:—

By the the kindness of the coal and iron masters I am enabled to furnish an almost complete return of the quantity of coal raised, and the number of persons employed during the year 1867. There were 147 companies working coal; they employed 29,000 men and boys, and 766 women; and raised 7,897,368 tons of coal, being upwards of 30 per cent. more than the quantity estimated for the year 1866. But many of those companies worked on a small scale, and more than three-fourths of the whole quantity were raised by 55 companies. About 4,000,000 of tons, or fully more than one-half, were raised by the long-wall method of working, and the remainder by the pillar and stall method. Of the number of persons employed in coal mines, 60 were killed, being one life lost for every 132,000 tons of coal raised. In inspected ironstone mines, seven persons were killed, making 67 the total number of lives lost in coal and ironstone mines. The accidents and rate of mortality in the different localities are as under:—

| | Lives Lost. | Males employed. | Coals raised. Tons. | Women employed above ground. |
|---|---|---|---|---|
| Lanark ... ... ... | 33 | 15,106 | 4,784,001 | 48 |
| Stirling (East) ... | 6 | 2,620 | 616,618 | 115 |
| Kinross ... ... ... | — | 98 | 22,000 | 7 |
| Perth ... ... ... | — | 190 | 31,273 | 23 |
| Fife... ... ... ... | 11 | 4,671 | 1,214,254 | 348 |
| Edinburgh ... ... | 6 | 2,511 | 489,160 | — |
| Haddington ... ... | 2 | 736 | 114,250 | — |
| Clackmannan ... | 1 | 1,100 | 237,777 | 92 |
| Linlithgow ... ... | 1 | 2,000 | 383,383 | 133 |
| Peebles ... ... ... | — | 16 | 4,656 | — |
| Totals and averages | 60 | 29,000 | 7,897,368 | 766 |

It is to be observed with regret that the majority of the accidents could have been prevented had managers and many of the sufferers duly observed the general and special rules laid down for their guidance.

Mr. Moore at some length specifies the character of several of the accidents with a view to substantiate this position, and then proceeds:—

The form of shafts and the mode of lining appear to be governed very much by the custom of each country, thus, in most parts of England, the shafts are circular; in Wales they are elliptical; and, in both cases, where the strata require it, the sides of the shaft are lined with stone or brickwork. In Scotland. the shafts are nearly all rectangular, varying from 10ft. in length by 5ft. in breadth, to 18ft. in length by 6ft. in breadth, and when it is necessary to line them they are lined with wood; they are also divided into compartments by wooden mid-walls, but the heat in the up-cast shafts, which is now necessary to be maintained where the furnace is the ventilating agent, shows that it will be necessary to adopt brickwork in the up-cast compartments. For the last twenty-five years it has been the custom in some of the collieries in East Lothian to have the mid-wall next the up-cast of brickwork, and also to line the sides of the up-cast compartment with brick instead of wood. I am informed that it is not more expensive than wood, and it is certainly safer and more easily kept tight. Competition, high wages, and the scarcity of workmen during the past two or three years are gradually leading to the application of improved machinery and appliances to economise manual labour in collieries. This is most observable in surface arrangements; winding engines with double cylinders and drums of large diameter on the crank shaft, instead of intermediate shafts and gearing, are now extensively used. They a great improvement, as thereby greater quantities of coal can be raised daily out of one pit without a corresponding increase of fixed charges. It is worthy of remark that there has been not a single accident from overwinding during the last year, nor has there to my knowledge been a breakage of ropes. The screening arrangements and waggons will stand comparison with any district. The arrangements underground, though advancing, have not made such rapid progress. The ventilation is much improved during the last ten years; in some cases, however, too little attention is paid to the Special Rule as to ventilation, for it will be observed that the explosions during the past year have more frequently arisen from the non-observance of the special rules by the overman and fireman (two of whom are sufferers) than from a deficiency of the general ventilation. Haulage by engine power on underground inclines is more frequently adopted, and many of the applications are very good. Horses are also more generally used for underground haulage, instead of men and boys. There has not, however, been the same amount of skilful planning and laying out of works underground as has been devoted to the surface operations, and there is still too much of this work left to the discretion of the overman. I look forward to improved arrangements and the adoption of machinery, coupled with discipline, as a great means of reducing loss of life in mines. Whatever arrangements enables the largest quantity of coal to be raised with the fewest men will be almost certain to reduce the loss of life to a minimum. Much may be done to prevent accidents if all parties connected with a mine were to see that the arrangements are good, and the discipline thoroughly maintained. The owner can take care that the machinery and the arrangements of the works are of the best kind and that they are skilfully laid out, that the mode of working is suitable, and that the system of ventilation is the proper one to be adopted. He can also take care that no pecuniary consideration stands in the way of their accomplishment. Those owners (and there are many such) who have not sufficient practical knowledge of the subject to enable them to decide upon those matters can place themselves in the hands of some competent consulting engineer to lay out their works on the most improved principles, and see also that they are maintained in that position. When the coal owner is not capable of judging of the propriety of expenditure, the manager may be hampered in his management, the owner with a natural view to economy may postpone or curtail the execution of some necessary improvement proposed by the manager, or the manager may have proposed an extravagant scheme which may be injurious. In such causes the aid of a consulting engineer would strengthen the hands of the manager, and would at the same time guard against erroneous views propounded by him. Whatever system then the manager may adopt he should see that the plans are thoroughly carried out, and that the discipline of the colliery is maintained with firmness and consideration. He can be careful not to impose rules so stringent that they will not easily be attended to, but whatever rules are established should be unswervingly maintained. Not one of the fatal accidents which occurred during the last year required any great scientific knowledge for their prevention; they were caused principally by inattention to the general and special rules. It has often been said by the workmen that the complaints from them are looked upon with suspicion by the managers, and that workmen do not make them from dread of displeasure or dismissal. I believe this seldom, if ever, occurs, at all events, if ever it does occur, the manager who does it loses valuable opportunities of becoming acquainted with the practical working of the mine, and of the various operations going on. When any workmen in a colliery, whatever be his position, finds that his information is listened to with attention, and its accuracy tested and appreciated, he gives it willingly, and soon becomes careful that it is accurate before he ventures to make it. Coal and iron trades, like all others, have suffered much during the prevailing depression of trade, and prices have fallen. As a natural result the miners' wages have been reduced, and are now about 20 per cent. lower than the highest point. In the western district an arrangement was gone into by some large firms, as a remedy for strikes and interruptions of labour, to have a sliding scale of wages, varying from 4s. per day in summer, to 5s. per day in winter, when the coals are generally higher in price and the masters can afford an advance, but owing to the depression of the iron trade (which in a great measure regulates the price of miners' wages) both the employers and employed found that the scheme could not be carried out, and the wages were not permanently advanced above summer prices. Notwithstanding the depression of the coal trade new sinkings are being made which will add largely to the present out-put of coal. These new works are all being fitted up with the most improved machinery. There is a considerable difficulty in obtaining compliance with the Double Shift Act, although instances are so frequently occurring which show the wisdom of that enactment. The most common attempts at evasion are all in small fields when a pit works 30 or 40 acres of coal; the pits are planted from 300 to 400 yards apart, and when they reach the coal and are opened up ordinary workings are carried on in all directions as well as the mines of communication, and in some instances the pits would have been communicated and the field exhausted at the same time.

### Western District.

Mr. Alexander, in his report for the western district of Scotland, also dated Glasgow, February, 28, 1868, says:—

It is satisfactory to be able to inform you that during the past year no unusually disastrous occurrence has taken place throughout the mines and colleries in the west of Scotland. The languid and depressed state of trade in general affects this extensive and indispensable branch of industry, and the out-put of coal, though slightly increased as compared with 1866, is considerably under the estimate of former years. The number of collieries in operation has been 211. The average number of persons employed in and about them has been 21,075, and the quantity of coal and dross produced, or the exhaustion of the mines, I estimate at 6,228,575 tons. In the getting of this material and raising it to the surface 35 fatal accidents happened, resulting in the loss of 35 lives. Of these, 18 were married men, 14 were single or unmarried, and 3 were boys. Under the usual form of classification each accident will be found briefly described in schedule No. 1, and the following is an abstract of it for 1867:—

| | |
|---|---|
| Explosions ... ... ... | 2 |
| Falls of Coal and Roof ... ... | 24 |
| In Shafts ... ... ... ... | 6 |
| Miscellaneous and above ground ... | 3 |
| Total Loss of Life ... ... | 35 |
| Number of Persons employed ... | 21,075 |
| Loss of Life per 1,000 Persons employed | 1·66 |

The dangers peculiar to those who work in mines, though much of the same character, are apparently more successfully guarded against in some divisions of this districts than in others, and while the average loss of life per 1,000 persons employed is 1·66, the highest mortality has taken place in the mines of Ayrshire, where the loss of life per 1,000 persons employed has been 1·90.

| | Explosions. | Falls of Coal and Roof. | In Shafts | Miscll. | Total Loss of Life. | No. employed. | Loss of life per 1,000. |
|---|---|---|---|---|---|---|---|
| Lanark ...... | — | 10 | 3 | 1 | 14 | 8,663 | 1·61 |
| Ayr........... | 1 | 13 | 3 | 2 | 19 | 9,966 | 1·90 |
| Stirling ...... | — | 1 | — | — | 1 | 1,011 | 1·00 |
| Dumbarton... | 1 | — | — | — | 1 | 696 | 1·43 |
| Renfrew ...... | — | — | — | — | — | 379 | 0·00 |
| Dumfries and Argyll...... | — | — | — | — | — | 360 | 0.00 |

I am thankful to be again relieved of the necessity of recording any untoward event occasioned by inundation from old wastes. Now that plans are made up, generally by competent persons, the risk from accumulations of water in old wastes is gradually being narrowed. When exploring in the neighbourhood of old and abandoned works, and in the absence of trustworthy plans, great care and caution are required. In such cases, common sense suggests that all known precautionary measures should be observed, and that, too, long before either the traditional line of "old waste" or of danger has been neared. From experience I find that these old traditionary records are in nearly every case exaggerated, and if trusted to implicity would lead to frightful results. To err on the side of safety, in a money point of view, does not involve much outlay, at most the cost of driving a few fathoms of a narrow mine with boreholes in advance. There is, I am glad to say, a strong feeling amongst all under ground workmen as to the danger of "old wastes" lying filled with water. It is fortunate that it is so, for in the event of a sudden flow of water into a mine where a number of persons are engaged, the most cool are suddenly thrown into disorder, and in many cases, from the limited nature of the roadways and outlets, the chances of escape are few indeed. In ironstone mines of the coal measures, and worked in connection with coal, or with any disused or exhausted coal mine, the number of fatal accidents was six. Of these one was occasioned by an explosion of fire damp, four by falls of ironstone and roof, and one by falling down a shaft. As there are nearly as many ironstone as coal pits in this district, it may be proper to explain that but a small number of ironstone pits come under the provisions of the Mines Inspection Act; and though accidents are reported to me from all mines, and I investigate every case, it is only those who come under the statute that are here admitted. The accidents of a non-fatal kind were 206; they refer to all mines of coal and ironstone, and the following table shows the comparative results for the last six years:—

Avergage for the Five Years ending 1866.

| | |
|---|---|
| Explosions ... ... ... ... ... | 82 1-5 |
| Falls of coal, ironstone, and roof ... ... | 91 |
| In shafts ... ... ... ... ... | 10 3-5 |
| Miscellaneous ... ... ... ... | 31 1-5 |
| Above ground ... ... ... ... | 7 2-5 |
| Total ... ... ... ... ... | 222 2-5 |

For the Year ending 1867.

| | |
|---|---|
| Explosions ... ... ... ... ... | 52 |
| Falls of coal, ironstone, and roof ... ... | 107 |
| In shafts ... ... ... ... ... | 11 |
| Miscellaneous ... ... ... ... | 35 |
| Above ground ... ... ... ... | 1 |
| Total ... ... ... ... ... | 206 |

The important subject, the education of the young, is at present exciting a great amount of public attention. It is to be hoped that it will be dealt with in a firm and practical manner, and that the scheme which may ultimately be decided upon will be so comprehensive and workable as to preclude the necessity of interfering with labour. The system of obliging children of a certain age, whose education has been neglected, to attend school for a given time weekly, after they have commenced to work, is not applicable to all trades; at best it is but a makeshift; the results are doubtful, and the regulation in mines relating to education receives no hearty support from those whom it was designed to benefit. The law recognises the obligation of parents to support their children, unless they are paupers; if that just and common-sense measure could be extended to their education, then all half measures, such as limiting the age at which children should be employed, would be unnecessary. It seems the most direct and practical way of carrying out a broad system of education, and any measure short of it will be as unpopular and expensive to enforce, and even when most successful can only check the evil which it attempts to cure. The means of education, with very few changes, could soon be brought within the reach of every family. It will be difficult to make arrangements alike suitable for all, and in thinly populated country districts there will always be difficulties which do not exist in towns. These hardships press most upon the children of cottars and small farmers, who have frequently to travel two or three miles to school; but it is worthy of remark, that these are not the neglected children, for notwithstanding the privations and disadvantages of such families they seldom fail to obtain a plain and useful education. In any general plan I think it would be a mistake to attempt too much. Every child should be able to read and write fluently, and do a few simple questions in arithmetic. Drawing is one of the most useful branches of education for tradesmen; hitherto it has been neglected; its importance is becoming every day more apparent: publications relating to machinery and manufactures are generally illustrated with plans and sections, and to peruse them with profit some knowledge of drawing is essential. It would be desirable in future to provide that mechanical drawing should take a prominent place in all schools, and that the teaching of it should immediately follow reading and writing. The grand object to be aimed at in the first place, however, is to establish a national system of education, by which every child would be taught to read and write. The ground-work, though narrow, would then be laid. Industrious and able workmen always distinguish themselves, even though possessed of only a limited education. They luckily are to be found connected with all trades and are the leading men in the factories and workshops. It might be judicious on the part of Government, in addition to any general scheme, to make some extra provision for aiding such workmen, by planting in centres of industry educational institutions adapted to meet the peculiar wants of the varied arts and manufactures of the country, of which mining is one of the most important.

## THE NEW MEAT MARKET, SMITHFIELD.

The new meat market, which is to supersede the markets of Newgate and Leadenhall, occupies a large portion of the site of the old Smithfield cattle market, now removed to Copenhagen-fields. The building itself is a parallelogram, 630ft. in length by 246ft. in width, and with an internal area of 625ft. by 240ft. The two principal fronts face nearly north and south, and through the centre runs from side to side an open roadway rather more than 50ft. in width, cutting the building into two entirely separate blocks, and affording a means of communication between the unoccupied portion of Smithfield on the one side and St. John-street, Cow-cross-street, &c., on the other. It was originally intended that the stalls on either side of this roadway should have had open fronts towards it. On consideration, however, it was decided that this arrangement would have a double objection, first, as giving an undue advantage to the holders of these stalls over their less prominent competitors inside the market, and secondly, as tending inevitably to collect a crowd on the side footways to the very probable embarrassment of the traffic. It was decided, therefore, to abandon this portion of the scheme, and the roadway is now bordered simply by an ironwork screen, of a highly ornamental character, by which it is cut off entirely from the market itself, the stalls on either hand being thrown into those behind, which are thus doubled in size. The effect of this roadway, about 250ft. in length, by 50ft. in width, and 34ft. in height, with its side-screens of richly wrought ironwork, and its open roof of ornamental girders, is exceedingly striking. It will be lighted, as will be the market itself, by exceedingly handsome gas-lamps, with tall, wrought iron standards and octagonal lanterns. It is approached at either end by two lofty and handsome archways, without gates, but ornamented with statues and various architectural devices in Portland stone.

The market, thus cut into two equal portions by the roadway running north and south, is again sub-divided by a central avenue running the entire length of both divisions from east to west. This avenue is 25ft. in width, and forms the main artery of the market proper, the roadway being merely a street for the use of the world outside. From this central avenue branch off on either hand a dozen side avenues; six in the eastern and six in the western section of the building, similar in construction and general effect to the central avenue, but about 11ft. only in width.

They are lettered in pairs from A to F, the first five pairs being devoted to the meat salesmen, while the sixth is set apart for poultry, &c., the market being thus divided off into 16 separate blocks, which, again, are subdivided into 153 stalls of various dimensions. At each of the four corners of the market is a large building with a dome-capped tower of about 90ft. in height, the dome-shaped roof being covered with bright copper scales moulded into the form of leaves. These buildings are to be used as taverns, or rather as hotels, for the arrangements are to be on an extensive scale and of a very elaborate description. A telegraph office is provided on one side of a court, about 125ft. in length by 112ft. in width, conveniently situated close to the centre of the building. On the opposite side of this court is a post-office, and beneath these two offices on either side a broad flight of steps leads down to the Underground Railway, the arrangements in connexion with which form an important item in the general plan of the market. The court is entered by gates leading from the roadway above referred to, as running from north to south, and is situated on its western side about 50ft. from its northern extremity. On its southern side a flight of steps, which would not have suffered from a little more liberal width, lead up to the market offices, which are situated on the upper floor on a level with the dining-rooms and the store-rooms of the salesmen's stalls. Besides these various offices there are also no less than seven hoists in different parts of the market, some of considerable size, communicating with the railway below.

The entire basement of the market is to be one large railway depot, and this is perhaps, one of the most important, as it is decidedly one of the most characteristic features of the whole arrangement.

As an architectural work, the new market is exceedingly effective, and will form one of the ornaments of the metropolis. Its general plan is simple enough, consisting simply of a parelllogram with four fronts of very similiar design, each consisting of a long low façade, broken only by a gateway in the centre, and flanked at either end by the towers to which we have already referred, and which serve, as it were, to draw the building together, and to give compactness to what would have otherwise a rather straggling appearance. The general style is Doric, freely treated, and exhibiting in many of the details a good deal of French feeling. The four façades are chiefly of red brick, the gateways and four corner towers being of stone, and the dome-shaped roofs of the latter being covered with copper scales about the thickness of a ship's sheathing, elaborately moulded by the hammer into a conventional leaf form. The roof of the remaining portion of the market is ventilated by means of louvre boards. Before commencing building operations it was necessary to excavate 3,600,000 cubic feet of earth, weighing 171,428 tons. The market itself covers an area of 3½ acres, and stands upon 180 pillars, and four miles and three quarters of iron girders, some of them five feet in depth. The roof of the market rests on two miles of lattice girders, supported on 180 cast iron pillars; the framework of the stalls, &c., consuming another three miles of girders, supported on 848 pillars—in all 1208 pillars and ten miles of girders. The contract price for the whole work amounts to £135,000, but this will no doubt be considerably exceeded.

## THE LIFE-COST OF COAL-GETTING.

The reports of the Inspectors of Mines for 1867 have just been published; and though the year was not marred by any great fatality like the Oaks, the Hartley, or the Lundhill accidents, there has been an immense sacrifice of life. The number of miners employed in the 3195 collieries in Great Britain was, according to the last census returns, 282,500, and the quantity of coal raised in 1867 was 105 million tons. Separate fatal accidents occurred during that year to the number of 907, causing a sacrifice of 1190 lives, being at the rate of 1 in every 280 persons employed, or, according to the quantity of coal got, 1 life per 88,000 tons. There were 286 deaths from fire-damp, against 651 in 1866, which was the year of the Oaks accident; 449 from falls of roof or coal, against 361 in 1866; 158 in shafts against 162 in 1866; 211 were fatal miscellaneous underground accidents, against 203 in the previous years; and 86 accidents occurred on the surface, against 107 in 1866. The total number of lives lost was therefore 1190, against 1484 in 1866. So far the comparative result is satisfactory; but, considering the cost and the theoretical perfection of mine inspection, it will challenge remark how, in a year marked by no unusual single catastrophe, 286 lives should be lost by explosions, 449 by falls of coal or roofs, 158 in shafts, and 211 more which are described as "miscellaneous undergrounds." Perhaps the best answer to this question will be gathered from the report of Mr. Baker, the inspector for South Staffordshire and Worcestershire. He says that in his district 300 collieries have been in operation during the year, and the get of coal has reached a little over ton and a-quarter million tons—a rate of working which he estimates will exhaust the South Staffordshire field "at no very remote period, and indeed within a few years." The average loss of life in Mr. Baker's district for the ten years ending 1860 was 162 per annum; for the seven years ending 1867, was 111. The last group of figures looks like an improvement till the inspector proceeds to say that, "if ordinary care, ability, and supervision had been exercised by the managers and persons connected with the mines, 30 per cent. of this sad havoc might have been prevented." In South Staffordshire, there are fewer dangers from foul air than in some of the northern coal-fields, and the larger proportion of fatal accidents is therefore attributed to roof or coal falls in the mines. Sixty fatal events are traced to this cause, and 28 per cent. of that number have been brought about "through recklessness, insufficiency of timbering, and the 'hungry' practise of reducing pillars in thick seams." No fewer than twenty-two persons were fined during the year for various violations of the law, and the total amount of the penalties was more than £200. Mr. Baker comments at considerable length on the danger of neglecting to provide sufficient supports to the mine roofs. Every one of the twelve or fourteen reports either speaks or indisputably shows the necessity of stricter discipline and management; and those who are in favour of increased official inspection will be able to draw many arguments in favour of their views.

## INSTITUTION OF ENGINEERS IN SCOTLAND.

### DESCRIPTION OF A CHIMNEY AT THE WEST CUMBERLAND HÆMATITE IRON WORKS.

By W. J. Macquorn Rankine, C.E., L.L.D., &c.

(1). *Object of this Paper.*—The chimney now to be described presents nothing new in design or construction, and it is not of any extraordinary size or figure; but as it is a successful example of the application of correct principles and good workmanship to a structure of an useful and ordinary kind, the publication of an account of it may prove serviceable. It has now (April, 1868) been in operation for about eight months, and has withstood the gales of an unusually stormy season.

(2.) *Duty.*—The duty which this chimney has to perform is to carry off the gaseous products of combustion from four blast furnaces, and from various stoves and boilers that are heated partly by burning the inflammable gas from the blast furnaces and partly by coal. The total quantity of solid fuel consumed may be estimated at about 10¼ tons per hour when all the furnaces are at work.

(3.) *Figure and Dimensions.*—Above ground the figure of the chimney is the frustum of a cone with a straight batter. Underground there is a plinth or basement, octagonal outside at the ground line, and square at the bottom; cylindrical inside, and pierced with four circular openings for flues. The reason for adopting a straight batter, notwithstanding that a curved batter enables certain theoretical conditions to be more perfectly fulfilled, is that the accuracy of building with a straight batter can be tested at any moment by a glance of the eye without the aid of instruments. The principal dimensions are as follows:—

| | |
|---|---|
| Height above the ground line, | 250 feet. |
| Depth of foundation below the ground line (including a layer of concrete 3ft. deep), | 17 „ |
| Total height from foundation to top, | 267 feet. |
| Inside diameter at top of cone, | 13ft. 0in. |
| „ „ at 2ft. above bottom of cone | 21ft. 10in. |
| „ „ of basement, | 18ft. 10in. |
| „ „ of archways for flues, | 7ft. 6in. |
| Outside diameter at top of cone, | 15ft. 3in. |
| „ „ at 2ft. above bottom of cone, | 25ft. 7in. |
| Outside dimensions of square basement, | 30ft. × 30ft. |
| „ „ of foundation course, | 31ft. 6in. × 31ft. 6in. |
| „ „ of concrete foundation, | 34ft. 6in. × 34ft. 6in. |

The change from the square to the octagonal shape in the basement is made gradually by stepping the brickwork at the corners.

(4.) *Thickness of Brickwork, Stability, and Load.*—It had previously been ascertained by observation of the success and failure of actual chimneys, and especially of those which respectively stood and fell during the violent storms of 1856, that in order that a round chimney in this country may be sufficiently stable, its weight should be such that a pressure of wind of about 55lbs. per square foot of a plane surface directly facing the wind, or 27½lbs. per square foot of the plane projection of a cylindrical surface—that it to say, a pressure equivalent to the weight of a layer of brickwork 3in. deep, and of an area equal to the vertical section of a round chimney—shall not cause the resultant pressure at any bed-joint to deviate from the axis of the chimney by more than one-quarter of the outside diameter at that joint. (See proceedings of the Philosophical Society of Glasgow for 1856, page 14.) By calculating according to that principle the thicknesses of brickwork in the cone were determined to be as follow:—

| | | |
|---|---|---|
| Uppermost | 80ft. of height, | 1½ brick. |
| Next | 80ft. „ | 2 bricks. |
| Next | 88ft. „ | 2½ bricks. |

Lowest 2ft., increasing by steps from 2½ bricks to 4 bricks, in order to spread the pressure on the basement.

The *bed-joint of least stability* is 2ft. above the ground line; and the deviation of the resultant pressure from the axis of the chimney at that joint which would be produced by such a wind as has been mentioned would be 6ft. 4in., being a fraction of an inch less than one fourth of the outside diameter.

The thickness of the arching in the openings for flues is 3 bricks.

The following are the intensities of the mean pressures due to the load on different bed-joints :—

| | Tons on the square foot. |
|---|---|
| At 2ft. above the ground line, | 8 |
| In basement at the springing of the arches, | 3 |
| On the upper surface of the concrete, | 2 |
| On the ground below, | 1·6 |

(5.) *Firebrick Lining.*—The thickness of brickwork already stated include the fire-brick lining, whose thicknesses are as follows:—In the uppermost 160ft. of the cone, ½ brick; in the lower part of the cone, the basement, and the flue archways, 1 brick. The fire-brick lining is bonded with the common brick-work in the ordinary way—the only difference being that the fire-bricks are laid in fire-clay and the common bricks in mortar.

The reasons for adopting this mode of construction in preference to an internal fire-brick chimney are as follows:—*First,* when the fire-bricks are bonded with the common bricks, they contribute along with the common bricks to the stability of the chimney; whereas if an internal fire-brick chimney had been used, an additional thickness of common brickwork would have been required in order to give sufficient stability to the outer cone; *secondly,* unless the internal chimney is carried up to the top of the outer cone, there is a risk of damage through the explosion of inflammable gaseous mixtures in the space between; and *thirdly,* under the same circumstances there is also a risk of the cracking of the outer cone at and near the upper end of the inner cone through unequal heating of that place. Vertical cracks in a chimney are the more dangerous the higher the level at which they occur, because the safety of the higher part of a chimney depends more on cohesion and less on weight than that of the lower part. When such cracks take place near the ground, they are of little or no consequence.

The basement is paved inside with 6in. of fire-brick resting on 6in. of common brick, which rests on the concrete.

(6.) *Ordinary Brickwork.*—The ordinary brickwork is built of white bricks of very good quality, supplied by the Iron Company. It is built in English bond; in the basement there is one course of headers to every two courses of stretchers. Strips of No. 15 hoop-iron, tarred and sanded, are laid in the bed-joints of the cone at intervals of 4ft. in height, with their ends turned down into the side-joints. Care was taken to bed the hoop-iron on the common brickwork, and not on the brick lining. The length of hoop-iron in each bed-joint in which it is laid is twice the circumference of the chimney.

(7.) *Mortar.*—In the concrete foundation, the basement, and a small part of the cone, the mortar was made of hydraulic lime. Owing to an unexpected difficulty in obtaining such lime on the spot, it had to be brought from a distance at considerable expense; and therefore the mortar for the rest of the building was made of a very pure lime from the immediate neighbourhood, rendered artificially hydraulic by a mixture of iron scale from the rolling mills at the works—it having been in the first place ascertained that the supply of iron scale could be furnished to the contractor with sufficient rapidity. The following are approximately the proportions of the ingredients of the mortar by measure :—

| | |
|---|---|
| Lime, | 2 measures. |
| Scale, | 1 measure. |
| Sand, | 5 measures. |
| Total, | 8 measures. |

It is scarcely necessary to state that the use of iron scale for hardening mortar and making it artificially hydraulic is familiar to engineers, architects, and builders in Glasgow and its neighbourhood, but in many other parts of the country that process appears to be less known than it deserves. The principal constituents of the iron scale are probably silica and protoxide of iron, but its action upon lime, and the nature of the artificial cement which it forms, have not hitherto, so far as I know, been investigated by chemists. Considering the benefits that have arisen from the chemical analysis of other cementing materials, it is much to be wished that come chemist should undertake the examination of this material also.

8.—*Cast Iron Curb.—Lightning Conductor.*—On the top of the chimney is a pitch-coated cast iron curb, one inch thick, coming down three inches on the outside and inside. The lightning conductor is a copper wire rope, about ¾in. diameter. It terminates in a covered drain, in which there is always a sufficient run of water.

(9.) *Scaffolding.*—In the construction of the internal scaffolding care was taken that the needles, or horizontal beams, should be supported wholly by the brickwork, and not by the upright posts; for great danger has been known to arise from the brickwork coming to bear upon the ends of the needles, and through them on the posts, owing to the settlement of the lower part of the chimney.

(10.) *Precautions against too rapid building.*—In order that the concrete foundation might have time to harden before being subjected to a heavy load, it was made by the Iron Company themselves before the contract for the chimney was let; for it is known that intense pressure tends to retard the hardening of concrete. The progress of the building was restricted by the specification of a rate not exceeding six feet of vertical height per day.

(11.) *Contract and Execution.*—Tenders were taken from a limited number of builders in the north of England and in Scotland; and the lowest offer was accepted, being that of Messrs. William Wilson and Son, of Glasgow. The work was executed by that firm in a manner that left nothing to be desired.

(12.) *Cost.*—The following were the amounts of the estimated and actual cost respectively:—Engineer's approximate estimate, £1,672; actual cost, including designing and superintendence, £1,560; being at the rate of almost exactly fourpence per cubic foot of the whole space occupied by the building which is 94,000 cubic feet nearly.

(13.) *Present Temperature and Draught.*—According to the latest account the temperature inside the chimney when doing about three-fourths of its full duty is 490° Fahrenheit; and the pressure of the draught is $1\frac{5}{8}$in. of water, which agrees to a very small fraction with the pressure as deduced theoretically from the temperature and the height of the chimney.

(14.) *Comparisons with some other Chimneys.*—The dimensions and stability of the chimney which has just been described are nearly the same with those of the second highest chimney at St. Rollox Chemical Works, built about ten years previously, except that in the older chimney the joint of least stability is 100ft. above the ground. In the great St. Rollox chimney, 455½ft. high from foundation to top, the greatest pressure of wind which can safely be borne is almost exactly the same, viz., 55lbs. per square foot of a plane surface, or about 27½lbs. per square foot of the plane projection of a cylindrical surface. The bed-joint of least stability is 210ft. above the ground. In the great Port-Dundas chimney, 468ft. high from foundation to top, the bed-joint of least stability is 200ft. above the ground; and the greatest safe pressure of wind is 67lbs. per square foot of a plane surface, or 33½lbs per square foot of the plane projection of a cylindrical surface; so that in this case it may be considered there is an excess of stability.

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# MEETING OF THE BRITISH ASSOCIATION AT NORWICH.

## NOTES ON THE CHARACTER OF THE COAL FIELD OF NATAL, SOUTH AFRICA.

By Robert James Mann, M.D., F.R.G.S., F.R.S.A., &c., Superintendent of Education at Natal, and at present Special Commissioner of the Natal Government.

For some few years it has been known that deposits of coal of useful quality exist in the upper region of the colony of Natal. The blacksmiths of the colony have been mainly dependent upon this native fuel for their work, having sacks of it brought down to them by wagons returning light through the district. Until recently, however, this is the only use to which the mineral has been applied, in consequence of the region where it occurs lying a considerable distance away from the more settled portions of the land and from its port, and in consequence of there being no less costly mode available for heavy transport than the slow ox wagon. The commercial and social progress of the colony are, however, now bringing the existence and character of this coal deposit into prominent notice, and the hope is sanguinely entertained that it will be found practicable before long to get the mineral conveyed to the port at a cost which will enable it to be shipped on board steam vessels at rates which will allow of its extended use, and which will gradually convert the harbour of the colony into a largely-frequented coaling station for vessels bound to the eastern seas. In the face of this anticipation, and of the attention which is now being shown to the matter, a few brief notes of the facts that have been so far ascertained in regard to the character of the deposit and the quality of the coal are submitted in this memorandum for the notice of the Association.

The colony of Natal in which this coal deposit lies, is situated on the south-east border of the African continent, looking towards the Indian Ocean, and 800 miles to the east of the Cape of Good Hope. The whole colony is, indeed, merely a small segment of the slope by which the great table-land known as the African continent descends to the sea. The edge of the table-land where it begins the seaboard dip is above 6,000ft. high, and the slope between this elevated edge and the sea extends through a breadth of space measuring from 100 to 120 miles. At one point the table-land sends forth a leading ridge which runs across the middle of the colony as a bold highland district of scarcely less elevation than the surface of the table-land itself. This central highland is essentially the key to the physical configuration of the entire land. Downwards towards the sea it fingers away in a series of successive sinuous ridges, which have a distinct and isolated watercourse between each pair, so that in a course of 150 miles of coast not less than fifty rivers, large and small, are poured into the sea. But landward of the highland the face of the country again subsides a few hundred feet, and there a very large extent of land, scarcely inferior to the many-rivered portion of the colony, is drained by a single river known in its lower and larger portion, where it constitutes the north-eastern frontier of the colony for seventy miles, as the river Trigela.

The lower portion of the colony lying seaward of the central highland, and grooved by these many rivers, is mainly moulded of the older rocks—granite, sienite, and sandstone in different varieties. In one part a very large mass of white metamorphic marble occurs. The higher portion to the landward side of the central highland, and especially all that tract which lies in the basin, or water-drainage of the one river, is composed mainly of younger sandstones and shales, very largely interspersed with intrusions of greenstone and trap, in some places forming vast overlying and tumbled masses of hard surface rock. It appears, very much indeed, as if the lower maritime region and the descending slope had been chiselled out and bared by the chipping away of the younger and and covering sandstones still encountered in position in the higher region. It will be observed as an interesting geological feature that the central highland of the colony, with its seaward fingers or ridges, is connected with a salient fold of the mountain frontier; while the more northern depression, or one-river basin, is associated with and issues from a bayed-in or retiring fold of the same frontier. This mountain frontier—itself known locally as the Dragon's Mountain, or Drakenberg—is properly a ledge, dipping precipitously down for several hundred feet, and so simulating a mountain range from the lower ground beneath rather than a true ridge or chain.

The coal deposit lies principally in this northern basin-like district of the colony, and especially in that further portion of it included between the inland mountain frontier and the northernmost feeder of the river Trigela, and aptly known as the Newcastle division, having, however, been so named not on account of its mineral character, but in compliment to the noble duke who was Secretary of State for the colonies at the time that this division was made into a distinct magistracy. In this part of the colony the coal is encountered in beds 5ft. and 6ft. thick, and has been traced through an extent of certainly many miles. No borings have yet been made anywhere. The mineral is only known where the beds are cut through by the ravines of rivers, where they crop out in the natural faces of hills and cliff, and where the coal happens to constitute the actual exposed surface of the ground. It is also seen in thinner seams in other portions of this basin—as, for instance, where the high road from the capital to the north crosses the Bushman's river, one of the southern affluents of the Trigela river. Coal deposits of an apparently inferior character also occur on the coast, to the north of the port of Durban, about the lower portion of the Umblah river, where they break out in the face of the sea cliff. The coal is associated everywhere with fine-grained sand, coarse-grained and micaceous sandstones, and shales bearing ripple marks, and some of them densely packed with impressions of plants. The coal lies conformably to the sandstone beds, but is of very irregular thickness, varying from inches to feet within short distances, and being often lenticular in section. One gentleman who is well-acquainted with the coal deposits of Staffordshire, recently visited the great known centre of the surface deposit, with a view to satisfy himself of the commercial value of the mineral, and after a ride of a couple of days came away fully impressed with the vast abundance that could be obtained with the utmost facility.

In a preliminary experiment recently made upon a small scale with a few pounds of the coal at Durban, by Mr. W. H. Evans, it was found that 20lbs. of the coal burnt in a furnace with great readiness and fierceness, and left about 19 per cent. of incombustible ash, and not more than a quarter of an ounce of clinker. The same sample yielded a large abundance of pure and brilliant gas, with a residue of 89¼ per cent. of coke. A more important trial, however, has been made since Mr. Evans' initiatory experiments, and the report of this trial has just been officially communicated to the author of this paper by the honourable the Colonial Secretary at Natal. Seven tons of Natal upland coal were placed on board her Majesty's surveying ship *Hydra*, and carefully tested by the engineer, Mr. Lodge, in comparison with an average sample of north country English and a best quality sample of Welsh coal. Captain Shortland, commanding the *Hydra*, reported from Algoa Bay, in a communication dated the 2nd of June, 1868, the result of this trial, which was to the following effect:—

The number of minutes and quantity of coal required to get up steam with the various samples were first tried. The result was:—Cardiff coal: steam up in sixty minutes, with 26 cwt. consumed. West Hartley coal: steam up in fifty minutes, with 32 cwt. consumed. Natal coal: steam up in fifty-five minutes, with 30 cwt. consumed. The Natal coal in these particulars therefore stands between the average English and the best quality Welsh coal. It gets up steam more quickly than the Welsh coal, and with less consumption than the English coal. It gets up steam less quickly than the English coal, and with somewhat larger consumption than the Welsh coal.

In the steaming on the third grade, with the same amount of water raised into steam, the consumption of coal per hour was, for the Cardiff coal, 1553lbs.; the West Hartley coal, 1648lbs.; the Natal coal, 1568lbs. In steaming on the second grade, with the same amount of water raised into steam, the consumption of coal per hour was, Cardiff coal, 1624lbs.; West Hartley coal, 2293lbs.; Natal coal, 2128lbs. The general samples yielded of ashes, Cardiff, 9 per cent.; West Hartley coal, 9 per cent.; Natal coal, 16 per cent. Of Clinker, Cardiff coal, 2 per cent,; West Hartley coal, 5 per cent.; Natal coal, 7 per cent.

The Cardiff coal yielded very little smoke of a light brown colour. The West Hartley yielded a large quantity of black smoke. The Natal coal yielded a moderate amount of light brown smoke. The engineer of the *Hydra* states for easy steaming the Natal coal is nearly equal in commercial value to the Cardiff coal; that when as much steam is required as can be generated the work requires a considerably larger quantity of Natal coal than of Cardiff coal, in consequence of the greater abundance of earthy matter contained in it deadening the fires and making it impracticable to keep the full steam up without constant use of the picker and rake. Less Natal coal than West Hartley coal is required for the same amount of steam; but it is easier to keep up steam with West Hartley than with Natal coal. The engineer adds that if samples of Natal coal could be obtained with smaller proportions of earthy matter than this sample contained it would be fully equal, for all purposes, to the best qualities of Welsh coal.

Whether or not superior samples can be procured in ample quantities is a matter that has yet to be investigated. But there is no doubt that the samples hitherto brought under investigation have all been simply gathered promiscuously from the surface of the ground, and that therefore analogical experience in other fields fully warrants the presumption that better samples at least will be discovered under systematic investigation and search. The Colonial Government is now purposing to have a complete geological survey of the coal district made to determine the question of both quantity and quality; and a competent mining engineer for the carrying out of this survey has been named by the director of the Government School of Mines in London.

The precise geological character of the Natal coal deposit has not hitherto been absolutely and finally determined, but there has been a general notion, especially held by the Surveyor-General of the colony, Dr. Sutherland, that the deposit is of more recent age than the Palæozoic coal. The author of this paper has just received from Dr. Sutherland a considerable quantity of the inorganic impressions contained in the sandstones associated with the coal deposit of the Bushman's river locality already spoken of, and Mr. Etheridge, the palæontologist, of the Jermyn-street museum and school, has kindly given a cursory examination, with the author, of these remains. Mr. Etheridge has no doubt that the most abundant form contained in these impressions is that of a Glossopteris, and most probably that of the Glossopteris Browniana, which is also abundant in the coal deposit of India, Port Jackson, and South America, and which is eminently characteristic of a Mesozoic formation and age. Mr. Etheridge thinks that there are also traces of Dictyopteris and of seed cases and stems of Phyllotheca, which are also indicative of Mesozoic age, and have therefore the same meaning. Mr. Etheridge has also little doubt that further search will bring to light characteristic shells which will satisfactorily prove that the Natal coal is either jurassic or cretaceous. The coal, when ignited in a small flame, has precisely the same smell which belong to the lignites of those Mesozoic epochs, and it will be observed how exactly the report of the engineer of the *Hydra* gives the predominant characters of the lignites of those periods, which, as a rule, contain a higher percentage of water and ash than the Palæozoic varieties of coal.

## THE WATERING OF ROADS.

By W. J. Cooper.

The subject of the watering of roads is an important one as regards the comfort of communities; it is an operation which has only been performed of late years, and the appliances have been improved upon, and are still capable of further improvement. At one time, about thirty years ago, the streets were watered by damming the gutters, and spreading the water by means of shovels; then a barrel on wheels was used with a wooden box filled with holes which dribbled the water the width of the cart.

Since then we have arrived at square, ugly looking boxes, generally painted black, with iron distributors, constantly in the way, interfering with traffic, and drenching the streets, which are always in either one extreme or the other of mud or dust.

That without water-carts we should be in a very great predicament, the state of the streets of the metropolis on many Sundays during the past season has made painfully evident, for on the Sabbath there are only one or two parishes in London who allow watering to be done, and the consequence is that the plague of dust is rampant.

Walking or driving through clouds of dust is very detrimental to personal comfort, and when it is stated by Dr. Letheby, in a recent report, that a very large percentage of London dust consists of organic matter of a deleterious nature, so that we are liable to be poisoned in addition to the minor inconveniences of being half blinded and smothered, more importance will perhaps be attached to the object of allaying this evil than at first glance the subject may seem to deserve.

The actual damage to property caused by dust is very considerable; tradespeople's goods, which are necessarily exposed, suffer a depreciation in value to a very great extent, and they are often rendered completely unsaleable; and people who have been at considerable expense in getting their houses, fronts, and doors newly painted are often annoyed by seeing the work spoiled before it is dry.

Recreation on Sundays, when the leading metropolitan thoroughfares are not watered, is rendered unwholesome by the presence in the air of this most unsavoury compound of pulverised road detrital and organic matter, a modicum of which is deposited in the eyes, nose, throat, and lungs, as well as over the habiliments of the wayfarers.

During the late extraordinary dry season the attention of local authorities has been particularly called to the necessity of improving this condition of affairs.

The heavy, lumbering vehicles used for spreading water in the streets and obstructing the thoroughfares have been increased in number, but their efforts have been futile, for they scarcely reach the end of a street of any length before the dust would be blowing at the part they began, so scorching was the sun and so arid the atmosphere.

At an expense of about £100,000 the various parishes of London have been watered this season, but notwithstanding this enormous outlay, the dust could not be laid, and it is quite evident that the time has arrived when the assistance if deliquescent salts is absolutely necessary to aid in this operation, and from the results obtained by the use of the chlorides of calcium and sodium mixed with the water in certain localities, there can be little doubt that they will soon be generally adopted.

A patent was taken out in September last for a compound of these well-known deliquescent salts, and for its application to the purpose of road watering.

The proportions used are 1lb. or ½lb. of the mixed salts to one gallon of water; the salts are put into the cart before it is finished. The water is then laid on, and by the time the cart is full the salts are in solution.

The extraordinary dryness of the atmosphere during the past season has been exceedingly unfavourable to the development of the vital principle of the invention, the benefit the roads were expected to receive from the well-known affinity of these salts, for moisture has been withheld; but notwithstanding that drawback the application of the salts has produced a most important effect upon the surface of a macadamised road, hardening and concreting the material in such a manner that when it is perfectly dry, no dust whatever arises from the passage of ordinary traffic. The light dust always found upon a dry road surface which is usually watered with plain water is not to be seen, the surface remaining smooth, firmly bound down, with no detritus whatever upon the surface.

In considering the economy of road-making, this state of the road is very important. There is scarcely anything for the scavenger to sweep up and take away; and what has usually been carted away by wagon loads, as waste, remains an integral part of the road, consequently the repairs to the road would be much less frequent, and a considerable saving would be effected. The chlorides employed being antiputrescent, tend to alleviate the evils arising from organic matter deposited on road surfaces, a sanitary advantage is therefore gained, and the economy in the water is also a favourable feature of this method of watering roads.

The water consumed in watering roads in London is about one-sixth of the daily supply for all purposes; and, as by the introduction of the chlorides, so much less water is required—a saving of at least 75 per cent. would be effected which is really an important consideration, as this water is required at the hottest period of the season when the demands for other purposes are more urgent than usual, and the necessity of an increased water supply is being seriously discussed.

Thus the effect produced by the use of deliquescent salts mixed with the water is not only the effectual and complete laying of the dust, but the collateral advantages of economy in labour in road-making and in consumption of water. It also obviates the necessity of Sunday labour in road watering.

Nearly all the shopkeepers in Baker-street, Portman-square, have given their testimony with regard to the favourable results of the application of the chemicals in their street, which was chosen as one having a constant traffic.

They state that instead of having their shops filled with dust that they scarcely see a particle, and that on Sundays, when other streets are smothered in dust, that they rejoice in their immunity from this nuisance.

There were certain essential conditions necessary to be attained to render the application of deliquescents universally practicable.

It was important that the chlorides used should be harmless, inodorous, and anticorrosive, and that they should be procurable in such quantities and at such prices to enable them to be used with a proper regard to economy considering the large quantity which would be necessary to meet the demand likely to arise should the method be generally adopted.

The chloride of sodium is plentiful enough, and easily obtainable in any quantity, nor is it probable that the price would ever become so enhanced as to prevent its use for this purpose.

The chloride of calcium is a peculiar article which has never been in great demand, but which can be manufactured to any extent, and at very reasonable prices.

There is therefore no practical difficulty in the way; the application has been tested under the most unfavourable circumstances for an entire season and has been completely successful in this country. There was some doubt as to the effect likely to be produced in tropical climates, but as we have had the opportunity of experiencing a tropical heat this season it may be considered that the same result will be attained in India. The municipality of Calcutta are about to test the method in their city where the plague of dust is also intolerable, and where the damaging consequences of dust (there it is brick dust, the road being made with brick) are sometimes seriously felt.

## DYNAMITE.

By M. Nobel.

Scientific and other papers have lately given much attention to a new blasting agent named "dynamite." It is nothing but nitro-glycerine absorbed in highly porous silica, and if I have given it a new name it is certainly not by way of disguise; but its explosive properties are so much altered as fully to warrant a new denomination.

Dynamite consists of 75 per cent. of nitro-glycerine and 25 per cent. of porous silica. Hence it appears to possess only ¾ of the power of nitro-glycerine, the specific gravity of both substances being very nearly the same. But, practically, there is no advantage in the greater concentration of power of nitro-glycerine. It cannot, or at least ought not, to be poured direct into the borehole, since it easily causes accidents by leaking into crevices, where it explodes under the miner's tools. It must, therefore, be used in cartridges, which leave considerable windage; whereas dynamite, being somewhat pasty, easily yields to the slightest pressure, so as completely to fill up the sides of the borehole, and leave no windage whatever. For this reason a given height of dynamite charge in a hole will contain quite as much nitro-glycerine as when the latter is used in its pure liquid state.

It is necessary, even at the risk of some lengthiness, to make this point clearly understood; for if the advantage otherwise derived from the transformation of nitro-glycerine into dynamite were obtained at the expense of a great depreciation of its power, the substitute might be a safe but not a useful one.

As it is, the block of wrought iron here deposited will bear testimony to its great power. It was originally a cylinder of 11in. diameter and 12in height, of best scrap iron, and cut off from a shaft. The borehole through its centre was exactly 1in., and the charge of 6 ounces was put in without securing either end by any sort of plug or tamping. The cylinder was blown at Merstham, on the 14th July, in the presence of a large audience. Allowing for the hole, and putting the tensile strength of the iron at 20 tons per square inch, the strain necessary to effect the rupture must have been equal to 2,400 tons; and since there was no plug at either end of the hole, it is evident that the charge was too much for the work. Besides blasting the cylinder, it had hurled the one half here deposited with such violence against a ¾in. boiler plate at some distance as to break it. No wonder that a substance which tells so well on iron should be effective against rock.

Coupled with this great power is safety, for proofs of which I will simply refer to the tests publicly made both at Glasgow and Merstham. A box, containing about 8lb. of dynamite (equal in power to 80lb. of gunpowder), was placed over a fire, where it slowly burned away; and another box, with the same quantity, was hurled from a height of more than 60ft. on the rock below, no explosion ensuing from the concussion sustained.

It is difficult to see what more can be required from a blasting material in order to be called safe; but some experiments made lately at Stockholm have put it to a still more severe test. A weight of 200lb. was dropped from a height of 20ft. on a box containing dynamite, which it smashed, of course, yet no explosion took place. An account of this experiment is to be found in the Stockholm paper *Afton-Oladit*, of the 7th of this month.

Such a test can leave no doubt that dynamite offers sufficient safety against concussion for all practical purposes; and we may say, as a Prussian military commission recently reported, that it appears to be the safest of all known explosives.

To those not fully acquainted with the nature of nitro-glycerine, it seems puzzling that a mere absorption should be sufficient to produce such a radical change in its essential properties; but when we come to examine the matter closely it is easily accounted for.

The greatest, and almost the only drawback, on nitro-glycerine is its liquid form. Much as has been written on the danger of congealed nitro-glycerine, I can confidently assert that if the solid form was its natural state at the ordi-temperature, we should hardly have had to deplore a single one of those fatal accidents which it has caused. Moreover, it is a very erroneous notion that crystallized nitro-glycerine is more sensitive to concussion than the liquid one. The reverse is the case, and in a very remarkable degree; but that is immaterial to the present question, and I only mention it to show how fancy notions take root, and defy even the plain truth of simple investigation.

Nearly all the calamities caused by nitro-glycerine have, in my opinion, been owing to leakage, which, for practical reasons, it is very difficult to prevent, and are, therefore, indirectly chargeable to its liquid state. A substance sensitive to concussion, unless it is quite unmanageable like chloride of nitrogen, can easily be protected against accidents by wrapping it in a soft material: but if that substance is a liquid and a leakage takes places, it becomes subject to the danger of direct percussion; and if nitro-glycerine in that condition becomes exposed to the sun's rays the heat which it takes up renders it so sensitive as to become dangerous under the slightest blow.

From the very first beginning I have given special attention to the packing of nitro-glycerine; but, much to my regret, I must say that it is as yet far from satisfactory. Casks are not tight enough for oily liquids, and the property of nitro-glycerine to expand when it congeals has obliged me to resort to square tins. These are left unpacked in the factory for a month at least, to ascertain whether they are tight, yet I can scarcely remember a single instance of a cart or cargo of nitro-glycerine having reached its destination without one case or more of leakage. The reason is probably to be found in the pressure to which the tin becomes exposed when the air which is confined inside, as well as the nitro-glycerine, becomes expanded by an increase of the external temperature.

Whatever be the cause, it is certainly wrong to lay the blame on nitro-glycerine for what has been due only to a practical difficulty. Let us suppose, for instance, the case of gunpowder being transported in cases dropping out continously part of the contents. Without leakages accidents would almost be a rarity, and it is really a proof of the safe properties of nitro-glycerine that accidents have occurred almost only on those occasions (as at Aspinwall and San Francisco) when it was forwarded under a wrong declaration, and consequently the necessity of cautious handling could not be known.

These hints will give sufficient insight into the importance of converting nitro-glycerine into a solid. It is not only a theory or some demonstrative experiments on which I base that assertion, but also on practical experience. Dynamite has only recently grown to be an article of commerce, yet the quantity sold hitherto exceeds fifty tons, and the most serious accidents it has caused was the case of a man who, having lighted the fuse, kept the cartridge in his hand till it exploded and blew off his arm. No explosive can be safe against accidents of that kind.

Besides the security derived from its solid form, dynamite has over nitro-glycerine other special advantages. Its sensitiveness to concussion is, as I have already stated, reduced in a very high degree, and since fire does not cause it to explode, it offers great security for transportation and storage. Besides, it is quite natural that miners should prefer, as more practical, a solid to a liquid explosive. Dynamite is now generally sold in ready made cartridges, and nearly all the workman has to do it to put them into his borehole, and fire.

Having now compared the two explosives, nitro-glycerine and dynamite, and shown the reasons why the latter, with equal power, is far superior to the former in point of safety and facility for use, I will briefly point out the sterling properties which render nitro-glycerine such a highly valuable blasting agent. The merits of dynamite are essentially the same, so that what is said of one is in the same measure applicable to the other.

The miner's work is divided in two parts, viz., to make a chamber for the explosive and to charge it. If that chamber was a matter of small expense it might be very immaterial whether the amount of power required to do the work occupied a great or small bulk. But drilling holes in any rock, and especially in hard ones, is a slow and tedious labour, and there are mines where it takes a man three days of hard work to make a 1in. hole of only 24in. depth. Three day's labour, exclusive of tools, represents at least 9s., yet the charge of gunpowder which can be lodged in such a hole is at most six ounces, or a value of less than 2d. It is easy, from such an example, to see why the miners should be anxious for a more powerful explosive, and ready to pay a much higher price for it. The instance here given is almost an extreme one, yet even in rock of very little hardness the cost of labour alway greatly exceeds the value of the explosive used. It needs no explanation why an explosive containing, within the same bulk, ten times more power than gunpowder, should greatly reduce the number of boreholes and warrant a common saying amongst the workmen in Sweden, that they would blast with nitro-glycerine even if they could get gunpowder for nothing.

I have been frequently asked for a positive statement as to the economy in labour which the use of dynamite effects. This, however, is a question which cannot be answered in a positive manner, for every kind of rock would require a special estimate based on its hardness, the nature of the strata, &c., and which greatly vary, not only in different localities, but within the limit of a single mine. Every one will therefore have to form his own estimate, but as far as I have been able to ascertain the use of dynamite or nitro-glycerine generally causes a reduction of at least one-third on the general cost of blasting, which is a very great saving indeed, considering that the cost of the explosive rarely figures for more than ten per cent. of the expense.

I am, however, not in a position to give on this subject as full informtion as I might desire. The miners are generally extremely sparing in communications of that kind. Amongst my correspondents I can find only one who gives clear and positive statements in figures of the saving effected. It is Mr. Alexander, manager of the "Phœnix" mine on the Lake Superior. His letter is dated February 2, 1868, and the mine had up to that time used 7,000lb. of nitro-glycerine (they have no dynamite yet), so that the result is certainly based on sufficiently practical experience. The material had been purchased from New York at the price of 1 dol. 50 cents per lb. irrespective of the cost of transportation to the Lake Superior.

Another statement in figures is that of Mr. Nendenfelt, director of the Great Northern Railway, in Sweden, who, as far back as the 12th July, 1865, asserted that the use of nitro-glycerine had allowed his contracting for blastings with a reduction of 25 per cent. Mr. Unge, who has blasted with nitro-glycerine an extensive tunnel through Stockholm, states the saving to have been 23 per cent. on the cost of blasting, and the progress of the tunnel 87 per cent. quicker than when gunpowder was used. These results show that even in the present state of comparative inexperience in the use of the new explosive, a great economy is obtained. The saving of labour which dynamite causes is its greatest feature. Next to that we must class the saving of time. Nearly every mine is dependent on the progress of its shafts and pits; and as for railway tunnels, the famous one through Mont Cenis is only a glaring example of the necessity of quickening the tedious work. Next to the saving of time ranks its peculiar adaptability to wet ground, since water has no effect on the charge. Every miner has had more or less experience how difficult it is to blast with gunpowder wherever the rock is water-bleeding, which is only too common.

(*To be continued.*)

## MECHANISM AND CONVICT LABOUR.

By C. J. APPLEBY, of London, M.I.M.E., and Assoc. Inst. C.E.

The profitable employment of convict labour has long been a subject which has engaged the attention of prison authorities in this and other countries, and the instances are extremely rare in which, without the aid of machinery, the value of the work produced by a given number of convicts has been equal to the cost of their maintenance.

This arises from a variety of causes, such as the small amount of work done by convicts generally, the indifference of some, and the inaptitude of others, for any sustained effort, mental or physical; but the principal difficulty experienced is the ever varying conditions of such labour, both as regards the number of hands available, and the absence of previous training for any particular trade or occupation. Those who have been brought up to any trade—such as that of a tailor, shoemaker, baker, &c.—are of course employed in their respective trades, and those convicts undergoing long sentences, who have previously followed no specific occupation, are usually taught one, and their labour is thus eventually made more or less profitable, and a means is provided for their earning a living by honest industry when their term of imprisonment has expired.

In other cases, as at Dartmoor, the convicts are largely employed in farming and gardening operations, at Portland on the breakwater works and quarrying, and at Chatham they have been extensively employed in the excavations for the Chatham Yard extension works, now in course of construction, and more recently in making the greater part of the bricks used on those works. These works were under the direction of that very able officer, Mr. William Scamp, the late deputy director of works, who for many years gave great attention to the utilisation of convict labour.

Finding, however, that unaided by mechanical contrivances, the amount of work done was so small, that it would be cheaper to employ free labour in the ordinary way, the writer was requested to design and construct machinery which would at the same time assist the men and be a sort of check upon the quantity of work done. This machinery consisted of steam lifts which raised the barrows, filled with earth in the excavations, and deposited them on the surface ready for another gang of men to wheel them away; the machinery made a certain number of lifts per hour, and the result of this mode of working was that if a man failed to do his proper proportion of work it was immediately and unerringly detected.

As the excavations were being completed, a large number of bricks were required for the dock walls, &c., and (the earth excavated being suitable for the purpose) the experience gained in the application of machinery on a small scale being highly favourable, it led to the adoption of the most approved brick-making machines, each driven by its own steam engine, and the economical working results is even more favourable than that obtained in the excavations, as many as 60,000 bricks per day having been made, and the whole of the operations from first to last carried out by convict labour

These, however, are exceptional circumstances, and the situations where convicts can be employed in out-door operations will always be confined within narrow limits, any paper on this subject would, therefore be incomplete if it did not deal with the appliances necessary for the purposes indicated in the prisons of our large cities and towns.

Up to a comparatively recent period the "hard labour" sentence was usually carried out by making the men go through a certain amount of unproductive labour, such as shot drill, or, more commonly, turning a line, or lines, of cranks of about 14in. radius, connected together and subjected to the pressure of a friction brake; but this gave a most unsatisfactory result, inasmuch as it was impossible for the warder to tell whether each man was giving out his due proportion of work on the crank, and this frequently led to the men being punished, no doubt often unjustly, and these machines are now practically obsolete.

The treadwheel then became more generally adopted, but until recently the power developed was rarely employed for any useful purpose, because working the treadwheel is a punishment which cannot be extended beyond certain limits clearly defined by Act of Parliament,* and the result in any but the largest prison is, great irregularity in the number of men employed throughout the day, and at different times of the day.

The conditions to be dealt with are, therefore, to accomplish the maximum amount of useful work to the extent of the minimum amount of labour which can be depended throughout the day, and for this purpose it is necessary that any excess of power developed by the fluctuations in the number of men employed at various times, should be instantly and automatically absorbed, an uniform motion of the wheels being equally necessary for the quality of the work produced, and for the safety of the convicts.

Under these conditions the prisoner's labour is reduced to a constant amount due to the weight of his body, and, assuming the speed of the treadwheels to be uniform, there can evidently be no variation in the amount of work performed, or distress occasioned by sudden fluctuations in the speed of the whole.

Various methods have been devised for accomplishing the objects indicated. In some cases an ordinary friction brake has been regulated by the warder in charge. This is an inexpensive arrangement; but as its efficiency depends entirely upon the eye and the hand of the man in charge, the variations in the pressure are necessarily very wide, and sometimes the prisoners are distressed by the wheel "running away," and at others by having to work under too much pressure; or in some cases the friction brake strap is actuated by the ordinary ball governors. Another arrangement is similar to a windmill working on a horizontal axis, the sails being fitted with louvres which are opened or closed by means of the ordinary ball governors.

The latter description of governor works well within certain narrow limits but it is cumbersome, exceedingly expensive, and requires some attention to maintain it in good working order.

One of the most recently constructed treadmills is that erected at Walton, near Liverpool, by the Corporation of Liverpool, from the design of their own architect, the general arrangement of the machinery having been designed by Mr. William Fairbairn, of Manchester, the consulting engineer to the Corporation, and the details of construction were carried out by the writer.

In describing this mill it is proposed to give,

1st. A general description of treadwheels and the power developed.
2nd. The method of utilising the power.
3rd. The mode of governing the speed of the machinery, and,
4th. The practical working results obtained.

*Description of Mill.*—The general arrangement, provides for six lines of wheels, each line capable of accommodating 36 men, or, supposing each wheel were full, 216 men in all. Four of these lines are in the galleries and two on the ground floor, space being left for two more lines on the ground floor if required; but this space is now occupied by the "good conduct men," who are allowed to work in association—that is, not isolated from each other.

The six lines of wheels are connected together by suitable gearing fixed in the central passage between the two mill-houses, to which the convicts are not allowed access. Each line of wheels consists of 36 strong cast-iron shafts of double T section, thickened out to a round section at four points to receive the four wheel rings; these rings are each 6ft. 6in. diameter, and are furnished with 32 brackets, to which the footboards are attached; the shafts are connected together by double socket couplings, and the centre of these couplings form the bearings, which run in gun metal journals supported on cast-iron standards spaced 12ft. 6in. apart from centre to centre.

The treadwheels being 6ft. 6in. diameter, the circumference is about 20ft., and as they are speeded to make one and a half revolutions per minute, each convict must make 48 steps, which is equal to about 30ft. rise per minute, and thus produce an useful effect due to raising the weight of his own body 30ft. high per minute.

In the centre of each division of the wheel house is a raised platform approached by steps at one end for the use of the attendants; one warder thus obtains a full view of every man both in the galleries and ground floor of that division; these galleries are in electric communication with the central hall of the prison for the purpose of summoning assistance in case of any outbreak, and thus enabling the number of warders and consequent cost of attendance to be reduced to a minmum. This system of electric communication is also carried to the rope walk, weaving shed, &c. The whole of these buildings are admirably ventilated, and are supplied with steam heating apparatus.

Taking the average weight of the men at 8 stone = 112lb., we obtain the following result: 112lb. × 30ft.=3360 foot pounds ×216 men=725,760 foot pounds or $\frac{725,760}{33,000}$ = about 22 horse power.

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* Prison Act, 1865, 28 and 29 Vic., cap. 126, sec. 12.

But although the wheels are capable of accommodating 216 men one third of the number usually rest whilst the remaining two-thirds are on the wheels, so that practically the working number is reduced to a maximum of 150 men, giving an effective result of 504,000 foot-pounds, or nearly 16 horse power. Owing, however to fluctuations in the number of prisoners, there may not at times be more than 70 men at work on the treadwheel, when, of course, the power developed will be decreased in direct proportion to the number of men employed.

*Utilisation af Power.*—The power developed is used for weaving cocoa-nut fibre matting, working mat-dressing machines, and pumping the whole of the water for the prison and officers' quarters.

A weaving shed running the whole length of No. 1 Mill House is supplied with six power looms for weaving cocoa-nut fibre matting, with the accessory machines for winding bobbins, &c., made by Lieming and Co., of Bradford. The power to drive this machinery is conveyed from the treadmill by a line of shaft in the central passage, with the gear necessary to increase the speed from 1½ revolutions of the treadwheel to 50 revolutions per minute in the weaving shed, which is the speed required for working the power looms.

Another line of shaft conveys the power to the mat-dressing house, and to the well house for driving two sets of deep well pumps.

*Governing the Speed of Machinery.*—None of the appliances shortly mentioned in the foregoing description appeared to the writer to be sufficiently reliable to govern the speed of the machinery when the power applied fluctuated between such wide limits, and as it was necessary, that whether the greater or lesser, or any intermediate number of mem were employed, or even when none of the machinery is in operation as will sometimes occur, one uniform speed should be maintained, and any surplus power should be instantly and automatically absorbed, he decided to use the Siemens cup governor. As this beautiful invention has been described, and the theory of its action fully developed in a paper read by Mr. C. W. Siemens before the Royal Society (April, 1865), and published in their philosophical transactions, it will be unnecessary to enter into the theory of the apparatus, or to do more than describe its application for the purpose under consideration.

A cylindrical vessel, 5ft. 8in. high and 4ft. 10in. diameter, containing about 12in. of water, forms the outer casing, and to it are fixed a number of vanes, as shown in the diagram No. 3. Inside the vessel, and dipping into the water, is a parabolical cup. Hung on a central vertical spindle, on the outside of this cup, are a number of vanes, spaced to come between the vanes on the outer casing.

A rotatory motion of about 80 revolutions per minute is imparted to the cup; and so long as the velocity of rotation does not exceed 79.2 revolutions per minute, the water in the casing will rise inside the cup to nearly the brim without overflowing, and the only retarding influence produced consists in the friction of the lower edge of the cup slipping through the water, and amounting to much less than one man's power.

So soon, however, as the speed of the cup in the smallest degree exceeds 79.2 revolutions per minute, the water will immediately overflow, which overflow will continue, inasmuch as the same water will evidently be raised continuously from the reservoir below, and returned to it after being acted upon by the series of rotating and stationary vanes already described.

The quantity of water thus mechanically acted upon being large, the power absorbed is also very considerable, and rises with the slightest increase in the velocity of the cup to more than 30 horse power, and this power may be increased or diminished to almost any extent by simply increasing or diminishing the depth of water in the outer casing.

This governor was put to work on the 1st of May last, and has been in constant use ever since with such satisfactory results that, whether the number of men on the wheel is the minimum of 70 or the maximum of 216, there is no appreciable variation in the speed of the treadwheels.

In the official trials conducted by Mr. Fairbairn the whole of the machinery was put to the most severe tests to which it could ever be subjected. In the first instance forty men were ordered on the wheel, working the governor only; the number was then suddenly increased to 216, still driving the governor only without the slightest perceptible increase of speed; the whole of the machinery was then thrown on full work, in addition to the governor, and still there was no appreciable variation in the speed of the mill. A number of other tests were then made which it will be unnecessary to describe.

From the results obtained in the instances under consideration, there can be no doubt that where great regularity of speed is required and a frequently varying load, the Siemens governor can be most advantageously employed. and this has induced Mr. Fairbairn to adopt a governor precisely similar to that at Walton Gaol for the new gaol at Manchester.

*Working Results.*—The average number of prisoners of both sexes and classes at Walton Gaol is about 900, and the daily allowance of water for each prisoner is six gallons; in addition to this there are 46 houses occupied by the officers of the prison, and previously to the machinery described being in operation, the whole of the water supply for them and for the laundries was pumped from a well 80ft. deep, and distributed to the large storage tanks in various parts of the building; for this purpose a steam engine was continuously employed, but it is now used only on Sundays, when the prisoners do not work on the treadmill, the whole of this work being done by convicts, whereby a saving of the cost of fuel, oil, attention, &c., is effected, and even the expenditure on Sundays will be probably avoided by increasing the capacity of the storage tanks.

In addition to this, the power looms are driven by the treadmill, each loom producing three square yards of matting per hour, of a quality certainly not inferior to that previously produced by hand. The same power is also applied to working the mat-dressing machines, and there is still a large surplus. It is now under consideration in what manner this power may be most advantageously employed; and as it is sufficient to work flour mills and bread-making machinery to provide for the wants of the gaol, the value of the labour hitherto entirely lost evidently becomes a matter worthy of serious attention.

There can be no doubt that both in prisons and workhouses a proper arrangement of machinery for rope and twine making, pumping, bread-making, and laundry operations would often turn an annual loss into some profit.

The machinery has been made, and the arrangements described in the foregoing remarks have been for the most part carried out by the firm of which the writer is a member.

The whole of the large range of buildings forming the Liverpool Borough Gaol having been recently constructed, the most improved appliances and arrangements have been adopted by Mr. Robson, the architect to the corporation, and under the able management of Captain Veitch, R.N., the Governor of the Gaol, the organisation and discipline is of the highest order.

## SOCIETY OF ENGINEERS.

### ON THE SCREW PROPELLER.

By Arthur Rigg, Jun.

There is much difference of opinion upon what are the essentials of a good screw propeller; and no generally acknowledged basis exists which can form the starting point for investigation. Such a fact is the more remarkable, for probably there have been a greater number of experiments made upon this subject than upon any other of so circumscribed a character; yet in spite of all that has been done there is still great want of an exhaustive series, to decide beyond dispute what are facts. Not only are these differences of opinion upon the secondary influences of the currents upon the screw, and the screw upon the currents, but the very mode by which it propels a ship at all is often disputed.

Paddles evidently drive a volume of water backwards, and the hydraulic propeller renders this process actually visible. All birds and creatures that swim on the surface propel themselves by their feet as paddles, and nobody thinks of disputing the principles by which a paddle or an oar works any more than they would dispute the manner in which a duck swims. The cases of fishes comes under another head, and there is as much difference of opinion as to how they propel themselves as there is about the screw. Some assert that the fins are a species of paddle; but such is not altogether the case, for if all the fins are cut off from a salmon, it swims about as before, though the steadiness and guiding power of the fins are gone. The real mode by which fishes move is by the flexure of their bodies, and this is an oblique action closely analogous to that of the screw.

It is thus necessary to take into account the essential differences between the paddle and the screw; in the former case the motion is altogether backwards, but in the latter case it is altogether sideways, the motion of the blades being at right angles to the direction in which the ship travels. The disturbing of the currents immediately in front of the screw will modify any action that would occur if it were alone; but as it is important to decide general principles before secondary effects can be fairly estimated, it will be best to assume the ship anywhere except directly in front. Each particular section of the blade describes a path which, although circular, is really equal in length to the circumference, and whether this length be measured circularly, or it be developed into a straight line, the effect in propelling the ship will be precisely alike. For example, the end of the blade of a screw 15ft. 6in. diameter travels 48ft, 8¼in. in one revolution, its course being exactly at right angles to the direction in which the vessel moves.

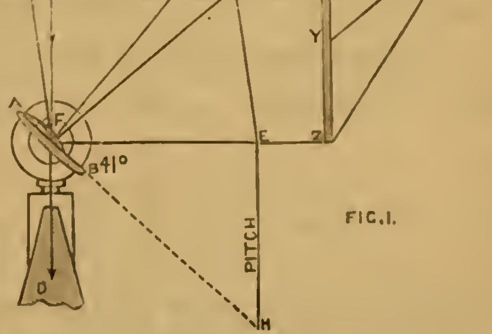


FIG. I.

It has been frequently assumed that water acts the part of a solid in resisting the screw, but this idea is altogether fallacious; so far from resembling a solid, the particles of water are free to move in any direction just as they may be driven and even gravity itself exercises no direct influence upon currents below the surface. Moreover, it would be impossible for water to act like a liquid and yield to the ship's advance, then immediately changing all its properties and becoming a solid resistance to the screw at the stern. This idea is probably more deeply rooted than many of the other curious theories concerning the screw propeller.

The chief influences upon currents of water are two; friction is one of these, and wherever there is an impelling force, the line of least resistance is always taken by the current in preference to any other.

Let A. B. (Fig 1) illustrate the end of a blade of a screw, 15ft. 6in. diameter and 43ft. 4½in. pitch; F, E is a space through which the blade moves. The forces acting upon this section are represented just as accurately by supposing the water to move from E to F instead of the blade from F to E, and it is much more convenient to show this arrangement upon the diagram than the other. A particle of water moving from E strikes the surface A. B at F with a certain force, and is at once reflected to L; the angles, E, F, B and L, F, A, being equal. Now, as there is a continual succession of particles of water moving from E to F and reflected to L, there are really two equal and opposed forces, E, F and L, F, acting at the same time upon the surface, A, B. These combine, and form the resultant, G, F, which is the real effective value of the movement F, E, whether it be a movement of the blade or of the water along this line.

In consequence of the screw being compelled to travel along C D, the line, X Z, will represent the actual movement due to a traverse, F E, measuring the movement in the direction of a ship's course. But the water driven backwards is quite free to follow the line, F G, and it really does this in actual fact, only modified by friction and other disturbing causes. It may, therefore, be stated simply that the ship advances along C, D, and that the reverse current moves backwards along F, G.

In order to determine the real direction of these reverse currents, a series of experiments were made with a screw 22in. diameter, with four and with two blades, set at 3ft., 4ft., and 5ft. pitch. This screw was mounted in a large iron trough, and driven at 150 revolutions per minute, the deviations in the currents being measured by a small vane in the water.

*Table of Experiments made to ascertain the deflection of Currents behind a Fixed Screw-Propeller.*

| Radius. | Four Blades, 3ft. pitch. | Four Blades, 3ft. pitch | Four Blades, 5ft. pitch. | Two Blades, 4ft. pitch. |
|---|---|---|---|---|
| In. | Deg. | Deg, | Deg. | Deg. |
| 11½ | 90 | 90 | 90 | 80 |
| 10½ | 80 | 85 | 70 | 80 |
| 9½ | 70 | 75 | 60 | 70 |
| 8½ | 55 | 50 | 55 | 55 |
| 7½ | 40 | 45 | 60 | 45 |
| 6½ | 30 | 40 | 55 | 40 |
| 5½ | 30 | 40 | 70 | 40 |
| 4½ | 30 | 45 | 80 | 40 |

In some cases the index finger oscillated very much, but the mean position is given above. It is curious to notice that there is not much difference between the deflection due to two blades or four. The water was 3in. over the top of the screw; and at 3ft. pitch there was much more unsteadiness and vibration than at 4ft. pitch.

It is therefore evident that when a screw-propeller is held fast there is a very great deflection of the currents; but it might be supposed that when moving through the water, and propelling a ship, this action will be greatly modified, if not wholly removed. In order, then, to set this question at rest an elaborate series of experiments were made on the steam-tug Dagmar, on the river Dee, at Chester. The screw was one with four blades, 3ft. 6in. diameter, and called 4ft. 6in. pitch. It was really a screw with an increasing pitch, as given in the following table:—

*Description of Screw on Steam Tug Dagmar.*

| Radius. | Width of Blade. | Angle. | Pitch. | |
|---|---|---|---|---|
| in. | in. | deg. | ft. | in. |
| 17 | 10 | 41 | 8 | 0 |
| 14 | 12 | 42 | 6 | 6 |
| 11 | 12 | 42 | 5 | 0 |
| 8 | 11 | 40 | 4 | 6 |

Figs, 2 and 3 explain the apparatus that was used for ascertaining the angle of the deflected currents below the centre line of the screw. A is the screw propeller above described; B the stern of the tug-boat; C, a light shaft set vertically, and left free to turn in any direction; it could also be raised to any desired position behind the screw; D is a vane of ten square inches area, attached to the spindle C, and having its centre 6in. from C; E, an index finger upon the deck. about 9in. long, with a set screw for holding the square shaft C, and having a pin upon it, E, set 6in. from the centre, and therefore exactly coinciding with the centre of pressure of the vane, D; F is an arc, graduated into degrees; and G is a small spring balance.

The mode of action is simple. Knowing the vertical position of the vane, D, by marks made previously, the screw is set into motion, and the vane naturally falls into line with the reverse current, indicating at the same time the angle of deflection, O Y, on the graduated arc, F. This process was repeated at different radii, and gave the following table of results.

FIG. 3.

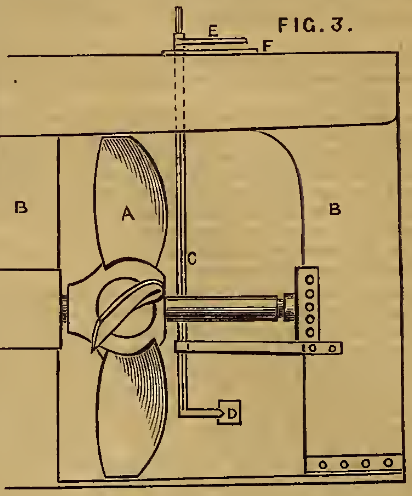
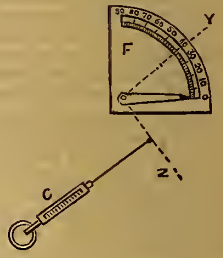


FIG. 2.



After ascertaining each deflection it was very desirable to know something about the pressures exerted by these reverse currents; so, to accomplish this point, the index finger, E, was turned at right angles to them, that is, into the line O, Z, and held in that position by the spring balance, G. Whatever pressure became indicated is the pressure of the reverse current upon an area of ten square inches; and it varies in a most remarkable manner.

It should be mentioned that there was at times very considerable vibration upon the index finger, but the mean indication was taken. There were four blades to this screw, and while the experiments named in the table were made the four blades were all perfect; but on another occasion, when these experiments were tried with the same boat and the same screw, while propelling itself alone and not towing a flat, the vessel got on a sandbank, and amongst the rocks; three of the blades were broken off, but no noticeable change took place in the deflections, and it was not suspected that anything was wrong until the boat was put aground.

*Experiments on the Screw Steam Tug Dagmar, on the River Dee, Chester, to ascertain the deflections of the Currents behind the Screw, and their Pressure.*

| Radii below centre. | Propelling itself alone. Steam pressure. | Propelling itself alone. Speed of screw. | Propelling itself alone. Angle of deflection. | Propelling itself alone. Pressure on 10 square inches. | Towing loaded barge. Steam pressure. | Towing loaded barge. Speed of screw. | Towing loaded barge. Angle of deflection. | Towing loaded barge. Pressure on 10 square inches. | Moored fast. Steam pressure, | Moored fast. Speed of screw. | Moored fast. Angle of deflection. | Moored fast. Pressure on 10 square inches. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| in. | lb. | Revs: | deg. | lb. | lb. | Revs. | deg. | lb. | lb. | Revs. | deg. | lb. |
| 17 | 6o | 141 | 35 | 21 | 60 | 160 | 45 | 10 | 46 | 136 | 72½ | 4 |
| 14 | — | — | 27½ | 18 | — | — | 37½ | 13 | — | — | 52½ | 8 |
| 11 | — | — | 25 | 15 | — | — | 31 | 13 | — | — | 50 | 13 |
| 8 | — | — | 25 | 12 | — | — | 31 | 14 | 50 | 144 | 45 | 11 |
| 6 | — | — | 27½ | 12 | — | — | 31 | 9 | — | — | 42½ | — |

These three experiments correspond with an ordinary steam vessel in fair weather, or when meeting with a head wind or sea; or, finally, when fast on a sandbank; and they prove how rapidly the power of the engines becomes absorbed in twisting the reverse current when it cannot propel the ship.

The angles of deflection given above correspond to the direction of the reverse current marked F, G, on Fig. 1; and it will be convenient in the present stage of the inquiry to follow this subject further. It is necessary to make an allowance for the part performed by friction, and for the increased rotation of the reverse currents due to each blade as it enters into it. Ten degrees will be a sufficient allowance. Add, therefore, 10 deg. to the angle C, F, G (Fig. 1), and it will become C, F, K. Let Y, Z be the ship's advance, and X, Y the corresponding reverse current, as given in the above table, when propelling alone. Then draw Y W parallel to F G, the deflected current. Then Y, W will be the angle of deflection of the water; but meanwhile the vane on the ship has been carried forward the distance Y, Z; then join W, Z, and the angle X, Z, W, will be the one actually seen upon the graduated arc F (Fig. 2). That this principle is correct may be seen by the very close approximation between the real and calculated deflections, as given below.

*Comparative Results between Observed and Calculated Deflections.*

| Radii. | Vessel alone, | | Towing a barge. | |
|---|---|---|---|---|
| | Observed. | Calculated. | Observed. | Calculated. |
| in. | deg. | deg. | deg. | deg. |
| 17 | 35 | 34 | 45 | 44 |
| 14 | 27½ | 30 | 37½ | 42 |
| 11 | 25 | 20 | 31 | |

*(To be Continued.)*

## INTER-OCEANIC COMMUNICATION BETWEEN THE ATLANTIC AND PACIFIC.

By D. S. Howard, C. E.

*(From the Journal of the Franklin Institute.)*

### *The Nicaragua Route.*

The natural advantages of this route were so apparent that every one wished to secure them to himself and his associates. Its early history shows that the first notice of it created a bitter controversy, which was kept up until another route, without any natural advantages, had been, by the sacrifice of an extravagant amount of money and human life. successfully established.

Nothing can flourish between belligerents. The victory is liable to be won by the party more skilled in strategy than the science of improving rivers and harbours, which was the case in this instance. But so much controversy as this route created, naturally raised the value of it in the eyes of the people of Nicaragua, so that now, after it has happened to fall into right hands for successful management, the government of Nicaragua increase their requirements for the privilege of improving their country, and lessen the exclusive privileges to be granted as equivalent. Thus the matter now stands. The present Transit Company, with Mr. W. H. Webb as President, with abundant capital to do anything that may be advisable to be done, only ask a charter that will guard them against any vicious competition, such as the great natural advantages of this route might elicit. The plan of improvement which the company have adopted, has been so far tested already, that its success scarcely admits of a doubt. They propose, first, to divert water enough from the Colorado outlet,, which leaves the San Juan River twenty miles from the Carribean coast at Greytown. This they will do by dredging at and below the junction of the Colorado. The declivity in the bed of the San Juan, below the junction, being about one and a-half feet per mile, renders it unnecessary to make the excavation more than four or five miles below the junction with the Colorado. By making this about eight feet deep, in the lowest water, and about two hundred yards wide—putting the material taken out into the Colorado—it will turn water enough down the lower San Juan to open the harbour at Greytown, and afford sufficient water for steamers drawing three or four feet at all seasons. For this purpose, the company have already provided a powerful dredging machine, capable of raising over 3,000 cubic yards per day of ten hours. This machine is provided with long spouts to run off the excavated material with water, for the purpose of dispensing with lighters, the expense and delay of towing to a place of deposit, &c., as much as possible, which was done with great success by a similar machine in the construction of the Corpus Christi ship channel, in Texas, in 1857-8. The same thing is now being done in the construction of the Suez Canal, by Mons. Lavalley, with the most gratifying results. This gentleman claims the above plan as his special invention. I do not wish to controvert this fact, presuming the idea was original with him, but, in justice to myself, I must say, that I made use of the same device in the construction of the Corpus Christi Ship Channel, as early as 1857, and successfully completed the work without the use of a lighter, except to hold up the outer end of the spouts. The idea was, then, original with me, whoever might have used it previously. I mention this fact, not to detract from the world-wide renown of Mons. Lavalley as an eminent engineer, but to claim the greater credit of preceding, in this instance, so successful an originator.

One great advantage of this route is its measurable availability, to begin with. Throughout the wet season, about half of the year, it is, in its natural state, a better route than any yet in use. It moreover affords important facilities for further improvement, so that every dollar properly expended upon it adds immediately to its value.

It is estimated that when three hundred thousand dollars shall have been expended on the plans adopted by Mr. Webb, that this will successfully compete with any other route that can be made, short of a ship canal of the largest class. These plans are so adapted to the natural advantages of this route, that improvement may go on until a first-class ship canal shall have been completed, without abandoning anything, at any time, as useless, that may have been done previously, so that, in the meantime, the navigation will have been improved by every days' labour, and every dollar expended during the progress of the work; rendering loss of interest on capital actually expended, in case of any unforeseen delay, impossible at any time.

The great objection raised to investing money in the improvement of this river, is stated to be the "movable sands in the bottom." This sand can be excavated and transferred from the San Juan to the Colorado, at less cost than any other material. It is also more readily removed from the channel, by a judicious application of currents for scouring, than the more faultless materials. There has been so much time, talent, and money heretofore expended on rivers of this character, having a limited supply of water, with no resource for adding to or increasing the amount, with little or no success, that the improvement of this river is considered almost impossible by those who do not happen to know and appreciate the exceptional condition here existing, which is an abundant supply of water at all seasons, so situated as to be readily controlled. The rapids, on the upper river, may be improved for boats drawing four feet water, without the obstructions of locks and dams, by grading a sufficient channel to an easy ascent, adapted to the requirements of the boats to be used. This may be done at a trifling expense, compared with that of dams and locks.

With the rapids and lower river and harbour improved at Greytown, the route is complete to within twelve miles of the Pacific. This part the company propose to improve, by the construction of a railroad, from Virgin Bay, on the Lake, to Del Sur, on the Pacific.

From the increase of inter-oceanic trade, since the completion of the Panama railroad, it is reasonable to predict the early necessity of a ship canal, in addition to these improvements. The feasibility of such a work has been made evident from a very exact survey by O. W. Childs, one of the most accurate and skilful engineers of his time. To show that his estimate was ample to provide for the full completion of the work, I will state that, during the six years he was chief engineer of the State of New York, he was never known to under-estimate any work in his charge.

His report on the Nicaragua ship canal was submitted to Cols. Albert and Turnbull, of the Topographical Bureau at Washington, who pronounced it ample for the purpose mentioned, and no person had attempted to criticise his items or question his amounts, until Rear Admiral Davis made his report on inter-oceanic communication, who seems to question it in a way which conveys the idea that a much larger sum than is named in the estimate will be required. To make this appear, he mentions that "costly improvements, possessing the character of artificial harbours, will be necessary at the two points of departure from the lake," &c. It is well known by every person that has been through the route, with any degree of discrimination in such matters, that no such structures are necessary.

The western departure from the lake is perfectly protected by the form of the shore and Ometepe Island. The eastern departure is the outlet of the lake, and is as perfect a harbour as can be made, well known to be perfectly safe for the native bungoes—large open boats navigating the lake and river from Granada to Greytown at all seasons of the year.

Mr. Davis' report bears the marks of a questionable design, by some person or persons, on whom he depended too much for information concerning this route, who, probably, in the first instance, suggested the propriety of such a report to some influential member of Congress, for some private speculative purpose. I do not mean to cast any unworthy reflections upon Mr. Davis, who so worthily received the compliment from Congress of being selected to make this report: but the indications of some special design, in the manner of treating the description of this route in connection with others, are so plain to any person at all conversant with it, that it would be inconsistent with a proper regard for the true character and condition of the subject, to pass it unnoticed.

No country in the world can boast of a more salubrious, healthful climate, particularly along this route, There is no stagnant water, the river having a uniform descent of about one and a half feet per mile, between the rapids, except seventeen miles immediately below the lower rapids, which partakes of the nature of a deep, pure lake, rendering any accumulation of vegetable mud anywhere in the river-bed impossible, while all that may be deposited on the banks by freshets, is dissipated by the extraordinarily luxuriant growth of vegetation.

The delightful scenery along this route is not surpassed in any other uncultivated country. The luxuriant vegetation of various species of vines, and numerous varieties of parasites which cover every tree in the first stages of decay, so that nothing is presented to the observer but the liveliest shades of living tropical vegetation on every side.

## DORSETT'S SYSTEM OF BURNING LIQUID FUEL.

Amongst the numerous plans that have lately been tried with more or less success for burning liquid fuel, may be mentioned the system invented by Mr. Dorsett, of the firm of Dorsett and Blythe, which has been constantly worked by him during the past year. In consequence of the great saving effected during that time at his tar distillery, Mr. Dorsett determined to give his system a thorough trial by applying it to the boilers of the screw steamer *Retriever*. This vessel which has been a regular trader for many years, is of 90 horse power, nominal, and 500 tons burden. The engines are of the usual over head or steam hammer plan, the cylinder being 30in. diameter, and 24in. stroke; number of revolutions about 60; speed of vessel about 8 knots.

Mr. Dorsett's system of burning creosote or other hydrocarbons, consists in raising the liquid in a separate boiler or generator to such a heat that the vapour arising therefrom stands at a considerable pressure. This vapour is then conducted by means of suitable pipes into the furnace chamber, and permitted to rush out through small holes drilled in the pipes; when being ignited by simply throwing in a piece of lighted paper an intensely powerful flame is immediately produced.

In applying this system to the *Retriever* everything has been done in a rough and ready manner. A couple of old upright boilers, one about 3ft., and the other about 2ft, 6in. diameter, have been pressed into the service and placed on the deck, from which the vapour was conveyed to the furnaces of the steam boiler, by means of 1in. unclothed wrought iron pipes. All the firebars were removed from the furnaces and replaced by two layers of perforated firebrick. The boiler of the *Retriever* has three furnaces, in each of which at about the same height as the fire-bars would have been, was placed a double oblong coil of wrought-iron pipe; the shape of the coil being somewhat similar to the outline of the plan of the furnaces, only smaller, so that the pipe was from one to two inches distance from the sides of the furnace. The lower of the two coils was perforated by four small holes, or jets about 3-16thin.diameter, viz., one at each side, and one at each end of the coil. The vapour was caused to pass first through the upper coil of pipe, and thence to the lower, by which means a considerable additional amount of heat was imparted to it just before issuing from the jets. The doors and ash-pits of the furnaces were fitted with perforated plates by which the amount of air could be regulated. The boiler which is on the usual return tube plan, has eight rows of tubes, but the four upper rows were stopped. At first starting coal is used in the furnaces of the generator, which are about three-fourths filled with creosote. As soon as the vapour of the creosote is raised to about 5lbs. pressure, it is admitted by means of a small pipe which runs down from the top of the generator into the furnace beneath it, when from that time no more coals are used as the vapour issuing from a small jet in the furnace, performs the required duty. The most advantageous pressure at which the creosote vapour should be used appears as yet to be scarcely determined; in this case it was used at from 30lbs. to 40lbs. for the steam boiler.

A very interesting trial of this system was made on the 12th ult., when the *Retriever* ran from Deptford to a short way below Gravesend and back, a distance of somewhat over fifty miles, without the slightest hitch of any kind. The steam was kept up at the working pressure of 15lbs. during the whole time, and with one exception, which was purely the result of carelessness, and which only lasted about a minute, the smoke was scarcely perceptible during the entire journey, and it was evident that this minute quantity was entirely owing to the temporary nature of the arrangements for regulating the admission of air to the furnaces. As regards the merits of this system over coal burning, we cannot venture to offer a decided opinion without more accurate data than can at present be obtained. It was stated that the average consumption of creosote during the trip was 35 gallons, while the usual consumption of coals was 8cwt. As the present price of creosote is less than one penny a gallon, this shows a large direct saving, to which must be added the great saving effected by entirely dispensing with stokers, and the increased carrying capacity of the vessel.

We believe that this is the first thoroughly practical exhibition of the merits of liquid fuel for steam navigation, and it has certainly, so far, proved a success, as to justify perfecting the various mechanical details, and giving the system a fair trial.

## A GEOLOGICAL SECTION.

Some of our readers may perhaps wonder what can be said on a subject so simple; others may think time thrown away in reading an article that professes to teach a lesson in practical geology best learnt in the field. However this may be, there is much worth recording even in so simple a matter in field geology as the making of a section, and much that may be taught by description. Let us see how sections are made, what they suggest or teach, what varieties there are, and what are the faults and mistakes sometimes made in making use of such representations of nature. Without in any way exhausting the subject, we have already gone over a long list of occasions in which geological sections are useful and instructive. It is indeed difficult to know in what other way so many and such valuable facts could be so well represented. They are a picture language appealing at once to the eye and the intellect, saving long descriptions, and capable of being wrought up into almost any degree of accuracy when required. But in proportion as they are easily made and easily understood they require to be carefully looked after. They may be misunderstood either by giving them credit for accuracy that does not belong to them, or by the want of a due consideration of the exaggerations and disproportions that so often accompany them. Very few geological books give real sections. The great majority of purely geological and technical memoirs make no pretentions to accuracy in this respect. In them generally sections are used as diagrams to express certain facts and save long description. In this light they are eminently useful if thoroughly understood. Perhaps the account here given may assist some of our readers to regard them in the right light, and assist in rendering the ideas of the rising geologists definite in matters of stratification.—*Popular Science Review.*

## PORTLAND CEMENT.

Great difficulty is often encountered in performing satisfactory work in moist situations, such as sewers, foundations of buildings, water works, &c., in consequence of the unreliable nature of the cement employed in their construction. Sometimes one portion of the work will be very sound while in an adjoining part the cement will not set properly. This arises from various causes; it may be and most frequently, perhaps, is from bad or unskilful management, such as using it hot, or mixing it with hot water, or drying it with artificial heat; sometimes also from mixing with it too much water, sometimes from bad storeage, and not unfrequently the cement itself is imperfect. Mr. Anderson, C.E., under whose superintendence the Aberdeen Sewerage Works are being carried out, instituted a series of experiments upon the strength of Portland cement, and found that the best he could get (from Horner, Marsh, and Co., Great Yarmouth,) when used fresh, bore a test of 400lbs. breaking weight upon 1½ in square bar, and in some cases where it was found necessary to take down the brickwork built with it about three months previously, the bricks themselves frequently broke instead of the cement joints giving way. It thus appears that if properly manufactured and afterwards carefully managed there is not the slightest danger of imperfect or unsafe work in any building where it may be employed, and in those cases where it has failed either by swelling, flaking off, or being rotten, is simply the same as in the case of so many other failures—want of care.

## WONDERFUL DISCOVERY IN TELEGRAPHY!

Mr. J. H. Mower has made a discovery which, if the description given by the *New York Herald* is to be relied upon, will revolutionise trans-oceanic, and generally all subaqueous telegraphy. For some years he had been engrossed in electrical experiments, when the Atlantic cable gave a special direction to his investigations into generating and conducting substances, the decomposition of water, the development of the electrical machine, &c. By this summer his arrangements had been so far perfected that a few weeks ago he was able to demonstrate to himself and his coadjutor the feasibility of his project on a scale approximate to that which it is designed to assume. Selecting the greatest clear distance on an east and west line in Lake Ontario—from a point near Toronto, Canada West, to one on the coast of Oswego county, New York—at his first attempt he succeeded in transmitting his message, without a wire, from the submerged machine at one end of the route to that at the other. The messages and replies were continued for two hours, the average time of transmission for the 138 miles being a little less than three-eighths of a second. The upshot of the discovery—on what principle Mr. Moyer is not yet prepared to disclose—is, that electric currents can be transmitted through water, salt or fresh, without deviation vertically, or from the parallel of latitude. The difficulty from the unequal level of the tidal waves in the two hemispheres will be obviated, it is claimed, by submerging the apparatus at sufficient depth. The inventor, we are told, is preparing to go to Europe to secure there the patent rights for which the caveats have been filed here. At the inconsiderable cost of 10,000 dollars he expects within three months to establish telegraphic communication between Montauk Point, the eastern extremity of Long Island, and Spain, the eastern end of the line striking the coast of Portugal at a point near Oporto. The statement of the discovery is enough to take away one's breath; but with the history of the telegraph before us, we no more venture to deny than we do to affirm its possibility.—*The Round Table* (New York.)

## CORRESPONDENCE.

*We cannot hold ourselves responsible for the opinions of our Correspondents.*

*To the Editor of* The Artizan.

Sir,—Will you kindly allow me a small space in your valuable columns to state, as concisely as I can, a literary offence which if allowed to pass unchallenged, may possibly become a precedent of much import to all writers on professional subjects, and I am sure from knowing your high sense of what is right and honourable, that you will willingly afford me your support and assistance.

About fifteen years since I wrote a treatise on Marine Engines and Steamships for the series of rudimentary works published by the late Mr. Weale, to whom I sold the copyright of the book. Upon Mr. Weale's death this copyright became the property of Messrs. Virtue, the well-known publishers of Paternoster-row. At that time three editions of the book had been issued, and Messrs. Virtue continued the sale of the third edition until the present year. A fourth edition has now made its appearance, and not only have I been completely ignored in its production, but my text has been "revised" by another hand, (Edward Nugent, C.E., as

I am informed by the title page), and interpolated with new matter which is, for the most, entirely at variance with my own professional views.

I think, Sir, you will allow that it must be very "aggravating" to an author to find another man's writing thrust in, *nolens volens*, and without any distinguishing mark. amongst his own work, with a bit of adverse criticism introduced here and there by way of variety! Such a procedure appears to me to be not only most unfair and injurious to the reputation of a professional man, but, (apart from the question of morality) it must prove suicidal to the book itself. I read in the "advertisement" which is prefixed to this spurious edition, (my own preface to the former editions being suppressed) that "Mr. Murray's Treatise on Marine Engines and Steam Vessels has, since its first publication, held, in the estimation of engineers generally, the first place, as a clear and concise, yet sufficiently comprehensive hand-book on the subjects of which it treats." Why, then, it may well be asked, destroy the value and authenticity of the book by mixing up with it, in a hopeless jumble, the crude opinions of some other person, who has probably not enjoyed either the lengthened experience, or the professional advantages of the original author?

The new matter so ruthlessly introduced, will be seen, for the most part, to take the shape either of commendatory notices of questionable inventions, (a thing I had, for obvious reasons, studiously avoided in the book), or else of reckless assertions of quasi-scientific *untruths*, of which the following quotations may serve as examples: at Page 165 the following "revised" matter will be found:—"The law of atmospheric pressure upon the barometer is not universal; it is subject to many exceptions which are not yet clearly understood. It is now well known that when a storm blows from the North the barometer does not indicate the true atmospheric pressure. In some places, not far apart, a difference of ten inches (sic) has been observed in the height of the mercury in two similar barometers at the same time. Colonel Sykes, M.P. and F.R.S., states that he had known the barometer to stand at twenty inches (this is printed in letters) at Malabar, while at Coimbatore, only about 100 miles distant, it was at thirty inches." This is something like a fall! Again at Page 167 it is thus written. "An excellent mode of depolarizing iron ships has been discovered by Mr. Evans Hopkins. By the application of two Grove batteries of five cells each, with their electro-magnets, to the bow and stern, the vessel is completely depolarized in the course of a few hours"—a most ridiculous and untrue statement. At Page 168 we read as follows, in an attempted description of Ruthven's Hydraulic Propeller: "The force of the expelled water from the nozzles acting against the external water is the propeller," whereas every apprentice knows that the propelling power is derived from the reaction of the issuing water against the elbow of the nozzle, which is generally placed *above* the water line of the ship. Once more at Page 170, line 22, we are informed that "the skin of the hull (of the iron-clad "*Black Prince*," 6,009 tons), varies in thickness from ¼inch at the keel to ⅝inch at the gunwale." What has her builder Mr. Robert Napier, been about!

I could multiply instances of the extraordinary blunders of my "reviser," but probably enough has been quoted to show you the insult which has been offered to my poor little book. A further injustice has been done me by this edition dating from the present year, whereas my last revision was made in the year 1858. By this means I would appear to ignore altogether the advance which has been made in Marine Engineering during the last ten years, besides being deprived of the right of modifying my views of various matters by the further experience gained during that period.

I have only to add, as obvious deductions from my letter, that if some publishers' morals are so elastic, it becomes a very serious matter for any author, but more especially for a professional man with a reputation to lose, to part with his copyright without due discrimination; and secondly, that it is a disgrace to our profession that any ignoramus setting up for a civil engineer should have the power of adding C.E., to his name.

I am, Sir,
Your Most Obedient Servant,
Robert Murray.
Surveyor of Steamships to the Board of Trade.

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## CASTING GUNS, &c.

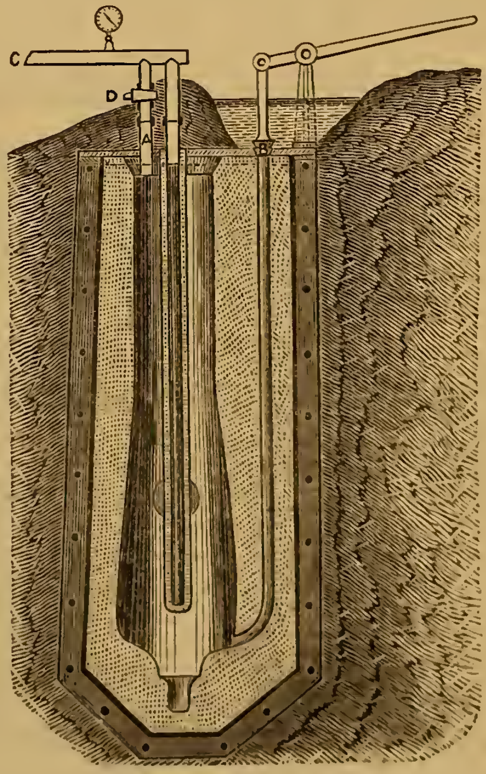
*To the Editor of* The Artizan.

Dear Sir,—I enclose you a rough sketch of an idea I have for casting guns and such like articles. Should you think it practicable and worthy of a place in your journal, I should be glad to furnish you with more perfect drawings if necessary.

Whether I am right in my idea I cannot say; as I do not suppose any experiments have ever been made in casting on the principle that I propose; which is simply that of casting in a vacuum.

We all know the great difficulty attending the casting of heavy articles, more particularly those which have cores, in getting off the gases generated from the case and mould while the metal is flowing in.

What I propose in the casting of guns is that the mould be made in a box or flask in the usual way, only it should be provided with a planed joint, so as to make it air tight; when bolted together, a thin strip of india rubber on the planed face would be sufficient, I should think. The core is supported in the usual way. The top plate, which covers the mould (and which, of course, must be made air tight also) is provided with a pipe A and a hole to receive the end of the core bar. The gate head to have a fire clay plug B, properly fitted and luted over so as to make it air tight, is connected with a lever for lifting it up. C is a pipe in connexion with an air pump. When the pipe on the top of the mould is ready for receiving the metal, the cock at D is opened and a vacuum formed in the mould; this could be ascertained by a vacuum guage placed on the top of the pipe.



When all is ready, and the pit on the top charged with metal, the valve, or fire-clay plug B, is opened and the metal allowed to flow in. As soon as the mould is filled and all the gases generated from it have been pumped off, a cold stream of air could be forced down the core-bar by closing the cock at D, and by proper arrangements in connexion with the air pump,

Whether metal cast under these circumstances would be stronger or otherwise, I do not know. One thing I should think, this casting would be sounder and free of air holes, &c.

I am, dear Sir,
Yours faithfully,
J. L. Watson.
Edinburgh.

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An American Railway War.—Another railway war has broken out in New York, between the Erie and Central Railways. They have begun the suicidal policy of reducing freight charges to less than the actual cost of handling the goods, in order to cut into each other's business. The Erie, for instance, which formerly carried goods from New York to Chicago, nearly 1,000 miles, for 1dol. 88c. currency per 100lbs., now charges but 10c. currency for the service. The reduction on the New York Central is as great, and the Pennsylvania Central, in order to compete, has also been compelled to reduce its tariff, and has issued a notice to shippers that it will carry goods westward at less rates than the other roads.

## NOTES AND NOVELTIES.

### MISCELLANEOUS.

State of Trade in Liverpool.—After an extraordinarily protracted depression in the trade of this port, the seeming approach of a better condition of commercial affairs is welcomed with a degree of heartiness proportioned to the relief of blight which it is supposed to indicate. From the report of the business done in the docks up to the 24th of June last, it appears that for the year ending on the date named 5,498,000 tons of shipping were engaged in the trade of the port, as against in the previous year 5,318,000 tons; the tonnage of 1868 being the largest ever noted, with the exception of that of 1866, when it reached the unprecedented extent of 5,580,000 tons, the last being proverbially the year of inflation. A further indication of the improvement commenced is to be found in the increased number of ships built in and for Liverpool. Another evidence of improving trade will be readily recognised in the fact that the cotton-spinners of Lancashire during the past nine months of the present year have purchased 259,000 bales of cotton more than in the same period of last year. Probably one of the most encouraging symptoms connected with these and other indications of returning prosperity will be found in the absence of speculative excitement, the general run of transactions being for the accommodation of a consumptive demand. In their monthly circular, published on the 10th ult, Messrs T. & H. Littledale & Co. say—"We are confident that the trade of the country, taken as a whole, has made a material advance since the beginning of the year, and that the tide is fairly turned."

Marinoni's Rotary Printing Press.—This arrangement of printing press is now introduced largely in newspaper offices where very heavy editions are required. *Le Moniteur Universal*, the leading French daily journal, will shortly be printed by these machines, five of which are in course of erection in Paris by Messrs. Wintersheim and Co.

The Utilisation of Sewage.—Mr. R. B. Grantham, C.E., F.G.S., has been commissioned by the British Association for the Advancement of Science to draw up annual reports on the treatment and utilisation of sewage in connection with the drainage of towns, in order that such facts and information as may guide future operations may be recorded from time to time. He is requested to include in the details of each report: 1. The special circumstances of each case, such as the extent of district, the population, and the number of houses with or without the benefit of drainage. 2. The character of the sewage and water supply adopted in the district, and the quantity of sewage at disposal. 3. The mode of disposing of the sewage, with description of the works, and their cost. 4. The result pecuniarily to the district, and to those who are selling or applying the sewage to the land or otherwise in any form whatever.

Artesian Wells in America.—A sensation has been caused on the Southern Coast by the success of an artesian well ten miles south of Los Angeles, on the road to Wilmington. The water, which was struck at a depth of one hundred and two feet, fills a seven inch pipe with a strong current, and rises four feet above the surface. This is the first artesian well south of Santa Barbara. A well enhances the value of land in that country very greatly, sometimes for miles around.

Steam Superseded.—Motive Power from the Sun.—After the expenditure of an ordinary life-time upon the perfecting of his caloric machine or hot-air engine, Mr. Ericsson has come to the conclusion that even still further economy may be effected in the production of motive power, by the utilisation of the rays of the sun, for the condensation of which he has now invented a novel apparatus. He writes:—"Calculations which I have just completed have satisfied me that if the sun's rays, now wasting their strength on the house roofs of Philadelphia, were condensed they might be used to set 5,000 steam-engines, of 20-horse power each, in motion. That the new force can be obtained without occupying ground put to other useful purposes is one of its remarkable peculiarities. To give an instance, let us suppose a Swedish square mile (equal to 49 English) covered with condensing apparatus and sun machines. Let one-half the surface be occupied by buildings, roads, &c., and we have still 648,000,000 square feet free for our purpose (2ft. Swedish equal to 0·593 metre). Now, as my condensing apparatus has demonstrated 100 square feet to be amply sufficient for the production of 1-horse power, it follows that 64,800 steam-engines of 100-horse power each, can be worked with the rays thrown on a Swedish square mile. Archimedes having calculated the force of the lever, explained that he could move the earth from its position. I assert that by condensing the rays of the sun a force could be created that might arrest the earth in its course. We have scarcely begun to work the coal fields of Europe, and already computations are being made in England when they will be exhausted. In a thousand years or so—a drop in the ocean of time—there will be no coal left in Europe, unless the sun be put in requisition. True, the rays of the sun are often prevented from reaching us, but, with such a large magazine whence fuel may be obtained without labour or transport to draw upon, experienced engineers will have no difficulty in laying up a store against the rainy day. A large portion of the earth's surface is, moreover, illuminated by an ever un-clouded sun. The area over which the sun machine can work, may, therefore, be regarded as equally unlimited as the amount of force that can be generated."

Professor Matteuci, the learned Italian physicist, and author of several valuable works upon electricity, is dead.

Utilization of Sewage.—The report of the sewage irrigation experiments made at the Lodge Farm, Barking, by the Metropolitan Sewage and Essex Reclamation Company, for the year ending 31st of August, has just been presented to the directors by the manager. The demand for the rye grass, to the growth of which one-fourth of the acreage is devoted, now exceeds the supply, as its value is beginning to be appreciated. That its use in cattle feeding is most satisfactory may be gathered from the fact that two young steers fed exclusively on the sewage-grown grass since May 13, had increased in weight by August 7 from 6cwt. and 7¾cwt. to 7¼cwt. and 9¼cwt. respectively. Experiments of a very interesting character are detailed, illustrative of the remarkable fertilising power of the sewage on land of the poorest and most sterile nature. And whereas it used to be one of the strong points urged against sewage irrigation that it was good for nothing but the growth of rye-grass, the manager of the Lodge Farm is able to speak now of wheat, rye, oats, mangold, cabbage, turnips, sugar-beet, parsnips, potatoes, &c., all yielding most prolific crops from poor land receiving no other manure than the sewage. It is confidently asserted that no amount of ordinary manure could produce six or seven crops of grass a season, weighing six to 12 tons each. In the case of mangold also, the knowledge that two dressings or floodings of sewage, consisting of from 200 to 300 tons per acre each, is capable of producing a crop of from 50 to 60 tons per acre, enables a comparison to be drawn with the ordinary crop of from 20 to 25 tons produced with a good dressing of farmyard dung. The crop of wheat grown last year without any manure was about 3½ qrs. to the acre; this year the yield with sewage was 5½ qrs. Not more than 1-350th of the whole of the sewage of North London is used on the Lodge Farm in a year; and as the results are so triumphantly successful, it may be hoped that the farmers of South Essex will begin to avail themselves of the means offered to them by the company for enriching their land with the valuable fertilizing stream which at present passes away in waste to the ocean.—*Lancet*.

Great interest has recently been created among sugar planters by the unexpected success of a new process of sugar extraction from the cane, which has been introduced at the Aska sugar factory, in the Madras Presidency. This process is known to sugar manufacturers as "Roberts's diffusion process," and has been applied for several years past to the extraction of sugar from beet on the Continent. Its main principle consists in extracting the sugar from the unopened cells of the plant, instead of extracting the juice by means of mechanical pressure, and the result obtained after the second year's working at Aska is an increase of the yield of sugar from the cane equal to 25 per cent., a purer quality of juice, due to the non-extraction of foreign matters, and a great simplification of the working operations. dispensing with the heavy and expensive sugar mills. The diffusion process is now about to be introduced into Cuba, South America, Java, and Australia.

### SHIPBUILDING.

Clyde Shipbuilding.—The following launches took place during the month of September, 1868:—The *Clydevole*, an iron barque of 540 tons, built by Alex. Stephen & Sons, Kelvinhaugh, for William Wylie, Glasgow; for the China trade. The *Ganges*, an iron screw steamer of 3000 tons, built by the London and Glasgow Engineering and Iron Ship Building Company, Govan, for John A. Dunkerly & Co., Hull; for the Baltic trade. The *Villa Real*, an iron screw steamer of 400 tons and 60 horse-power, built by Henry Murray & Co., Port-Glasgow, for Captain Sister, Valencia; for the Maditerranean trade. The *Nuovo Porto Maurizio*, an iron screw steamer of 230 tons, built by Henry Murray & Co., Port-Glasgow; for the Italian trade. The *Rozelle*, an iron ship of 1370 tons, built by Robert Duncan & Co, Port-Glasgow, for Robert Cuthbert, Greenock; for the East India trade. An iron screw steam hopper of 400 tons, built by Wm. Simons & Co., Renfew, for the Clyde Trustees, Glasgow; for dredging operations. The *Fanquai*, a composite barque of 340 tons, built by Robert Steele & Co., Greenock, for Robert Brown, Liverpool; for the Brazil trade. The *Koh-i-noor*, an iron screw steamer of 200 tons and 40 horse-power. built by Archd. M'Millan & Son, Dumbarton, for Robertson Brothers, Grangemouth; for the coasting trade. The *Spartan*, an iron screw steamer of 1250 tons built by J. G. Lawrie, Whiteinch, for Spartali & Co., London; for the Mediterranean trade. The *St Kilda*, a composite ship of 950 tons, built by Alex. Stephen & Sons, Kelvinhaugh, for Sandback, Tinne & Co., Liverpool; for the East India trade. The *Parsee*, an iron ship of 1328 tons, built by Robert Steele & Co, Greenock, for J. & W. Steward, Greenock; for the East India trade. The *Galatea*, an iron ship of 1450 tons, built by Randolph, Elder & Co., Govan. The *Jane M'Coll*, a wooden schooner of 100 tons, built by Mr. M'Lea, Rothesay, for John M'Coll, Glasgow; for the coasting trade. The *Trinidad*, a composite ship of 730 tons, built by Archd. M'Millan & Son, Dumbarton, for John Kerr Greenock, for the West India trade. The *Reward*, a wooden schooner of 103 tons, built by Scott & M'Gill, Bowling, for D. M'Arthur, Glasgow; for the coasting trade. The *Carisbrook Castle*, an iron ship of 1350 tons, built by Barclay, Curle & Co., Whiteinch, for Donald Currie & Co., Liverpool; for the East India trade. The *Dunaverty*, an iron steamer of 150 tons built by Robertson & Co., Greenock, for Thomas Brown, Campbeltown: for the coasting trade. The *North Glen*, an iron barque of 500 tons, built by Dobie & Co., Govan, for Lawson Hodgson; for the West Coast of South American trade. An iron screw steam hopper of 400 tons, built by Wm. Simons & Co.. Renfrew, for the Clyde Trustees, Glasgow; for dredging operations. Total—14,791 tons.

Our Old Ships of War.—During the past week thirty-four shipwrights and ten labourers have been entered in Sheerness dockyard for the purpose of breaking up the useless wooden hulks that are now rotting in the harbour; and fifty additional labourers have been entered for yard duty, making a total at present of ninety-four new hands. The first hulk to be demolished—viz., the *Hermes* (formerly the *Minotaur*, and which was re-christened upon the advent of her more formidable iron rival of the same name)—is already in the hands of the breakers. The *Hermes* is at present in the large basin; but when a sufficient portion of her upper works have been removed to reduce her to the water-line, she will be shifted into dock for complete demolition. Three or four other vessels, at present lying in the harbour, are also ordered to be broken up. It is stated that the *Hermes*, a third-rate two-decker, was never commissioned.

### LAUNCHES.

New Steamers.—Messrs. Backhouse and Dixon launched two iron screw steamers from their yard, at Middlesborough-on-Tees, on the 17th ultimo, viz., the *Thomas Vaughan*, 165ft. in length, 23ft. beam, 14ft. depth of hold, with water ballast, and engines of 70-horse power nominal. This vessel has been built for C. E. Muller, Esq., of Middlesborough, and is intended for the trade between that port and Rotterdam. The other vessel is a small steamer, named the *Kate*, 90ft. long, 18ft. beam, and 9ft. depth of hold, also fitted with water ballast, and engines of 25-horse power nominal, the property of the Southbank River Company, and intended for their Coasting Trade. Messrs Blackwood and Gordon lately launched from their yard at Port Glasgow a fine tug steamer, built to the order of Mr. Proudfoot, Glasgow. On leaving the ways she was gracefully named the *Rio Grande* by Miss Hunter, daughter of the late Captain Hunter, of port Glasgow. After the launch the steamer was taken into the builder's dock to receive her engines. She is expected to leave Port Glasgow for Buenos Ayres about a month hence.

Messrs. Walpole, Webb & Bewley, launched on the 17th inst., an iron screw steamer called the *Knockninny*, built for G. V. Porter, Esq., of Lisbelaw, Enniskillen, to be employed on passenger and market trade on Lough Erne. The following are her dimensions, length over all 70ft. 3in., ditto on W.L. 67ft. 8in., beam 12ft., depth to floors 7ft. 6in., tonnage O.M. 48 tons. Two independent engines, cylinders 10½in. diameter, stroke 14in., fitted with tubular boiler, and improved feed heater, there is also an arrangement for warming the cabins by steam from the boiler. The vessel was launched with steam up, and at once proceeded for a trial trip in Dublin Bay, her speed was about 10 knots.

### RAILWAYS.

The Erie Railway Company, it is stated, have contracted for the enormous quantity of 8,000 tons of steel rails, a portion of which have arrived, the remainder to be delivered during this year. It is proposed by the company to relay at once such portions of its lines as are subjected to the greatest service, but ultimately to dispense with iron rails altogether. The work of substituting the steel ones has already been commenced, and the indications are that by the return of winter the work will be completed, and the whole line placed in good condition.

Fifteen trains, averaging 35 cars each, and carrying an average of fourteen thousand bushels of grain each, pass daily over the Chicago, Burlington, and Quincy Railroad.

An underground railway, it is stated, is to be constructed in Paris for the purpose of bringing market produce into the city, the passenger traffic not being considered an object of importance. The road is to start from the Halles Centrales, at the extreme end of the Rue St. Honoré and take the line of the quays as far as St. Cloud, whence it will proceed to La Marche, famous for its steeple-chases, where an immense station is to be constructed, which will form the starting point of a new circular railway, passing entirely round Paris at several miles distance. The works are to begin at the Champs Elysée, between the Palais de l'Industrie and the Place de la Concorde.

**VALLEJO AND SACRAMENTO RAILROAD.**—Travel has commenced on this road, and there is a business done already of 2,000 dollars a day. Five hundred tons of grain are daily transported over the road. The hour of departure from Sacramento is 6 a.m. The company confidently state that the cars will run to the Sacramento River, opposite the city, by the middle of November, and that the new suspension bridge will be completed by Christmas day.

THE Hartford and New Haven Railway Co,, are relaying portions of their road with steel-headed rails, which are fastened with screws and rubber washers in such a way that the destructive jar of the trains is almost entirely obviated, it is said.

TWELVE cars of freight were recently taken from New York to the present termination of the Pacific line, 1,200 miles west of Chicago, a distance of about 2,100 miles from the starting point, without transhipment.

A portion of the track of the Bellefontaine and Indianapolis Railway, about 250ft long, sank fully sixteen feet, and the ground around sank with it. Traffic was interrupted until the track was raised by cribbing. Fish from twelve to eighteen inches appear where the water has risen out of the crack. A subterranean lake is supposed to exist under the track.

THE Union Pacific Railroad now runs daily trains to Black Butts, 793 miles west of Omaha. The road is graded to within sixty miles of Salt Lake, and is building at the rate of seventy-four miles a day.

**STATION INDICATORS OF RAILROADS.**—An excellent apparatus for informing travellers of the names of stations is used on the cars of the Ogdensburg and Lake Champlain railroad. It consists externally of a box surmounted by a bell, and having a glass plate in front, under which the name of a station appears in letters of about 3in. in length. When the train arrives at the station named on the indicator, the bell on the top of the box rings, and presently the name of the next station on the line appears under the glass plate.

## MINES, METALLURGY, &c.

LATE advices from Alaska are very encouraging. Coal mines have been discovered near Sitka, on the mainland. The quality is considered unequalled, and the seam is over twenty feet wide and traceable for some distance. The coal was tried on the United States steamer *Saginaw* and pronounced excellent. It has the appearance of pure anthracite, and is superior to any Lehigh coal. In addition to this discovery, Alaska is likely to become a place of fashionable resort in hot weather.

**MINERS' STRIKES IN AMERICA.**—The *Meadville Republican* says the recent strikes in the Shenango valleys, among the coal miners, have made a difference of over half a million dollars in the business of that region, have reduced the earnings of the railways and canal a quarter of a million, and have affected the lake trade and the country immediately interested in the mines more than half a million dollars more. All this loss is the work of a few ringleaders, who ought to have been arrested or driven from the country.

**IRONSTONE MINES.**—The Inspectors of Mines report that 70 lives were lost in the year 1867 by accidents in or about the inspected ironstone mines of Great Britain, which, however, are only the mines of ironstone of the coal measures worked in connexion with coal mines. The number of lives lost is 11 less than in 1866, one more than in 1865. There were 14 persons killed in the south-western district in 1867—Monmouthshire, Gloucestershire, Somerset and Devon; six in South Wales; five in the Midland district—Derbyshire, Nottinghamshire, Leicestershire, and Warwickshire; eight in the South Staffordshire and Worcestershire district; 23 in the North Staffordshire, Cheshire, and Shropshire; one in South Durham; and 13 in Scotland. The number of separate fatal accidents in 1867 was 68—50 in the mines, 15 in shafts, three on the surface. No less than 40 of the accidents in the mines (four in every five) were from falls of roof or of ironstone; and falls caused 41 of the 70 deaths. Mr. Brough, reporting on the coal and ironstone mines of the south-western district, says that the deputies should be charged with the setting up of timber, or, if that cannot be, the special rules should provide for the planting of numerous props, whether the top appears to require it or not. Roofs that look and sound like thick cast iron or rock of vast depth will fall without the slightest warning. The prudent course would be to set up much more timber; if the place appears to require three props, set half a dozen. As the timber can be used over and over again, the real loss of material would not be so very great.

THE quantity of railway iron exported from the United Kingdom in August was 54,618 tons as compared with 65,718 tons in August, 1867, and 39,723 tons in August, 1866. In the eight months ending August 31st this year, the total exports of railway iron were 388,676 tons, as compared with 383,776 tons in the corresponding period of 1867, and 352,455 tons in the corresponding period of 1866. It is noticeable that the deliveries of our railway iron have sensibly declined to British India, having sunk to August 31st this year to 53,469 tons, as compared with 101,995 tons in the corresponding period of 1867, and 90,778 tons in the corresponding period of 1866. On the other hand, the United States took 188,730 tons of British railway iron to August 31st this year, as compared with 125,551 tons in the corresponding period of 1867, and 62,806 tons in the corresponding period of 1866. The value of the railway iron exported in August was £443,976, as compared with £554,203 in August, 1867, and £354,131 in August, 1866; and in the eight months ending August 31st this year £3,058,582, as compared with £3,216,583 in the corresponding eight months of 1867, and £2,893,614 in the corresponding eight months of 1866.

## WATER.

**KIRKCALDY AND DYSART WATERWORKS.**—At a meeting of the commissioners of these works the provost reported that Mr. Leslie, the inspecting engineer, had gone carefully over the works, and expressed his entire satisfaction with the manner in which they were being carried out by the contractors. Mr. Sang, the engineer for the scheme, reported that the construction of the reservoirs was making rapid progress, and if the weather remained good, he expected they would be able to get the whole of the works at Ballo finished by the 1st of January, when they would commence to lay the pipes for the town. The provost, who had visited the works along with several of the commissioners, expressed his satisfaction with the progress that was being made, and said that he saw no reason to apprehend delay, or to expect that the works would not be completed by May next year.

## DOCKS, HARBOURS, BRIDGES.

An address, signed by about one hundred persons, including several noblemen, members of Parliament, and business men, has been presented to the Emperor Napoleon begging his Majesty to give his support to the proposed plan for a submarine tunnel between France and England.

THE Mont Cenis tunnel excavations made an advance of 100·85 metres during September. The position of these works up to the 30th was as follows:—Length driven at Bardonneche, 5,211·10 metres; length driven at Modane, 3,631·50 metres; total length of tunnel driven, 8,842·60 metres; length remaining to be driven, 3,377·40 metres; the total length of tunnel being 12,220·00 metres.

A 60-HORSE power double horizontal steam fire engine has arrived at Pembroke Dock from the makers, Shand and Mason, London. This powerful engine is intended to be a supplement to the hand engines already in the dockyard, but which would to a great extent be powerless against a heavy fire.

THE steamboat pier on the Embankment, at Westminster-bridge was opened last September. It is a very substantial and commodious structure, and reflects great credit upon the ingenuity of the contractor Mr. Dixon in utilising the wrought iron work previously employed in the construction of the Embankment.

## LATEST PRICES IN THE LONDON METAL MARKET.

| | From | | | To | | |
|---|---|---|---|---|---|---|
| COPPER. | £ | s. | d. | £ | s. | d. |
| Best selected, per ton | 76 | 0 | 0 | 77 | 0 | 0 |
| Tough cake and tile do. | 74 | 0 | 0 | 75 | 0 | 0 |
| Sheathing and sheets do. | 79 | 0 | 0 | 80 | 0 | 0 |
| Bolts do. | 78 | 0 | 0 | „ | „ | „ |
| Bottoms do. | 81 | 0 | 0 | „ | „ | „ |
| Old (exchange) do. | 68 | 0 | 0 | 70 | 0 | 0 |
| Burra Burra do. | 80 | 0 | 0 | „ | „ | „ |
| Wire, per lb. | 0 | 0 | 10½ | „ | „ | „ |
| Tubes do. | 0 | 0 | 11½ | „ | „ | „ |
| BRASS. | | | | | | |
| Sheets, per lb. | 0 | 0 | 7¾ | 0 | 0 | 8½ |
| Wire do. | 0 | 0 | 8 | „ | „ | „ |
| Tubes do. | 0 | 0 | 10¼ | „ | „ | „ |
| Yellow metal sheath do. | 0 | 0 | 6¾ | 0 | 0 | 7 |
| Sheets do. | 0 | 0 | 6½ | 0 | 0 | 6¾ |
| SPELTER. | | | | | | |
| Foreign on the spot, per ton | 20 | 10 | 0 | „ | „ | „ |
| Do. to arrive | 20 | 2 | 6 | 20 | 15 | 0 |
| ZINC. | | | | | | |
| In sheets, per ton | 26 | 0 | 0 | 27 | 0 | 0 |
| TIN. | | | | | | |
| English blocks, per ton | 100 | 0 | 0 | „ | „ | „ |
| Do. bars (in barrels) do. | 101 | 0 | 0 | „ | „ | „ |
| Do. refined do. | 103 | 0 | 0 | „ | „ | „ |
| Banca do. | 102 | 0 | 0 | „ | „ | „ |
| Straits do. | 99 | 0 | 0 | 100 | 0 | 0 |
| TIN PLATES.* | | | | | | |
| IC. charcoal, 1st quality, per box | 1 | 5 | 0 | 1 | 7 | 0 |
| IX. do. 1st quality do. | 1 | 11 | 0 | 1 | 13 | 0 |
| IC. do. 2nd quality do. | 1 | 4 | 0 | 1 | 5 | 0 |
| IX. do. 2nd quality do. | 1 | 10 | 0 | 1 | 11 | 0 |
| IC. Coke do. | 1 | 1 | 6 | 1 | 2 | 6 |
| IX. do. do | 1 | 7 | 6 | 1 | 8 | 6 |
| Canada plates, per ton | 13 | 10 | 0 | „ | „ | „ |
| Do. at works do. | 12 | 10 | 0 | „ | „ | „ |
| IRON. | | | | | | |
| Bars, Welsh, in London, per ton | 6 | 10 | 0 | 6 | 12 | 6 |
| Do. to arrive do. | 6 | 10 | 0 | „ | „ | „ |
| Nail rods do. | 6 | 15 | 0 | 7 | 0 | 0 |
| Stafford in London do. | 7 | 10 | 0 | 8 | 10 | 0 |
| Bars do. do. | 7 | 10 | 0 | 9 | 10 | 0 |
| Hoops do. do. | 8 | 2 | 6 | 9 | 15 | 0 |
| Sheets, single, do. | 9 | 0 | 0 | 11 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 6 | 0 | 0 | „ | „ | „ |
| Do. merch. Tyne or Tees do. | 6 | 10 | 0 | „ | „ | „ |
| Do. railway, in Wales, do. | 6 | 0 | 0 | „ | „ | „ |
| Do. Swedish in London do. | 10 | 0 | 0 | „ | „ | „ |
| To arrive do. | 10 | 0 | 0 | 10 | 0 | 0 |
| Pig No. 1 in Clyde do. | 2 | 13 | 6 | 2 | 18 | 0 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | „ | „ | „ |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | 0 |
| Indian charcoal pig in London do. | 7 | 0 | 0 | 7 | 10 | 0 |
| STEEL. | | | | | | |
| Swedish in kegs (rolled), per ton | „ | „ | „ | „ | „ | „ |
| Do. (hammered) do. | 15 | 0 | 0 | 15 | 10 | 0 |
| Do. in faggots do. | 16 | 0 | 0 | „ | „ | „ |
| English spring do. | 17 | 0 | 0 | 23 | 0 | 0 |
| QUICKSILVER, per bottle | 6 | 17 | 0 | „ | „ | „ |
| LEAD. | | | | | | |
| English pig, common, per ton | 19 | 0 | 0 | 19 | 0 | 0 |
| Ditto. L.B. do. | 19 | 5 | 0 | „ | „ | „ |
| Do. W.B. do. | 21 | 10 | 0 | „ | „ | „ |
| Do. sheet, do. | 20 | 0 | 0 | „ | „ | „ |
| Do. red lead do. | 21 | 0 | 0 | „ | „ | „ |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 0 | 0 | 22 | 10 | 0 |
| Spanish do. | 18 | 15 | 0 | „ | „ | „ |

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* At the works 1s. to 1s. 6d. per box less.

## 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 September 18th, 1868.

2874 C. H. Hudson—Washing apparatus
2875 E. T. Hughes—Wringing machines
2876 W. Cross—Carriage door stops
2877 H. Vansittart—Construction of screw propellers
2878 W. Clark—Manufacturing spring boots for horses
2879 E. Tempelhoff—Potato planting machine
2880 E. T. Hughes—Grinding, smoothing, and polishing glass, &c.
2881 W. Needham and J. Kite—Apparatus for depurating fluids
2882 J. Smith and J. Dewdney—Improvements in steam boilers

### Dated September 19th, 1868

2883 W. H. Hughan—Treatment of night soil, sewage, &c.
2884 G. Bernhardt—Preparing, spinning, &c., fibrous materials
2885 T. Berney—Defensive armour, &c.
2886 M. Macdermott—Street lamp reflector
2887 J. Blakey—Stretching boots
2888 F. Dyer—Hot water apparatus
2889 W. Haynes—Dressing leather
2890 J. Bruwn—Extracting water from raw material, &c.
2891 L. Desens—Miners' safety lamps
2892 G. Innes—Rifling machines
2893 B. Dickinson—Treating the leaves of the tea plant, &c.
2894 B. Dickinson—Withering and dessicating the leaves and flowers of plants
2895 N. Jarvie and W. Miller—Manufacture of oakum, &c.
2896 H. Foster—Graining leather, &c.
2897 G. Sauders—Safety lamps
2898 J. H. Johnson—Lighting and regulating the flow of gas
2899 W. C. Woodcock—Bakers' ovens

### Dated September 21st, 1868.

2900 W. E. Wiley—Cartridges
2901 N. Stevenson—Working ornamental fountains
2902 C. Wheeler—Tap for cutting off the supply of liquids
2903 J. Lorkin—Coffee pots, &c.
2904 P. E. L. W. Stockmann—Improvements in tents
2905 J. Kirk and J. Batstone—Fixing armour plates to vessels
2906 J. G. Piton—Bushing the sheaves of blocks
2907 C. Vero—Hats, &c.
2908 S. Fox—Umbrellas

### Dated September 22nd, 1868.

2909 F. W. Fox—Locomotive engines, &c.
2910 W. H. J. Grout—Machines for the manufacture of tobacco pipes
2911 W. L. Wiss—Axle box
2912 W. J. Murphy and J. B. O'Hea—Rifled barrels for small arms
2913 C. E. Brooman—Registering the speed of ships
2914 B. C. Scott—Measures used by publicans, &c.
2915 W. Leatham—Preventing accidents to steam boilers
2916 R. Harliog—Telegraphic instruments

### Dated September 23rd, 1868.

2917 T. Lucas and W. Grimshaw—Preparation of wool
2918 F. C. Calvert—Dyeing yarns
2919 E. H. Preutice—Treating sewage
2920 J. Macintosh and W. Boggett—Elastic fillets, cords, &c., to boots
2921 E. W. Halliday—Lubricating cylinders
2922 H. Lomax—Construction of sewing machines, &c.
2923 H. J. B. Kendall—Preservative paint or composition
2924 A. Barclay—Barometers
2925 A. Booth and J. Harrison—Improvements in sawing machines
2926 J. H. Glew—Button holes
2927 C. Hepstonstall—Improvements in looms for weaving
2928 W. Thomas—Circular saws

### Dated September 24th, 1868.

2929 A. M. Weir and M. A. Weir—Pneumatic apparatus
2930 H. Woods—Heating water
2931 C. Heugst, H. Watson, J. B. Muschamp, and N. Wilson—Luminous gas
2932 W Duuo—Dispensing with soldering in fitting up pipes
2933 E. Death and J. Ellwood—Improvements in pumping apparatus
2934 E. Death and J. Ellwood—Cutting leather, wood, &c.
2935 D. Cowan—Float valves
2936 J Fry—Wheels
2937 C. Catlow—Looms
2938 J. F. Wanner—Embroidering or ornamenting fabrics
2938 W. T. Wotts and D. J. Fleetwood—Hydraulic and other presses

### Dated September 25th, 1868.

2940 I. Baggs—White lead, &c.
2941 J Torbitt—Treatment, preservation, &c., of the potato
2942 C. E. Brooman—Breech loading firearms
2943 J. L R. Steckel—Improvements in wind musical instruments
2944 J. Wright and W. H. Williams—Manufacture of gas burners
2945 P. Kean—Dyeing textile fabrics
2946 C. Scriven and W. Holdsworth—Planing, &c., machinery
2947 W. E. Newton—Adhesive stamps
2948 G. Ritchie—Sun proof fabrics
2949 W. J. Ledward—Timekeepers
2950 R. Oxland and J. Hocking—Calcining ores and minerals
2951 E. Prevost—Electro magnets

### Dated September 26th, 1868.

2952 P J. E. Caron—Prevention of accidents from the breaking of chains
2953 H. Davey—Steam engines, &c.
2954 J. H. Johnson—Permanent way of railways
2855 J. Sutcliffe—Improvements in warping mills and hecks
2956 J. Ramsbottom—Communicating between the passengers, &c., of a railway train
2957 J. Heap—A new system of gearing applicable to lathes, &c.
2958 C F. Whitworth, G. Pearson, and W. Smith—Apparatus for the increase of safety on inclines of railways
2959 P. Spence—Manufacture of copperas, &c.
2960 J Petrie—Washing wool
2961 J. Jones and G. E. Wilkinson—Manufacture of paste and cardboard
2962 G. F. Morant—Artificial fuel
2963 V. Gallet—Cast steel
2964 H. Gibson—Tobacco
2965 F. B. Dœring—Machinery for boring in rock, stone, &c.
2966 J. Tangye and J. N. Kitching—Machinery for pulling heavy weights, &c.

### Dated September 28th, 1868.

2967 J Shepherd—Prevention of smoke
2968 C D. Abel—Converting cast iron into wrought iron
2969 W. McAdam—Apparatus for facilitating omnibus traffic
2970 J. Gregory—Preparing and cooling animal charcoal
2971 G. A. C. Bremme—Machinery for untwisting strands
2972 R. Duncan—Earth closets
2973 J. Robinson—Ploughs

### Dated September 29th, 1868.

2974 T Briggs—Connecting the ends of metal bands for securing bales
2975 J. Smith—Machinery for weaving and cutting fustian, &c.
2976 J. Wadsworth—Economising fuel
2977 W. E. Gedge—Swimming apparatus
2978 A. M. Clark—Machinery for raising and lowering weights
2979 J. H. Irwin—Illuminating apparatus
2980 E. T. Hughes—Gas burners
2981 A. H. Brandon—Watch case spring
2982 J. Foster—Preparing or damping and marking paper
2983 A. V. Newton—Boots and shoes
2984 W. Hallam and H. J. Madge—Conversion of tin plate shearings, &c.
298[illegible] L Hanart and N. A. Aubertin—Tool for moulding discs
2986 H J. Girdlestone and J. W. Girdlestone—Treating ships, &c.

### Dated September 30th, 1868.

2987 E. Horton—Chandeliers, &c.
2988 G. Dawa—Opening and closing, locking and unlocking cart gates, &c.
2989 W. Gadd and J. Moore—Improvements in looms
2990 H. Jewitt—A new game called 'Silver Chimes'
2991 V. Juge—Propelling ships, &c.
2892 J. Mabsoo—Candlesticks
2993 J Lambert—Raising water
2994 A. Lafargue—Gauges for indicating the pressure of steam
2995 W. Richardson—Machinery for burring and cleaning wool
2996 W. E. Newton—Treating metals, &c.
2997 W. E. Newton—Scissors sharpener
2998 J. H. Johnson—White lead, &c.
2999 G. A. F. E. Dalrymple—Apparatus for clipping horse, &c.
3000 O. W. Powers—Sewing machines
3001 J. Wollatt and W. B. Dodds—Obtaining motive power
3002 G. Unwin—Improvements in recapping cartridge cases
3003 B. W. Stevens—Picker spindles or guide bars of looms
3004 A. T. Becls and G. Johnson—Manufacture of rouge, &c.

### Dated October 1st, 1868.

3005 T. Fisher—Devices for supporting the ends of rollers
3006 H. Highton, M A.—Manufacture of artificial stone, &c
3007 G. T. Bousfield—Manufacture of tufted or pile fabrics
3008 J. D Scally—Filling casks
3009 J. F. G. Kromschrœder—Generating an inflammable gas
3010 J. Murray and O. Horling—Consuming smoke,
3011 D. Crichton, W. Donbavnod, and D. Crichton—Looms
3012 C. B. Chardon—Locomotive engines
3013 R. Legg—Manufacture of twisted or spun tobacco
3014 J. Olivier—Mode of obtaining motive power
3015 A. Thorpe—Chairs, &c.
3016 W. E. Newton—Decorticating grain
3017 W. R. Lake—Constructing the door frames of furnaces

### Dated October 2nd, 1868.

3018 F. A. Calvert—Machinery for opening cotton, &c.
3019 G. Holcroft and W. N. Dack—Improvements in steam engines
3020 J. Jenkins, F. Jenkins, and S. Jenkins—Sleeve links
3021 E. O'Connell—Supplying nourishment to infants, &c.
3022 A. Monsnergue—Kiln for burning clay
3023 N. Heuwood—Mowing machines
3024 R. F. Drury, J. E. Walker, and W. G. Walker—Ratchet braces
3025 S. Bates and W. Redgate—Lace made on bobbin, &c.
3026 C. E. Brooman—Treatment of fatty matters
3027 T. C. Parson—Skates

### Dated October 3rd, 1868.

3028 E. F. Rose—Machinery for breaking and peeling flax
3029 Z. Shrimpton—Packing needles
3030 J. Baker—Removing adhesions from the bottoms of vessels
3031 J. Rogers—Mode of reviving bone black
3032 D. West—Presses
3033 B. E. R. Newlands—Manure, &c.
3034 E. A. Cowper—Iron and steel

### Dated October 5th, 1868.

3035 J. Howden—Substances for preventing the escape of heat
3036 R. Heilmann and P. Hart—Utilising waste vapours
3037 J. B. Joyce—Improvements applicable to the valves of steam engines
3038 W. R. Lake—Extension chandelier
3039 C. F. Galand and A. Sommerville—Repeating firearms

### Dated October 6th, 1868.

3040 E. T. Bellhouse and W. J. Doroing—Hydraulic presses
3041 E. Simons—Breaks applicable to railway carriages
3042 N. Tchpelevsky—Enamel applicable to wood, paper, &c.
3043 J. R Wigham—Illuminating lighthouses
3044 G. Graveley—Steam pumps
3045 F. S. Gilbert and W. G. White—Self adjusting spanners
3046 A. G Straker—Sample bag
3047 R. Ramsay—Shoes, boots, and knee caps for horses
3048 T. Garnet—Hydraulic rams
3049 H. Steffansun—Improvements in machinery for sawing wood
3050 J. G. Wilians—Improvements in the manufacture of iron
3051 J. Aspinall—Telegraph and other ropes or cables
3052 J Jeffreys—Shipping, freezing, and preserving meat
3053 C. Eskrett—Envelopes or hairs used in extracting oil, &c.

### Dated October 7th, 1868.

3054 F. P. Warren—Apparatus for cooking and other purposes
3055 J. H. Johnson—Textile fabric applicable as blankets for printing presses
3056 D. Marshall—Packing for the tubes of surface condensers
3057 W. Sievwright, jun., and G. Worrall—Producing adjustable pressure on rollers
3058 J. H. Johnson—Flyers employed in twisting cotton
3059 R. T. Monteith—Fire bricks
3060 E. T. Hughes—Generating electricity by heat
3061 W. Rossiter—Warping machines
3062 J. Wood and J. Arundale—Improvements in shuttles
3063 W. E. Newton—Knitting machinery
3064 J. Watson—Wall papers
3065 J. Dupree—Sieves
3066 J. Watson—Improvements in the manufacture of wall papers
3067 W. Estar and C. T. Pearce—Disinfecting rooms, &c.
3068 W. Richards—Cartridges
3069 R. H. Bentham—Instrument for drawing lines radiating from a known centre

### Dated October 8th, 1868

3070 H. Josephi—Improvements in watches
3071 G. Speight—Applying adhesive substances to paper
3072 J. Chaudron—Boring pits
3073 J. Barcroft—Felted cloth
3074 J. M. Gray—Machinery for working war turrets, &c.
3075 E. J. Hughes—Recreative games played with balls and cues
3076 T. Sagar and T. Richmond—Improvements in looms
3077 F Ayckbourn—Lead pencils
3078 E. Prevost—Controlling restive and vicious horses
3079 J. H. Johnson—Saw handles
3080 W. Simons—Bricks or blocks to be used for building purposes
3081 J. Steel—Obtaining extracts from roasted malt
3082 W. Bland—Looms
3083 G. Davies—Paper boats
3084 J. Arnold—Improvements in the construction of steam boilers
3085 R. Winder—Boring holes to fix the hop poles in, &c.
3086 J. Dewar—Improvements in food
3087 J. Dewar—Improvements in making and preserving manure
3088 F. Zysel—Expanding frames for furniture
3089 T. Heacock—Door knobs
3090 M P. Manfield—Soles of boots, shoes, &c.
3091 W. E. Newton—Binnacle for iron ships
3092 A. Macmillan—Buttons, or fastenings to garments

### Dated October 9th, 1868.

3093 J. Varley and S. W. Varley—Treating waste silk
3094 H. A. Bonneville—Pumps
3095 J. Peel, J. F. Broadbent, and J. M. Baines—Picker for looms
3096 W. Jarvis—Label attachments
3097 T. W. Dyer—Anti-chimney smoker
3098 H. Deacon—Sulphuric acid
3099 L. Hannart, N. A. Aubertin, and W. J. Coningham—Door plates, &c.
3100 E Evans—Propelling boats
3101 H. A. Archereau—Obtaining heat
3102 W. E. Newton—Ascertaining and checking the amount of money taken by the conductors of omnibuses
3103 W. J. Curtis—Sewing machines
3104 S. Tragheim Washing, &c.
3105 J. C. Morgan, H. Macaulay, and F. W. Weide—Cast iron cisterns
3106 W. T. Read—Treating bottles to prepare them to receive beer
3107 B. Walker and J. F. A. Pflaum—Reducing bulldog or other substances
3108 J. Griffiths—Piles of iron or steel
3109 D. Hallas, G. Hallas, and S. J. Woodhouse—Regulating gas

### Dated October 10th, 1868.

3110 G. P. Grant—Bung bushes for casks
3111 F. Barnett—Improved system of paving
3112 T. Merz—Calcining ores
3113 R Tod—Separating and cleaning sharps or middlings, &c.
3114 S. J. Maccarthy—Fastening for securing boots, shoes, &c.
3115 F. A. Abel and E. O. Brown—Firing explosive compounds
3116 W. H. St. Aubin and B. Benton—Cocks, &c.
3117 W. R. Lake—Improved process for electro-plating
3118 F. W. Hart—Varnishes

### Dated October 12th, 1868.

3119 N. Smith—Treating and utilising waste acid liquors
3120 C. D. Abel—Propelling vessels
3121 J. Muon, I. H. Donaldson, and S. J. Harris—Making bedsteads
122 W. Moodie—Propelling ships
123 T. B. Jordan—Breaking and separating mineral substances
3124 S. Leoni—Heating apparatus
3125 A. Field and A. W. Tuer—Show boards
3126 W. Brailsford and J. Gadsby—Lace

### Dated October 13th, 1868.

3127 J. Ward—Communicating between the passengers, &c., of railway trains
3128 T. F. Cashin—Securing the joints of rails
3129 W. A. Lyttle—Electro-telegraph conductors, &c.
3130 H. C. Clifton—Making ornaments for picture frames
3131 F. A. Le Mat—Revolving and repeating firearms
3132 G. N. Sanders—Lamps
3133 W. T. Sogg—Regulating the supply of gas
3134 R Dawson—Gun boats for coast and harbour defences
3135 R. Spics—Construction of jars
3136 J. Worsier—Holding or supporting stereotype plates
3137 W. Yates—Furnaces and tools
3138 W. R. Lake—Dyeing hair

### Dated October 14th 1868.

3139 R. Rowbotham—Top bar for fireplaces
3140 J. Shanks—Waterclosets
3141 L. Clozel—Improvements in tanning all animal skins
3142 W. R. Lake—Drilling, &c.
3143 J. H. Carter—Lubricating apparatus
3144 W. R. Lake—Spinning wool
3145 J. G Jones—Getting coal, &c.
3146 J. Robertson—Obtaining and transmitting motive power
3147 E. Leach—Travelling lattices
3148 J. Atkins—Metallic tubes
3149 W. Lorberg—Treating cotton seed
3150 H. Hudson—Facilitating the stopping of railway trains
3151 W. R. Lake—Generating and burning the vapour of hydrocarbon liquids
3152 J. Denley—Coffee pot

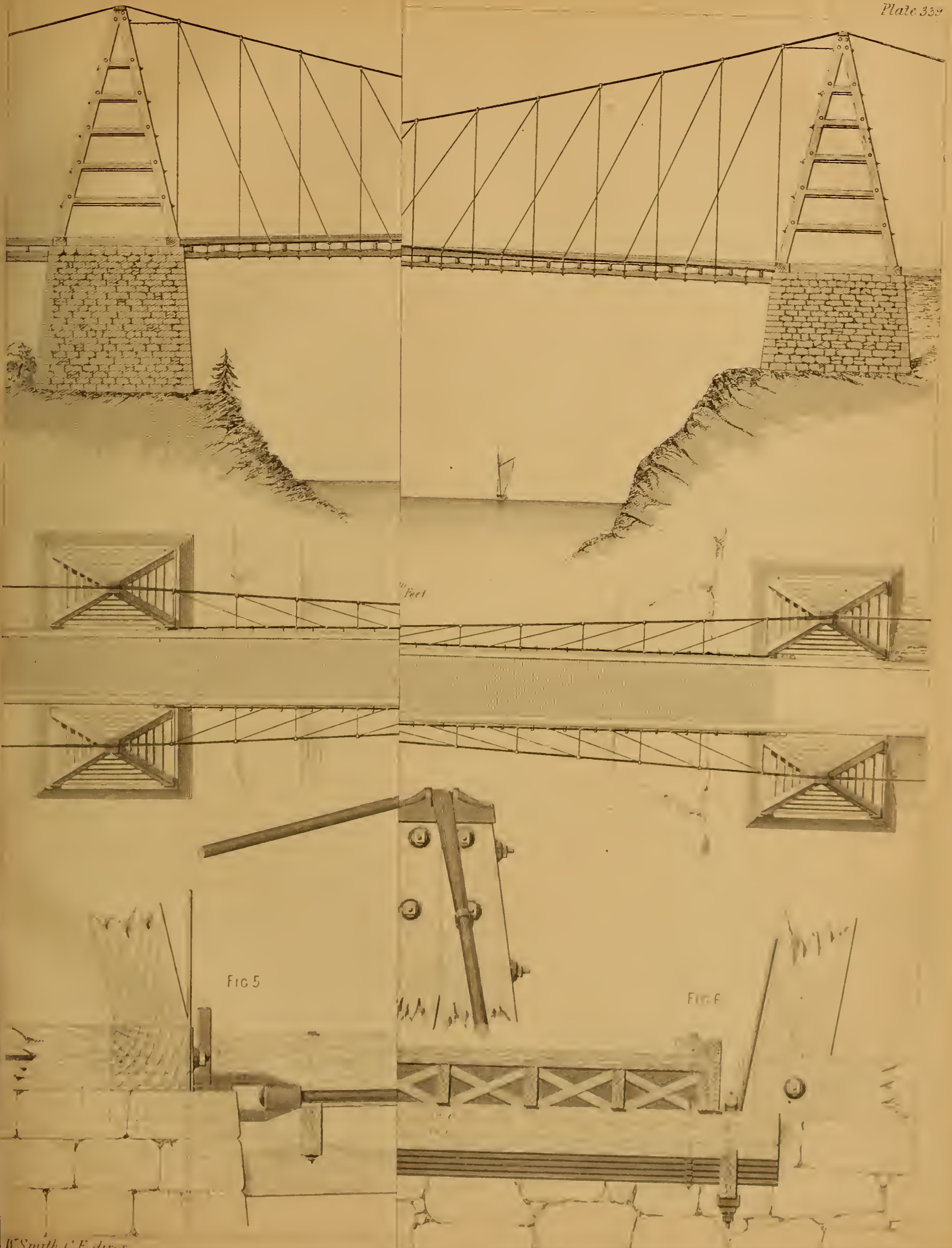
### Dated October 15th 1868.

3153 C. G. Gumpel—Locks
3154 W. E. Gedge—Agglomeration of the slack of coal
3155 H. A. Bonneville—Elastic moulds
3156 E. Fort and J. Lee—Furnaces
3157 G. C Attree and T. Dermer—Fastening scarves
3158 A. Robins—Water pipes
3159 E. Peyton—Spring mattresses
3160 T. Gray—Safety lamps
3161 J. Ball and A. Ball—Manufacture of lace made on bobbins
3162 R. M. Wood—Type cases
3163 I. A. Vacherot—Construction of buildings
3164 W. R. Lake—Breech loading guns
3165 W. R. Lake—Repeating firearms

### Dated October 16th, 1868.

3166 T. Vicars T. Vicars and J. Smith—Self feeding smokeless furnaces
3167 R. Pearce—Separation of copper
3168 R. M. Marchant—Permanent way of railways
3169 W. C. Church—Preventing damage in steam boilers
3170 R. Head—Stoves and boilers
3171 W. E. Newton—Syrup
3172 J. Sherman—Finger rings
3173 C. Churchill—Breech loading firearms
3174 J. Ashcroft—Safety valve
3175 A. Deoayrouze—Dresses in head gear
3176 J. Phillips—Apparatus employed for warming buildings

Plate 339

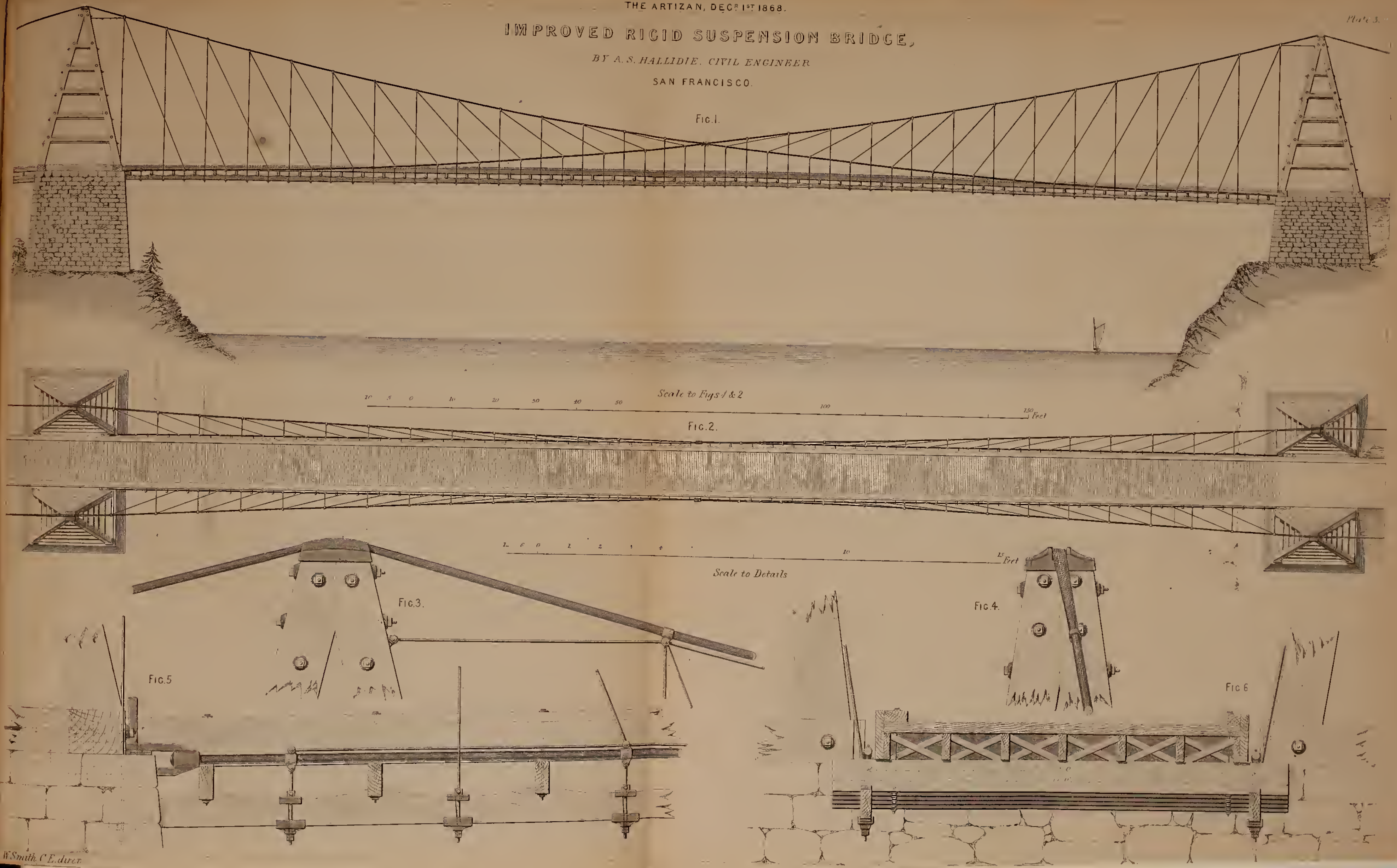


W. Smith C.E. direx

# IMPROVED RIGID SUSPENSION BRIDGE,

*BY A. S. HALLIDIE, CIVIL ENGINEER*

SAN FRANCISCO.



W. Smith C.E. direx.

# THE ARTIZAN.

No. 12.—Vol. II.—Fourth Series.—Vol. XXVI. From the Commencement.

1st. DECEMBER, 1868.

## IMPROVED RIGID SUSPENSION BRIDGE.

By A. S. Hallidie, San Francisco.

(*Illustrated by Plate* 339).

The suspension bridge is the oldest form of bridge in existence, excepting of course the rough and ready method of crossing a small stream or chasm, by means of a bamboo or tree laid from bank to bank. As in the case of so many other useful inventions, the Chinese were undoubtedly the first to employ this method for crossing channels of considerable width, although the inhabitants of many other countries were long before us in this branch of engineering. A Spanish writer (De Ullea) has described a kind of bridge called a *Tarabita*, which was used to cross the chasms in the Cordilleras in South America. In this case the bridge was made of bamboo, or of strips of hide, and stretched from one side of the chasm to the other. Two such ropes were used, inclined in opposite directions, so that a person getting into a basket could work himself across that one which was inclined downwards; while the other rope would be available for a person on the other bank. A more complete suspension bridge is mentioned by Capt. Basil Hall in his account of his travels in Chili. This bridge consisted of a narrow roadway of planks, laid crosswise with their ends suspended by short vertical ropes attached to a set of thicker ropes stretched across the river Maypo. The clear span was 123ft., and, says Capt. Hall "the materials being very elastic, the bridge waved up and down with our weight, and vibrated in so alarming a manner, that we dismounted and drove our horses one by one before us." In the northern part of India a very similar method was used, and a bridge accross the Sutlej is thus described:—"At some convenient spot where the river is narrow, and the rocks on either side overhang the stream, a short beam of wood is fixed horizontally upon or behind two strong stakes, that are driven into the banks on each side of the water, and round these beams ropes are strained, extending from the one to the other across the river, and they are hauled tight or kept in their places by means of a sort of windlass. The rope used in forming this bridge is usually from two to three inches in circumference, and at least nine or ten times crossed to make it secure. This collection of ropes is traversed by a block of wood, hollowed into a semi-circular groove, large enough to slide easily along it; around this block ropes are suspended forming a loop, in which passengers seat themselves, clasping its upper part with their hands to keep themselves steady. A line fixed to the wooden block at each end extending to each bank serves to haul it and the passenger attached to it, from one side of the river to the other." The spans of these primitive bridges are sometimes very considerable, one being mentioned as from 90 to 100 yards, with an elevation of from 30 to 40ft. above the water.

It is in China however, as before observed, that this system has not only been adopted from time immemorial, but has been carried to far greater perfection. In this country several suspension bridges exist made of iron chains. One built over the river Sampoo on the road to Lassa is made of five parallel chains with links about one foot in diameter upon which a bamboo flooring is laid. Another (the Solo-cha-zum) approximates in its arrangement to our modern suspension bridges. It is formed of two parallel chains, 4ft. apart which are suspended over stone piers about 8ft. high on each bank, the ends of these chains passing down in an oblique direction and embedded in the rock; each being fastened round a large stone which is kept down by a mass of smaller stones laid over it. A plank about 8in. wide extending across the river is suspended from the chains by bands made of roots, of such a length that the path is 4ft. below the chains in the middle of the length of the bridge. The suspending bands are renewed every year and the planks are loose, so that any part can be repaired separately. Here we have a suspension bridge proper, with a horizontal platform suspended from the main chains. It is however only of small size, 59ft. span, and only used for foot passengers. The date of the erection of these Chinese bridges cannot be ascertained, but they are no doubt of great antiquity.

The first European chain bridge was built across the Tees, two miles above Middleton, for the use of the miners in that district. The length was 70ft., the breadth rather over 2ft., and the height above water 60ft. The date of its construction is not absolutely known but is supposed to be about the year 1741. It was not, however, until the early part of this century that much attention was directed to this system, when Telford took up the subject with such magnificent results. The Americans have always been favourable towards this description of bridge, and as early as 1796, Mr. Finlay built one of iron, about 70ft. long, across Jacob's Creek, on the road from Union Town to Greenburgh. Mr. Finlay took out a patent in 1801 for the construction of suspension bridges, and was remarkably successful; it being stated in 1820 that forty bridges on his system had been erected in the United States. Some of these bridges were of a very large span, as for instance, that across the Schuylkill which is 306ft. long, and another over the Merrimac which has an arch of 244ft. span. Since that time an immense number of suspension bridges have been built in America, including that grand piece of engineering by Mr. Roebling—the celebrated Niagara Suspension Bridge.

In all these bridges, however, rigidity was either not necessary or very difficult to be obtained. A mere glance at the Niagara Bridge, with its cobweb-like multiplicity of stays, is sufficient to show the immense amount of trouble and thought Mr. Roebling must have exercised before he attained his object. Many other engineers have also endeavoured to devise some plan for giving rigidity to this description of bridge, among the

FIG : 1.

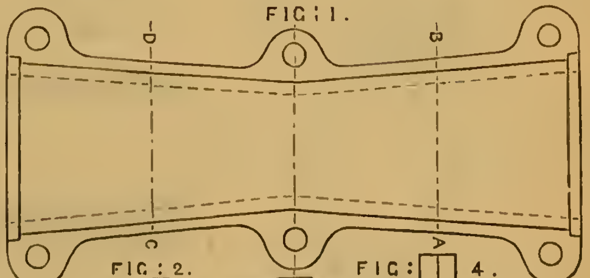


FIG : 2.

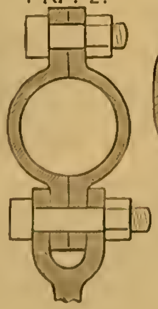
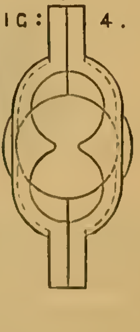


FIG : 3.

FIG : 4.



latest and apparently the simplest of which is by Mr. A. S. Hallidie (San Francisco), of which we give an illustration in Plate 339. In this bridge it will be seen that four main chains (or, as in this case, wire ropes) are employed, two being used upon each side of the bridge, running from the top of one of the main piers to the bottom of the opposite pier and *vice versa*. The roadway is suspended by vertical tie rods fastened alternately upon the two main ropes on each side, in addition to which a series of diagonal ties are employed to connect the vertical ties of the two main ropes upon the same side of the bridge, at their points of suspension. This system of alternate chains and diagonal ties was designed by Mr. Hallidie for the purpose of giving greater rigidity to the flooring of the bridge, and it has since proved to answer his intention most admirably. In order to prevent the vertical ties from slipping down the main ropes, a light tie rod is provided, which is attached to the pier (Fig. 3, Plate 339), and passes along to the junction of each of these ties with the main ropes; the bolt of the clip piece passing through it, as shown in Figs. 5 and 7 in the accompanying woodcut. In order to prevent any lateral swaying of the bridge, the centres of the piers are placed at a considerable distance further apart than the width of the bridge, as shown in the whole plan, Fig. 2, and an end elevation of the piers, Fig. 4, Plate 339. In the woodcuts, Figs. 1, 2, 3, and 4, are shown the method of joining or clamping the two cables on each side at the centre of the bridge; Fig. 1 being an elevation; Fig. 2, section through the centre; Fig. 3, section through A, B, or C D; and Fig. 4 an end elevation of the clamp, which is of cast-iron. Figs. 5 and 6 give, as mentioned above, the method adopted by Mr. Hallidie for attaching the vertical tie rods to the main rope, which is in the highest position; and Figs. 7 and 8 the attachment to the lower rope. The general arrangement of the bridge is illustrated so completely in Plate 339—Fig. 1 being a side elevation, Fig. 2 plan, Figs. 3 and 4 side and end elevation, respectively, of the upper part of the piers, on an enlarged scale, and Fig. 5 side elevation, and Fig. 6 cross section upon a similar scale of the roadway—that but little explanation is required. One thing, however, may be mentioned, viz., the method of carrying the roadway by means of short longitudinal beams. The lower end of each vertical tie rod carries a cast-iron shoe (Fig. 5, Plate 339) into which the ends of these short beams fit, the cross girders of the bridge resting upon the centre of these beams, and thus obviating any strain arising from excessive rigidity of the flooring. Several of these bridges have already been erected in California and the neighbouring states, and have proved in every way successful—a result not so much to be wondered at when it is considered that Mr. Hallidie has built over six and twenty suspension bridges of various sizes, and that the system now under consideration is the result of such extended experience.

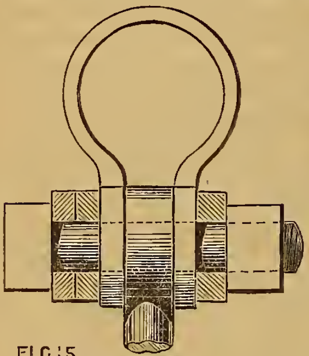


FIG:5.

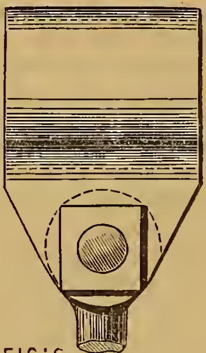


FIG:6.

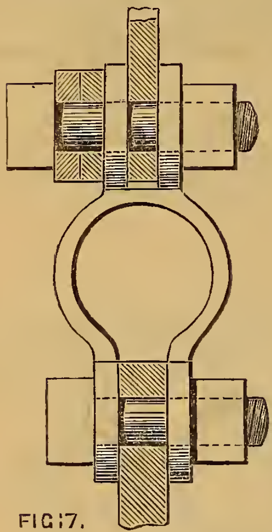


FIG:7.

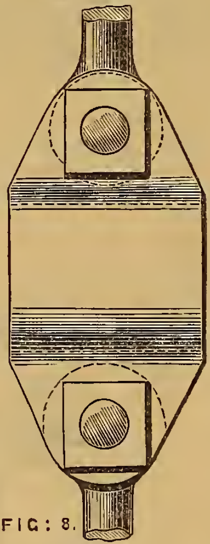


FIG: 8.

## LIQUID FUEL FOR STEAM VESSELS.

The following is the report of Dr. Paul on the results obtained at the practical trial of Mr. E. Dorsett's system of burning liquid fuel on board the screw steamer *Retriever* on a trip from Deptford to Coal House Point and back on the 23rd of October, when the quantities of oil used and of water evaporated were noted and checked by Mr. T. R. Crampton, C.E., of Great George-street, Westminster, Mr. Alexander Wylie, late of the Royal Mail Company's Service, and Mr. H. Anderson, of Messrs. John Penn and Son. These gentlemen, without following Dr. Paul through the chemical reasoning worked out in his report, have certified that the facts of consumption and evaporation on which his report is based are correct, and those which actually were observed by them on the occasion referred to.

### Report.

*Practical Trial of Liquid Fuel on Board the Retriever, October 23, 1868.*

Material used. Dead oil, weighing 10·5lb. per gallon.

Method of using the oil. Burning the vapour under pressure according to Mr. Dorsett's patent.

On starting, at 12·25 p.m., the level of the oil in the vapour generators was observed and noted, and, in order to estimate the quantity of oil consumed during the trip, the four cylindrical tanks containing the supply of oil were gauged, and their contents ascertained to be as follows:—

Internal diameter of drum tanks ... 30in.
Capacity at 1in. depth ... ... ... 2·55 gallons.

| | in. |
|---|---|
| Tank No. 1 contained at starting oil to the depth of | 22·25 |
| „ 2 „ „ „ | 36·50 |
| „ 3 „ „ „ | 38·50 |
| „ 4 „ „ „ | 37·50 |
| Total depth of oil in the four tanks ... | 134·75 |

The vessel ran down below Gravesend, and then returned to Deptford. On stopping there, at 5 p.m., the oil in the vapour generators was brought to the same level as on starting, and on measuring the oil remaining in the tanks they were found to contain as follows:—

| Tank | No. 1. | No. 2. | No. 3. | No. 4. | Total contents. |
|---|---|---|---|---|---|
| Depth of oil ... | 36·0 ... | 3 ... | 3 ... | 2·5 ... | 44·5in. |

Therefore, the quantity of oil which had been consumed during the 4 hours 35 minutes was 134·75—44·5 × 2·55=233·1375 gallons, and, as the oil weighed 10·5lb. per gallon, the weight of oil consumed was 2416·44375lb., or 1·078 ton during the 4 hours 35 minutes, the average rate of consumption being 527·6071b. (=50·25 gallons) per hour, or 8·7934lb. per minute.

In order to estimate the evaporative duty obtained with the oil, the capacity of a portion of the boiler corresponding to two points on the gauge glass had been previously ascertained and found to be 450 gallons, and when the water level in the boiler was at the higher one of these points, the feed-water and blow-off cocks were closed, and the time observed, which elapsed before the water-level was reduced to the lower point, the engines being kept going meanwhile. The evaporation of this 450 gallons of water occupied 36 minutes, and, according to the foregoing determination of the average rate of consumption, viz., 8·7934lb. per minute, the quantity of oil consumed during the 36 minutes was 316·5624lb. The pressure on the boiler was, on the average 15lb., corresponding to a temperature of 252° Fahr., and the rate of evaporation under these conditions amounted to—

$$\frac{4500\text{lb.}}{316\cdot5624}=14\cdot215\text{lb. per lb. of oil consumed.}$$

Reducing this observed evaporation to the equivalent evaporation at 212° Fahr., the result becomes 14·428lb. per lb. of oil consumed, which is equivalent to an evaporative duty of 12·356lb. of water heated from 60° Fahr., and converted into steam at 212 Fahr.

During the trial very little smoke was produced, and during great part of the time none at all. The temperature of the furnace gas passing into the funnel ranged from 250° to 350° C. (=482° to 662° Fahr.), or, on the average, about 572° Fahr., and, as the external atmospheric temperature was about 50° Fahr., the waste of heat in the discharge gases corresponded to an increase of temperature to 522° Fahr. above that of the air consumed in feeding the furnaces.

For the purpose of arriving at some approximate estimate of the extent to which the result obtained in this practical trial corresponds with the actual evaporative power of the material used, it seemed to me desirable to calculate theoretically the amount of heat it is capable of generating, and the maximum effect to be expected from its application under the ordinary conditions obtaining in practice, upon the same principle which I have already applied in the case of petroleum and shale oil. So far as the chemical nature of dead oil is known, it is a mixture of several substances—such as phenol and cressol, which contain, besides carbon and hydrogen, some oxygen, together with a variety of hydrocarbons, such as napthaline, xylol, cumol, cymol, and perhaps others. According to the chemical composition of these substances, and on the assumption that the combustible carbon and hydrogen they contain will generate, when burnt with just sufficient air for perfect combustion, quantities of heat sufficient for converting respectively 11·359lb. and 41·895lb. of water at 60° into steam at 212° Fahr. for each pound of carbon or hydrogen burnt, when allowance is made for the heat rendered latent by the vaporisation of the water resulting from the combustion of the hydrogen, and for the waste of heat due to the furnace gas being discharged at a temperature of 600° Fahr. above that of the air supplied to the furnace for combustion, the theoretical evaporative powers of these substances and the evaporative duty they are capable of effecting will be as follows for 1lb. weight of each :—

| | Evaporative power, lb. of water at 212° Fahr. | Evaporative duty, lb. of water at 60° Fahr. |
|---|---|---|
| Phenol | 12·2437 | 10·5025 |
| Cressol | 13·0096 | 11·1632 |
| Naphthaline | 15·4635 | 13·2675 |
| Xylol | 16·5866 | 14·2415 |
| Cumol | 16·7838 | 14·4126 |
| Cymol | 16·9422 | 14·5500 |

It is possible that dead oil may contain other substances richer in hydrogen than any of the above, and in that case the oil would have a proportionately greater evaporative power; but having regard only to those constituents of dead oil which are known, it will be seen that their evaporative power varies from 12·24 to 16·94, and that when burned under the conditions above mentioned the evaporative duty of which they are capable varies from 10·5 to 14·5 per lb. of each substance, the average evaporative duty being equal to 13·023lb. of water heated from 60° Fahr., and converted into steam at 212° Fahr.; consequently the evaporative duty of dead oil will vary about this amount, according to the relative proportions of these substances, which it may happen to contain.

The result thus arrived at on theoretical grounds presents a very striking approximation to that obtained on the practical trial on board the *Retriever* on the 23rd inst., viz., 12·356lb. for the evaporative duty which is only ·667 less than the maximum duty indicated by calculation. If it be correct to regard the composition of dead oil as represented above, this approximation between theoretical and practical results would indicate that the application of liquid fuel, according to Messrs. Dorsett and Blythe's system, insures not only a very perfect combustion of the oil, but also a very full utilisation of the heat generated. The very small amount of smoke produced during the trial would involve some waste of heat, and would to some extent account for the difference between the two results; but it must be remembered that in the trial the average temperature of the furnace gas discharged into the funnel was only 572° Fahr., or 522° Fahr. above that of the air supply, while in the calculated result it is taken as being 600° Fahr. above the air supply, so that in the practical trial there was a more efficient and economical application of the heat generated than has been assumed in the calculation. A still further economy of the heat generated might be effected by heating the air supplied to the furnaces by the waste heat passing away into the funnel, and it is probable that in this way the combustion might be regulated and rendered so perfect that there would not be any waste of heat arising from smoke. These considerations lead to and justify the presumption that when the various appliances for burning liquid fuel according to this system shall have been more thoroughly perfected and adapted to the conditions and requirements of steam navigation an evaporative duty of 13lb. per lb. of oil burnt may be realized.

But, having regard only to the result actually obtained at present, it will be seen that the evaporative duty realized in this trial is about 100 per cent. greater than that ordinarily obtained with an equal weight of coal in steam vessels—that is to say, a duty of about 7lb. per lb. of coal consumed. Therefore the weight of oil required to fuel a vessel would be only one-half that required of coal, or the weight of fuel to be carried would be only half as much as when coal is used. Then, taking the ton of coal as stowed on board a vessel to occupy 43 cubic feet and the ton of oil as occupying 34 cubic feet, the quantity of oil equivalent to one ton of coal would occupy only 17 cubic feet, so that the saving in stowage space would amount to 60·4 per cent. of the space required for coal. (Signed) Benj. H. Paul.

8, Gray's-inn-square, October 26, 1868.

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## ON THE APPLICATION OF CHLORINE GAS TO THE TOUGHENING AND REFINING OF GOLD.

By F. B. Miller, F.C.S., Assayer in the Sydney branch of the Royal Mint.

The methods now in use for effecting the above purposes are all more or less unsatisfactory, and the author has therefore devised a process which appears to satisfy all the requirements of the case in a single operation.

A French clay crucible is saturated with borax by immersing it in a hot saturated solution, and drying. The gold is then melted in this crucible with a little borax, and a stream of chlorine gas is allowed to pass through it by means of a clay tube (a tobacco-pipe stem was found suitable). The chlorine generator is fitted with a safety tube 7ft. long, and is connected with the clay tube by a caoutchouc tube. In a few hours the whole of the silver is converted into chloride, which floats on the gold. The borax prevents the absorption of the chloride by the crucible, and also its volatilisation, except in very minute quantities. As soon as the gold has become solid, the still liquid chloride of silver is poured off, and the gold is now found to have a fineness of say 993 parts in 1,000. The apparent loss of gold is very little greater than is found in ordinary gold melting—being 2·9 parts in 10,000—whereas in the ordinary process it is 2. A small sample of the gold is removed, from time to time during the operation by means of a piece of tobacco-pipe used as a pipette. This is rapidly assayed approximately, and thus the progress of the operation is judged of.

The fused chloride of silver obtained as a slab after the operation, is reduced by placing it between two plates of wrought iron in a bath of dilute sulphuric acid. The spongy silver so obtained contains gold, which may be separated by nitric acid. The nitrate of silver can of course be precipitated as chloride, and subsequently reduced. The gold appears to be present in the chloride of silver in the form of a double chloride, and the author has succeeded in separating it directly from this combination by precipitation by metallic silver.

The chairman, in proposing a vote of thanks to the author, remarked upon the great importance of the new process. Much of the gold imported into this country contained 60 or 70 ounces of silver in 1,000, which could not at the present time be profitably extracted. The new method would probably be soon adopted by English assayers.

Mr. Forbes had listened to the reading of the paper with great pleasure. It had hitherto been supposed that the volatility of chloride of silver was too great to allow of such a method of separation being adopted, but the author's experiments seemed to leave no doubt that borax would prevent the volatilisation.

Professor Foster remarked that the action of borax in this case probably consisted in its shutting out the atmosphere. The chloride of silver could not evaporate without an atmosphere into which it could diffuse itself. Dr. Matthiessen, in some of his experiments, made use of fused paraffin for the same purpose—viz., to avoid evaporation.

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## ON A MODE OF EXTRACTING THE METALS MOLYBDENUM AND CHROMIUM.

By J. Eneu Loughlin, M.D.

Molybdenum was first prepared by Hjelm in the year 1782. His method consisted in heating the trioxide of molybdenum in a porcelain crucible for two or three hours. Several other methods have since been used, prominent among them being that of heating the acid molybdate of potassium; also the reduction of molybdate of ammonium by heat, or the reduction of trioxide of molybdenum by carbonate of soda. Molybdenum is described as a silver-white metal, not altered by contact with air at ordinary temperature. Sp. gr. 8·5; not attacked by chlorhydric acid or dilute sulphuric acid. Strong sulphuric and nitric acids, on the contrary, act very powerfully upon it with evolution of sulphurous acid and hyponitric acid. Having had occasion during June, 1867, to use some molybdenum, I tried the methods above stated; they were all very satisfactory as regards the yield of pure metal, but the time was rather long. I then had recourse to the reducing action of cyanide of potassium. Molybdic acid was prepared and tested according to Fresenius, the result being satisfactory as regarded the purity of the molybdic acid, 10 grains of molybdic acid thus prepared were mixed with 15 grains of cyanide of potassium placed in a porcelain crucible, which porcelain crucible with the lid luted was placed in another crucible, then surrounded by powdered animal charcoal and exposed to a white heat for twelve minutes. At that time the crucibles were removed, allowed to cool, and examined; the porcelain crucible was found lined with a brilliant silver-white metal of a sp. gr. 8·56, which was not attacked by chlorhydric acid, but violently attacked by nitric acid with evolution of hyponitric acid fumes; it reduced oxide of mercury and oxide of silver when triturated with these substances. An analysis of this showed it to consist of—

| | |
|---|---|
| Molybdenum | 98·7 |
| Impurities, $SiO_2$, C | 1·3 |
| | 100·0 |

By the same process, using sesqui-oxide of chromium in place of molybdic acid, chromium was obtained, possessing a sp. gr. 6·2. The best results were procured by using a reducing mixture of cyanide of potassium and animal charcoal.—*American Journal of Science.*

## IMPROVED WOOD SCREW AND DRIVER.

The following description of a new screw-driver which, like so many other ingenious "notions," comes to us from the United States, is extracted from the *Scientific American*:—

The slotted head of the common wood screw is frequently split when much force is required to seat it or to remove it, and every mechanic has been annoyed by the slipping off of the screw-driver blade from the head of the screw. To provide a remedy for these objections is the object of the inventor of the screw and driver shown in the accompanying engravings. The screw head has three V-shaped notches cut equidistant in the edge, instead of the single cross slot. The screw-driver, seen in perspective in Fig. 1, has three corresponding jaws which by a simple arrangement automatically open and close upon the screw head.

The stock, A, is intended to fit into a bit-stock, and is hollow for the larger part of its length, and has three longitudinal slots in which slide the jaws, B, all moved simultaneously by a sliding ring, C, with which they engage. They are opened and closed by means of the incline of their forward portion sliding through corresponding apertures in the collar end of the implement, designated by D in Fig. 1.

FIG. 2.

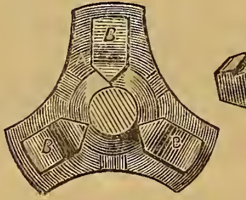
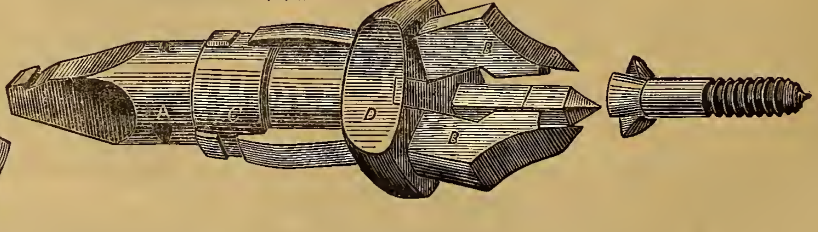


FIG. 1.



When held in an upright position, the jaws down, the combined weight of jaws and ring cause them to fall, and the points of the jaws open sufficiently to receive the head of an ordinary screw. Now if pressure is exerted the stock is forced down and the jaws compressed, griping the screw-head with an energy proportioned to the force exerted; the harder the pressure the greater the tenacity of the grip. The edges of the jaw points, when they are seated on the screw-head, project sufficiently to cut a countersink to seat the head, preventing the necessity of using a separate tool for this purpose. In fact, unless in very hard wood, there will be no necessity of previously boring a hole to receive the screw. In removing a screw this driver is equally effective. One advantage of this device may not be apparent at first sight; that is the absolute connection between the screw and driver which will enable the workman to drive the screw into wood at any angle, perfectly governing its direction. The increased strength of the screw-head from this style of construction, the certainty of grip on the screw, and the entire control over the course of the screw appear to us to highly recommend this invention.

## ROYAL GEOGRAPHICAL SOCIETY.

The President opened the session 1868-9 with a few remarks on events of geographical interest which had occurred since the last meeting in June. He expressed his deep regret at the destruction of the wings and arcades of Burlington House, by which the society had lost the capacious hall for its meetings, so long granted by the Royal Society and the University of London. During the summer researches had been carried on in deep-sea soundings in the Atlantic, and into the nature of the sea-bottom, currents, and submarine life; some of the results of which would be communicated to the Royal Society by Dr. Carpenter. Dr. Livingstone had been heard of down to December 14th, 1867. He was then in Cazembe, but in two days would depart for Ujiji, on the eastern shores of Lake Tanganyika, whither stores and a fresh supply of medicines had been sent from Zanzibar to meet him. He had found at the southern end of the lake a string of smaller lakes, connected by a river, bearing different names. Next in interest to this subject, were recent journeys in Central Asia, especially in the vast elevated tract lying beyond the north-western bend of the River Indus. Here lay the Pamir Steppe, or as it was called, "The Roof of the World," in which the Oxus, the Zarafshan, and other rivers took their rise; and near which the Kuen-lun, the Himalaya, and the Hindoo Koosh radiated. The President remarked on the desirability of friendly co-operation between our own and the Russian governments in exploring the geography and trade-routes between the populous cities of Kashgar and Yarkand and the Russian and Indian territories. Papers were expected to be read during the session, on Western Abyssinia, by Dr. H. Blanc; and on Manchuria, by Mr. Alexander Williamson. A new problem awaited solution by explorers in the part of Central Africa to the west of Albert Nyanza, where a large river flowing west had been discovered by the agents of Messrs. Poncet, traders on the White Nile; and another immense lake had been heard of by Carlo Piaggia, an Italian traveller, formerly in the employ of a skilful geographer, the Marquis Antinori.

A paper was read by Major-General Sir H. C. Rawlinson, K.C.B., on "Trade Routes between Turkistan and India." The author stated that the great Karakorum range of the Indian Caucasus, hitherto considered an almost insurmountable obstacle to traffic between the populous region of Central Asia and India, had been recently shown to be transitable, even by laden camels. The route on leaving Leh, in Little Thibet, instead of ascending the Karakorum Pass, lay by the western end of Lake Pangong, and up the Changchenmo Valley, to the Karakash River, thence following its banks past Shadula to Ilchi and Yarkand. This route has lately been described by Mr. T. Douglas Forsyth, and it had been also pointed out by Mr. Johnson, the Indian surveyor, in 1861. Mr. Johnson, when he crossed the Kuen-lun, heard of another route further to the east, by Changthang, passable to Leh by wheeled vehicles. The populations of Eastern Turkistan, having shaken off the Chinese yoke, were seeking new outlets for trade, and at present tea had to perform a journey of 5,000 miles (by Bombay, Bokhara, and Kohand) to reach them; whereas, if the new route described were opened, it would have to travel only 500. Mr. Hayward, a gentleman travelling under the auspices of the Geographical Society, had recently sent home a copy of the itinerary of a Yarkand merchant, who had traversed the route from Yarkand, over the Pamir Steppe, past the sources of the Oxus, and over the Chitrall Pass to Jellalabad to Peshawar. This was the first information we had had of this route since the journey of Benedict Goez in the sixteenth century whose account could be turned to little use, even by the learned Colonel Yule in his "Cathay, and the Way Thither," but was now rendered quite intelligible. It was the route alluded by Ptolemy, quoting from Marinus of Tyre, and described by Marco Polo. Two lower passes lay between Yarkand and the Pamir Steppe; and the third, or highest pass (Chitral), was passable by carts during nine months in the year. The author, when at Jellalabad twenty-six years ago, had ascended for a short distance the Chitral Valley, which opens towards the Cabul River, and it was there termed the "Gate of Turkistan," as indeed it now proved.

The following gentlemen were elected Fellows of the Society:—Daniel Griffin, Alexis de Lomonossof; Dr. H. E. Mackay, R.N.; and Lionel Shirley, C.E.

## INSTITUTION OF MECHANICAL ENGINEERS.

The general meeting of the members of this Institution was held on Thursday, the 5th ult., in the Lecture Theatre of the Midland Institute, Birmingham, Frederick J. Bramwell, Esq., Vice-president, in the chair.

The secretary, Mr. W. P. Marshall, having read the minutes of the previous meeting, several new members were elected, and the officers of the institution were nominated by the meeting for the next annual election.

The first paper read was "On the further Utilisation of Waste Gas from Blast Furnaces, and the Economy of Coke due to increased capacity of Furnace," by Mr. Charles Cochrane, of Dudley. With the increased capacity of the present large blast furnaces in the Cleveland district, the waste gas given off from the furnace is so far impoverished, both in quantity and quality, that, in order to maintain an uniform supply of gas for heating purposes at the steam boilers and hot blast stoves, it is of importance to utilise the whole of the gas given off from the furnace, by preventing the loss of gas hitherto occurring at the times of lowering the closing cone or bell for charging the materials at the top of the furnace. Although the time during which the gas can thus escape through the open mouth of the furnace is not long at each lowering of the bell, the entire loss of gas amounts to fully 6 per cent. of the total quantity of gas evolved from the furnace; and the escape of gas at the furnace mouth occasions an interruption in the supply for heating purposes, and a liability to explosion on restoring the supply of gas at the boilers and stoves. These objections have been obviated by the writer by a plan of doubly closing the furnace top, the ordinary closing bell and hopper being completely closed in by the addition of an outer cover, containing flap doors, through which the charging materials are filled into the hopper. These doors are closed at the time of lowering the bell for dropping the charge into the furnace, so that the only escape of gas that can take place is a quantity equal to the capacity of the hopper at each time of lowering the bell, which is insignificant in amount. This plan of closing the furnace top has now been in successful operation for nine months at the Ormesby Ironworks, Middlesborough, and continues to work most satisfactory. The economy of coke due to increased capacity of furnace is shown by the working of one of the original furnaces at the above works, having an internal capacity of only about 7,000 cubic feet, as compared with that of the larger furnaces at the same works, having a capacity of about 20,000 cubic feet. The average consumption of coke per ton of iron made is 26½ cwt. in the larger furnace, being fourteen per cent. less than in the small furnace, and at the same time the waste gas from the larger furnace is evolved at a temperature of only about 560 degrees Fahrenheit, or 110 degrees below that at which it leaves the smaller furnace, on account of the heat of the gas being taken up to a greater extent by the materials in the top of the larger and higher furnace. The causes were explained that account for the economy of fuel in the large furnace; and assuming that, by further enlarging the capacity of the blast furnace, the further reduction of temperature effected in the gas taken off would be in the same proportion as the reduction already obtained with the present increased size of furnace, it was shown by calculation that the extreme theoretical limit of economy, when the escaping gas would be reduced to the temperature of the external atmosphere, would be reached by increasing the capacity of the furnace to about three times that of the present large furnaces in the Cleveland districts, provided that no practical difficulties interfered.

The next paper was "On an improved Friction Coupling and Break, and its application to Hoists, Windlasses, and Shafting, &c., by Mr. Thomas A. Weston, of Birmingham. This friction coupling and break is composed of alternate discs of iron and wood, threaded upon a shaft, and pressed together laterally with sufficient force to produce the requisite amount of friction between their contiguous flat faces. The iron discs slide longitudinally upon a feather on the shaft, so as to revolve with the shaft; and the wood discs are not connected to the shaft, but are held at their outer edges within an external casing or drum, so as to revolve with the drum, while capable of sliding longitudinally within it. By this arrangement, when the entire series of discs are compressed together longitudinally, the friction produced between the contiguous faces of any one pair of discs is multiplied by the total number of discs; and thus, by increasing the number of discs employed, any desired increase may be obtained in the extent of frictional area, without any reduction in the pressure per square inch upon the rubbing surfaces. In applying the series of discs to the purpose of friction couplings for shafting, they are compressed together by set screws or other means, with a permanent pressure adjusted to give the exact amount of adhesion required for transmitting the limit of driving power desired; and for the purposes of friction breaks, the compression of the disc is effected by a hand lever, so as to apply the power of the break to the extent required at any moment. In either case the amount of frictional adhesion can be increased to any required extent by employing a sufficient number of discs, so as to avoid subjecting them to a degree of pressure enough to occasion wear of the rubbing faces. The applications of this friction coupling and break to hoists, windlasses, and shafting, are very numerous and varied, extending up to large ship's windlasses, holding safely under a strain of more than thirty tons on a ship's cable; and descriptions were given of several of the principal applications, illustrated by working models and specimens. In the case of light hoists, for raising sacks, &c., the drum containing the wood discs forms the chain barrel, and runs loose upon the main shaft carrying the iron discs, which is prevented from turning backwards by a ratchet-wheel and pawl. A hand rope wheel with screwed boss fits upon a screwed portion of the shaft at the outer end of the series of friction discs; and on turning this wheel in the direction for raising the load, it traverses endways along the screwed shaft until it has compressed the discs together with force enough to give sufficient frictional adhesion for raising the load. On turning the hand wheel backwards, the unscrewing of the wheel on the shaft releases the discs from pressure; and the load then runs down freely, until stopped by applying the pressure again upon the discs through the hand-wheel. Another form of hoists is also constructed, in which the load is prevented from running down freely and can be lowered only by continuing the process of turning the hand wheel backwards. In this case both the chain barrel and the hand wheel run loose upon the main shaft, which is prevented by a ratchet-wheel from turning backwards; and the contiguous faces of the chain barrel and hand wheel engage with each other by a spiral clutch, consisting of a single turn of a very slow spiral. The outer face of the hand wheel is a plain disc, of larger diameter than the chain barrel, rubbing against an equal disc on the ratchet wheel keyed upon the main shaft; and the outer face of the chain barrel is also a similar plain disc, rubbing against another disc secured upon the main shaft. On turning the hand wheel forwards, for raising the load, the inclined surface of the spiral between the hand wheel and chain barrel tends to separate them endways, and thus produces an end pressure, tightening together the external plain discs with the pressure required to produce friction enough for raising the load. For lowering the load the hand wheel, being turned backwards, withdraws one incline from the other in the spiral clutch, and thereby releases the friction discs from pressure, so that the load can descend; but the descent of the load can only take place so long as this withdrawal of the inclines is continued by the hand wheel continuing to be turned backwards, allowing the chain barrel to follow; and the moment the hand wheel is stopped the inclines become tightened again upon each other by the load acting on the chain barrel, which is thus jammed endways between the friction discs, preventing the load from running down further. This arrangement accordingly provides the means of lowering the load with perfect safety, avoiding the risk of injurious jerks on the chain.

The last paper was "On the Moulding of Toothed Wheels, and an improved Wheel Moulding Machine," by Mr. George L. Scott, of Manchester. The object of the machine is to afford the means of obtaining strictly accurate castings by machine mouldings, with a portable and self-contained machine of small cost, capable of being readily and quickly applied at any part of a foundry. The whole machine is carried upon a centre pillar, which fits into a socket into a cast iron pedestal, sunk in the floor of the foundry below the depth required for moulding, and fixed truly vertical; several of these pedestals are placed in convenient situations in the foundry floor, so that the moulding machine can be employed successively upon the moulding of different wheels. The centre pillar of the machine carries a horizontal arm, capable of adjustment radially to suit the diameter of the wheel to be moulded; and the extremity of the arm carries a vertical slide, on the bottom of which is fixed the pattern for moulding the teeth of the wheel. This pattern consists of two teeth only, for moulding one space only at a time, whereby absolute equality is ensured in the size and shape of all the teeth in the wheel. After moulding each tooth, the pattern is drawn from the sand with perfect steadiness by the vertical slide of the machine; and by means of a set of change wheels and a worm wheel keyed upon the centre pillar, the radial arm is turned round through a space equal to the pitch of the teeth, and the pattern is then lowered again for moulding the next tooth of the wheel. On the completion of the whole of teeth, the moulding machine is lifted off the pedestal by the foundry crane, the cores for the arms are put in their places, and the top box put on, ready for casting; the flat surfaces of the top and bottom boxes having been already prepared, before the moulding of the teeth was begun, by means of strickle boards of the required shape, working round a centre pin fixed in the same pedestal which afterwards carries the centre pillar of the moulding machine, so as to ensure strict accuracy for the whole of the work. The important practical advantage is afforded by machine moulding of greater accuracy than can be attained by patterns, together with an unlimited variety of dimensions, pitch, and forms of teeth, so as to meet exactly the requirements of any case that may occur, without being restricted to some existing range of patterns, and without incurring the cost and delay attending the preparation of a new complete pattern. A specimen of the moulding machine was exhibited and shown in operation, together with samples of spur and bevel wheels moulded by it.

The meeting then terminated.

## CIVIL AND MECHANICAL ENGINEERS' SOCIETY.

### ABSTRACT OF ADDRESS,

By B. Haughton, President.

We regret, that owing to the length of the President's most interesting address, we are unable to insert it *in extenso*. We have endeavoured, however, to give those portions which are of most general interest:—

The discussions of the society during the past year, I am pleased to say, have been conducted with vigour and temperately.

The last was, perhaps, the very best of the season, prompted by joint papers on Engineering Architecture, by two of our oldest and most valued members. The meeting discussed the question with a spirit worthy of the combatants in the battle of the styles, even the visitors warmly assisting. This is a subject on which there is a great deal more to be said, and we will look forward to further consideration of it. It is one which the society would do well to keep continually before it, because it is a line in which we can see our way, and in which everyone admits there is room for improvement; it is, indeed, humiliating to think of the vast sums that have been spent in England on grand engineering works, with an utter disregard of appearances, and where a modicum of æsthetic skill would have given us so much effect and beauty. It will be said that utility and not beauty should be the cry of the engineer; but this is after all only the twaddle of incompetency, for it is well known to those who have given attention to art, that it costs no more to arrange materials in effective and pleasing forms, than to pile them in the shapeless masses that attract the eye.

We must at once dismiss the assertion that beauty is costly; it is not meretricious ornament that is advocated, such as may be seen in at least one of the latest engineering works, and which is a reactionary effort, worthy of praise, as showing a step in the right direction, but still unworthy as having overshot the mark, and having given us, as it were "a jewel of gold in a swine's snout." I allude to the Abbey Mills Sewage Station, the design for which is the more remarkable, seeing that it has come from the hand of the engineer who has shown so much artistic excellence in the severe lines in which the Thames Embankment is conceived.

What I ask you to aspire after in those engineering works upon which you are, and shall be in the future engaged, is *form* in the æsthetic sense, in place of that *deformity* which is sown broadcast around us, in which the British engineer has hitherto glorified himself, and in which he would seem to wish to idealize and deify sheer *strength*, which in his simplicity he sees to be incompatible with beauty of outline. How, then, is this *desideratum* to be attained? The British engineer in his efforts to redeem engineering architecture must look to himself and to himself alone, and the present recess is perhaps an opportunity given him for this very purpose, and to enable him to direct his mind to a subject which demands his closest attention. He will again, notwithstanding our prophets of evil, be called upon to construct works on English soil equal to, if not surpassing in magnitude, those of to-day. Let him endeavour in them to improve on those of a bygone generation, and to hand down to posterity a legacy of beauty in connection with such works, as he has received from the past its legacy of strength and endurance.

Let him above all things refuse to entertain the thought that veneration for the beautiful is beneath him as a man, or derogatory to the dignity and character of his race; for during all time those races which made themselves famous for their prowess and their majesty, their power alike over matter and mind, were equally renowned for the beauty and for the magnificence of their public works—those monuments of glory by which, history apart, we can now alone judge of their aristocracy of race. If Egypt has had her Pharoahs of the camp and the battle-field, she has had the Pharoahs of the Pyramids, of Thebes, and Phyle; if Greece has given to the world an Epaminondas and an Alexander, who has left his traces visible to this day upon the banks of the Sutlej, the Dhelum, and the Indus, she has also given it a Phidias, an Apelles, and a Praxiteles, who live at this moment in the columns, entablatures, and friezes of the Acropolis, in the inimitable statue of the Venus, and in the thousands of miracles of art which have made their countrymen, as a race, unique upon earth; if Rome has had her Romulus, her Pompey, and her conquering Julius, who has left his stamp upon these banks of Thames, she also had her Augustus and her engineers and architects by the score, beneath the walls of whose grand buildings the Englishman loves to wander during the period of his own dark winter; and if Carthage has had her Hannibal, she was also one of the most exquisite of cities. These facts should at once disabuse us of any idea that being possessed of an eye to admire, a head to conceive, and a hand to construct what is beautiful, is incompatible with those qualities of *physique* and of *morale*, and of general manhood, on which we as a nation rely and pride ourselves; on the contrary, history tells us that the very highest types of the human race are those in which all these qualities have been combined, and, further, that wanting in any of them, we cannot claim to rank as equals, but only as degenerate and effete imitators of the mastering races named, sent into the world by the King of Kings and great Engineer of Engineers for the guidance and instruction of the 1,200,000,000 of his creatures who incessantly inhabit it, and whose instruction and example they stupidly reject and ignore.

Let us then look for better days for engineering art, and if we shall succeed in our aspirations and efforts to restore and to perfect it, when the time comes that we are to be conquered as a people—it may be by the Cossack, it may be by the western Vandal—as conquered we shall be, if history is to repeat itself, we shall have that glorious consolation, which Horace describes as having remained to Greece after her conquest by Rome—"Captive Greece took captive her fierce conqueror and introduced her arts amongst the rude Latins. Thus, their rough Saturnian manners became polished, and delicacy expelled rank virulence; though for a long time remained, and this day remain, the traces of rusticity."

But while there is so much with which to find fault in our engineering architecture, it will be asked—are there no examples which may be held up as such and which are worthy of praise?

Happily there are works of this class to be found in England; few they are in number, and standing on the very summit of the pinnacle of excellence; wonders of beauty as well as of the constructive art, in which their authors seem to have risen with the occasion and exceeded themselves and all their previous efforts. I shall mention their names with reverence. Those of Telford, Stephenson, and Brunel, whose powers have culminated in the production of the Menai, Britannia, and Saltash Bridges, works unequalled and unapproached upon earth. The Britannia Bridge, viewed in its fore-shortened aspect from the approach by the mainland, in which its sentinel lions *couchants* appear in the foreground, its five towers, connected by their iron beams, receding towards distant Anglesea, can only be said to be æsthetically perfect; while for Saltash to which we must give the palm, if it were practicable or at all admissible to make a comparison, viewed from the gorge below seems rather to be of Divine than of human origin. Its famous history adds to it a halo wanting in its exquisite compeers; while its two grand segments, braced by their pendant chains and carrying the girders of the railway suspended, delineate upon the sky a mathematical figure, in which he who runs may read the directions of the giant forces whose restrained energies are here exercised for the benefit of mankind in general, if for the glorification also of their great manipulator.

The one bridge expresses the majesty of the bull, in which there is evidently an excess of material, in proportion to the requirements of the situation; the other conveys the idea of having cost a greater intellectual effort—in it every ounce of material does its work, and, moreover, all the work that is in it. This is the one and final commercial test of the value of a work of engineering art; in an engineering point of view, æsthetically, its graceful proportions and delicate tracery are unquestioned; both senses are then here gratified. The result is unique.

A fourth colossal railway bridge will shortly be added to this splendid category built from the designs of the talented Engineer of the London and North Western Railway, and which will doubtless, when unveiled, satisfy the most exacting desires of the Engineer critic. It crosses the River Mersey at Runcorn, its object being to shorten considerably the distance between Liverpool and London. It will consist of three bays, of 300ft. each, crossed by open lattice girders; the piers and abutments are capped by Gothic crenellated and machicolated towers, the whole structure flanked by lofty and long brick viaducts. This bridge, lying, as it will, in one of the great trunk lines of railway communication, will command a large share of public attention. The other great works named, placed as they are in remote corners of the Island, two of them devoted to the special interests of the Irishman, the third to those of the man of Devon, are hardly known to the general public save through the medium of prints and photographs.

Since I had the honour to address you last year, two sections of the Thames Embankment have been opened for foot passengers. On that occasion I ventured to assert that the public were scarcely aware of the great boon they were about to receive in this addition to the many streets of London; the result has been all that could have been anticipated for it. This exquisite Boulevard affords the finest *coup d'œil* in the City, and exposes the river, hitherto a *mare clausum* to the ravished eyes of the Londoner; during those days when the customary canopy of London fog condescends to rise we really can get a view of this great City, for so much of which, owing to the contracted nature of the streets, we have hitherto been obliged to trust to our imaginations.

The very favourable building sites to be had here will be rapidly appropriated. The idea then recorded touching the absurdity of placing a magnificent Palace, such as the Law Courts will be, in one of the worst slums of the City, when such a magnificent site awaited it on the Causeway, has rapidly advanced in strength. The question has been warmly debated in the House of Commons, and has found supporters amongst all of those who are distinguished by their care for the improvement of London and the opening up of its resources.

It is to be hoped that artistic feeling will, in this case, gain the victory over prejudice of the antique British type, and that in the face of those changes for the better, which are taking place all around us, especially in the adjacent City of Paris, where reigns a modern Augustus, we shall not be found behind, but shall rather rise equal to the occasion and make use of the opportunities which offer. Within the short space of one year these matters have come under discussion, and the space between the Temple and Somerset House will most probably be that selected for the Law Courts. For such a purpose a finer situation is not conceivable, and if the stream of Classic Thames will contribute its assistance towards the embellishment of the place, on the other hand, the expenditure of £2,000,000 sterling upon his left bank as described, will add a lustre to its sparkling waters. The whole community will be the better for this exchange of courtesies. But our fluvial renovations and decorations are not to terminate here; for it is very probable that that scheme, called *the Concentration of the Public Offices*, will find its local habitation in the rectangle lying between Montague House and Bridge-street, Westminster, this is Sir Charles Trevelyan's plan, thus acquiring a street frontage on three sides, and a river frontage upon the fourth. Mr. Gilbert Scott favours this idea, which ought to become chrysalized ultimately. *malgré* a majority of one of the Treasury Committee, that has declared in favour of the plan of the Chief Commissioner of Works; the main features of which are to extend the Admiralty into Spring Gardens, and to place the War Office by the side of the Horse Guards, on the ground now occupied by the Treasury, Board of India, and Privy Council. These offices are to be removed, and to form part of a block of buildings which are to extend from the present India and Foreign Offices into Great George-street Westminster.

Sir Charles Trevelyan would place the Admiralty, Horse Guards, and War Office, in conjunction and under the same roof, between Parliament-street and the River, on the rectangle before alluded to, and would arrange all the other offices in two great blocks on the opposite side of Parliament-street, terminating on the south by Great George-street.

He proposes to open a fine street by the Banqueting Hall to the embankment, and to extend the Mall, at the rear of Carlton Terrace, into Cockspur-street. The difference of cost between the two plans will be not worth naming; strategically, as it unquestionably does, from the artistic point of view, the latter plan, it is thought by Mr. W. H. Gregory, M.P., would be preferable to that of the Chief Commissioner of Works, as affording at once the most complete protection to both the Houses of Parliament and the Royal Palaces in the case of popular tumult.

Of works of importance at home, there remains to be noticed the opening of the Metropolitan Extension between Paddington and Brompton—a segment of the inner circle; a second of which all but finished, and will shortly be opened, is that lying between the last named place at Gloucester-road Station and Westminster. The completion of this last portion will give us as near as may be three quadrants of the inner circle. The fourth is still *in nubibus*.

Lastly amongst railway works completed is the Midland Railway Extension, Bedford to London, terminating here in a station such as belongs to no other railway in the world. For amplitude of dimension and general magnificence it has not been approached; and it may be said never will be. The shareholders having been called on for an honorarium of £5,000,000, a few months ago, to complete this branch of their railway with its four pairs of rails, reeled under the demand, and the shares fell to 104. Having recovered their senses, however, their faith in their property and directory revived, and the shares now stand at 112.

This station is the work of Mr. W. H. Barlow.

It differs from the rest of the Metropolitan Stations of the new type, in its slightly pointed roof, and in the fact that its principals spring right up from the side platforms, and further, that they are genuine ribs standing without the aid of tie rods and king posts. Its wind ties are plainly visible, giving a diapered appearance to the soffit; its purlins are very remarkable, from their numbers and continuity. The general effect observed from beneath a haunch of one of these immense principals, taking care to carry it in the eye from springing to summit, is sublime, from its immense reach and graceful proportions; but it must be said that when gazing upwards into the high skylight it looks cagey; and, preposterous though it be, it suggests the idea that it would make an admirable crib for the Aeronautical Society's birds to perform in. Perhaps Mr. Alport will be induced to consider an application from the Society having this object. The screens at the ends are heavy, and one wishes for a touch from Brunel's magic hands to give them a finish, as he has done for the similar screens at Paddington—the exquisite arabesques of which are a study worthy of commemoration. The glass on top is arranged on the ridge and furrow system, which gives facility in throwing off the rain water; while it adds to the external effect. The platforms and docks are as spacious as 210ft of span can make them.

The Station is approached from Euston-road by a gentle incline; the entrance verandah is, doubtless, a temporary structure.

The ventilating apertures of the roof are placed at some distance below the ridge, in a row on each side, where glass and slates meet; the result of which will be that the smoke and steam of the engines will collect in the zone above the chord line connecting the two rows, if not dissipated before arriving at this upper region.

I shall not pretend to describe its imposing aspect when its huge gable first greets the eye from the Euston-road approach.

It is a splendid monument of the genius of its illustrious engineer, and of the patient skilled labour of the British workman. The enterprising company who have enabled them to raise it, deserve the applause of united England. It is a work of national importance; a new triumph of British mind over matter; "a thing of utility"; "a thing of beauty," and "a joy for ever."

An adjunct to the terminus must not be forgotten—viz., a curve connecting the line with the Metropolitan Railway, and running out at the south-east corner from beneath the crypt. This will enable the Midland Company to collect for its system all the traffic tending thereto from the vicinity of the metropolitan annulus.

In cataloguing the home works of the season we must not forget that most important department of such for the improvement of our harbour accommodation. Our ships increase in size and number every year, and just as our Railway Companies are almost daily called on for additional station space, so our harbour Boards are required to extend their Dock areas. In London the Millwall Docks have just been finished under Mr. Fowler's superintendence. They are of large extent, and replete with the latest inventions necessary to afford the most perfect and complete accommodation for vessels, furnished throughout with the Elswick Hydraulic Machinery for which Sir William Armstrong and Co. have become famous. A very fine specimen of the Telescope Bridge is found here, of probably 80ft. span, and which, actuated by water pressure, rises from its bearings and slides endways from off its span, when called on, with incredible facility. The docks are entered from the river by a lock of two steps or levels. The Isle of Dogs has at last found its appropriate occupation and use.

A further extension of the West India Docks is in hand, under Mr. Hawkshaw's guidance. London, it will be seen from these works, is determined not to be behind Liverpool in her dock arrangements.

Liverpool has so far gone in advance of her requirements that we do not hear of further extensions there. The Morpeth Dock has been remodelled, and within the past month the Cunard Company have taken possession of it, the *Scotia* having been safely berthed there, with five feet of water beneath her keel when passing through the entrance lock. This is the first advance made by a Liverpool Ship Company towards the Birkenhead side of the stream where a complete new dockage of 160 acres awaits occupation. In connection with the latter a grand block of corn warehouses has been erected, also a similar one on the Liverpool side, built in a massive and thoroughly engineering style of architecture. An immense expenditure has been going on here of late, under the direction of Mr. Lister, engineer, to the Mersey Docks and Harbour Board.

At Hull, Mr. Hawkshaw has got a very large wet dock in hand, separated from the river Humber by a broad wharf, having a slope on the outside pitched with square sets resting on a bed of chalk metal; it remains to be seen what will be the resisting power of this defence against a run of sea driven by a south wind and with a two mile fetch,

At Leith, a large new wet dock is being constructed, protected from the run of the Firth of Forth by a slope pitched as at Hull. A hoarding of 8ft. high of great strength, has been erected on the top of the slope, rendered necessary to protect the wharf from the extraordinary force of the sea under the influence of north and north-east winds, to which the slope is exposed.

At Dundee, notwithstanding large additions lately made, a further expenditure of £200,000 is intended on Wet Docks. The dock arrangements here are very good, and the whole town and neighbourhood wear the aspect of successful enterprise and its results. Here may be seen a fine specimen of the rectangular-hinged Caisson Dock-gate; it is manipulated with facility, and bears the nameplate of a Dundee engineer.

Hard by at Broughty may be seen a railway ferry, whereby goods trains are carried bodily across the Tay estuary. The manner of launching and receiving the trains is exceedingly simple and crafty. A similar example of this kind of ferry exists in the estuary of the Forth, between Granton and Burntisland, only as above stated for goods trains, passengers traffic is effected in both cases by means of well appointed steamboats of the ordinary class. The train boats carry about 25 trucks at each trip, and run both day and night all the year round; the operation of launching the trucks is effected in 15 minutes. The boats seem weatherly notwithstanding the great deck weights which they carry.

At Glasgow all sorts of increased accommodation are promised, which is to be expected considering the great and increasing trade of this flourishing port, celebrated for the tenacity it has exhibited in providing itself with what may be called a ship canal throughout from the sea; for its splendid water supply from Loch Katrine; for its good intentions in respect of utilization of sewage; and, above all, for the extent and extraordinary variety of its manufactures, foremost amongst which latter is that of shipbuilding, an art carried by it to an admirable perfection.

At Greenock, the Liverpool of Scotland, much has already been done, there is much doing, and much is about to be done, in all those conveniences that go to make up a safe and secure harbour. The famous competition opened by the Docks and Harbour Trust this year has made its name a household word in Westminster. It is evident they mean to go with the age and to have the most modern and very best dock system possible upon their estate lately purchased for this purpose. They have a fine future before them, and will without doubt prepare for it as becomes men in their position. Let us wish them success in arriving at a decision as to the best mode of dealing with the situation.

At Holyhead the great breakwater pier approaches completion, under Mr. Hawkshaw's auspices. It is a noble specimen of marine engineering. For solidity and perfection of workmanship it surpasses every work of the kind that I have ever seen. It is constructed chiefly of stone taken from the mountain adjacent. The upper structure of random-worked ashlar, presenting a flush face on the inside or harbour front, while on the sea face the material is quarry-faced and, as far as may be practicable, set on end, giving it the appearance of being vertically ribbed. The base of the pier consists of *pierre perdue*, having a slope, of the angle of repose of the material on the inside, while on the outside its form is that of a flat glacis, on which the sea must lash with intense fury as the stone is much pulverized by its action, especially so in the gorge caused by the re-entering angle of the work. The plan of the work is that of a continuous wall, of one and a-half miles long, *zig zag*, with two kants springing from the land at one end, and at the other resting in thirteen fathoms of water at low tide. The upper structure carries a causeway of thirty-eight feet wide, at twelve feet above which, on the sea side, there lies a banquette of fifteen feet wide, floored with tooled limestone, and surmounted by a parapet of four feet high, of the same material and class of workmanship; which latter throughout appears to be as near perfection as possible. The high level is connected with the causeway by flights of stairs at intervals. From the base of the parapet on the external face projects an echinus of two feet overhang, which, however it may add to the effect of the sectional profile, will surely meet with rough usage from the waves towards the extremity of the pier. Here green water of yards thickness comes over the parapet during a gale.

The pier head is not yet completed. It will be, in plan, of a T section, the arms of the T showing a very slight projection and rounded at the ends. The facework here will be of granite blocks, of from eight to twelve tons weight each; the hearting of red sandstone, of the same dimensions.

As this Harbour of Refuge is protected so far by only this one pier or breakwater it is exposed very much from the opposite side, so much so, indeed, as to forfeit its claim entirely to such a title, under the influence of winds from that quarter. Its defence on this side will probably be undertaken at a future period. It will be remembered that the Great Eastern narrowly escaped being wrecked here a few years ago, though anchored within the point of the pier.

The ports of South Wales have large wet dock extensions in hand at present, the exact character of which, however, I am unacquainted with.

Milford Haven, that port which some persons believe will ultimately become the Piræus of England, from its great natural advantages, and from its salient position, now possesses through railway communication with Manchester and the northern districts. The last link in the chain, that between Llandovery and Llanwrtyd, an extension of the Central Wales line of the London and North Western Railway system, having been opened for traffic a few months since.

Of foreign works to be enumerated there is of course in the place of honour the irrepressible Suez Canal. The report of the directors of this company, up to the date August, 1867, stated that the chief source from which funds had been obtained immediately previous to this date was the sale of the domain of Ouady, an extensive tract of country upon the banks of the canal, and which realized a sum of £2,000,000 sterling. Up to that period there still remained to be removed a cube of 40,000,000 metres, out of a total of 70,000,000, which quantity it is confidently asserted must be completely accomplished by the month of October, 1869, owing to the great power of the numerous dredging machines now at work. The sinews of war are, however, requisite to keep their wheels in motion, and the company have lately had to appeal to the capitalist for a lottery loan of £4,000,000 sterling, which I learn from the newspapers has been responded to satisfactorily. This sum, it is thought, will serve to open the navigation of the canal from sea to sea.

The possibility of constructing a Euphrates Valley Railway from Antioch, on the Mediterranean, to Bussorah, at the head of the Persian Gulf, is still ventilated. This or a direct railway to India is the only scheme that can compete with M. Lesseps; until that line of country be opened up he will remain master of the situation, and will be able to tax *ad libitum* our eastern trade, a position which he will have most fairly and creditably won.

A new feature in Continental Railways has been the opening of the extension of the Swiss line between Bouveret, at the head of the Lake of Geneva, and Sion, in the Canton Valais—the extension is from Sion to Sierres. This event will be hailed with satisfaction by those who advocate a second railway over the Alps. The line will of course ultimately cross the Simplon. Tourists will hardly object to a further extension to Visp, at the foot of the Zermatt Valley. The Alpine Club will no doubt give all possible opposition in the Federal Committee Rooms to any branch extensions to the foot of the Liffel, and of the Matterhorn. Happily, the Weiss Thor, and the Theodule are for ever closed against the Locomotive.

The Mont Cenis Tunnel is being pushed through the mountain successfully, 8842 metres out of a total of 12,220 metres having been completed, leaving 2 miles, 174 yards of rock between the two working faces still intact. The *Times*' Paris correspondent has given his verdict that this block can only be worked from the French face; as when the working party on the Italian face have come to the end of their gradient, rising at one in 2,000, they will then have to dip into the other or falling gradient at one in forty-five. They will be like a ship without a compass; and, besides, any water likely to be met with will run down upon them and flood their heading. Difficulties will arise here as in all engineering works, but that they will be overcome finally is now considered certain, and we may expect that the two faces of the rock will be worked as usual.

The sciences of artillery and fortification have probably made greater advances during the past twelve months than they have ever before done during what may be called the new *regime*; for the first time we have heard of experiments in which Mr. Palliser has succeeded in driving his shell projectile through eight-inch plates of iron with ease. This success would seem to place the attack on a level with the defence once more, as far regards sea-fighting. In the case of land fortifications, where a plate of iron of any desirable thickness can be erected, the shell will still remain out of court.

During the latest trials the Millwall Shield has resisted the battering of the most powerful ordnance yet invented.

Amid the din of iron against iron which we have been incessantly listening to of late, it is pleasing to find that an entirely new invention has appeared on the tapis, by Captain Moncrieff of the Edinburgh Militia Artillery. He has invented a gun-carriage in which the force of the recoil of the gun is absorbed by a balance weight, and the gun falls leisurely beneath the parapet after delivering its fire. In this position the gun is loaded, a pawl is detached, and the gun is elevated to its firing position as before, by the reaction of the counterpoise.

This is a most important discovery, and will give our military engineers an entirely new line of country to be investigated. It may cause the introduction of changes in our adopted systems both of attack and defence that may be called revolutionary. On the other hand, the new invention has its weak points, and these are all contained in the fact that it is a creature of the long-since abandoned barbette system. A fortress defended by such guns can be easily silenced by the vertical fire of mortars, wherever such can be brought to bear; and with guns like Captain Moncrieff's, we shall soon hear of such mortars being made for the purpose of attacking them as have never before appeared. A part of the Moncrieff system is that the gun-carriage may be mounted on a railway carried on the banquette; but this arrangement will make impossible the introduction of the traversing wall between each pair of cannon, a device to resist the devastating action of an enfilading fire. It may be that Captain Moncrieff's fertile genius will arise equal to the occasion, and produce an overhead shield for the protection of his gun from mortar fire. Anyhow, artillerists have got a new problem to solve that will keep them on the *qui vive* for a long time to come.

All these late inventions in this science tend to a vast increase of cost in the carrying on of war, for which the country will do well to prepare itself. The necessary expenditure will be of course inevitable.

While on this subject, we may notice two unusual events in connection with the Royal Engineers—viz., the appointment of an engineer officer to the command of the Abyssinian forces, and the gazettal of a member of the royal family to the corps; each of which will add a new lustre to this highly educated and renowned branch of the army, and on account of which we of the civil side of our splendid profession will with satisfaction congratulate them—the more so, as we are permitted to inscribe upon the list of honorary members of this society the name of one of the highest and most distinguished of their officers, Sir Henry James, K.C.B., F.R.S.

During the past season this society has visited the Lambeth and Chelsea Water Works, the East London Water Works, and the New River Water Works, by permission of their engineers. These have been amongst some of our most interesting visits of the year.

One cannot look upon such large collections of powerful machinery and other extensive works as these without feeling a certain amount of regret that so much valuable property is doomed, as doomed it certainly is in its present condition. These works are striking, on account of the very neat and cleanly arrangements observed in all of them. The system practised is similar throughout; but of what avail is this if, as we are told by the first authorities, medical and sanatory, that the most baneful elements of the water are those which chemically combine with it, and which no known process of filtering and purifying can remove. London, with its 3,000,000 of inhabitants, is a new feature in the world's history, and must accordingly be managed, and governed, and directed by laws and processes not known or practised in the histories of other cities.

We constantly find novelties of the most startling and warning kind turn amongst us. We have had a great plague in London, which decimated its population. We have had, within our own generation, a cholera morbus, a potato disease, and a cattle pest, which have come upon us inexplicable and unexpected, and which could only be received by the community collected in these islands with mute astonishment, and with a full confession of our dense ignorance and stupidity.

London, with its masses of people, such a large proportion of whom inhabit the vilest of slums, will do well to keep in advance of, and prepare for, these hidden forces, which will surely continue to assail us. We cannot comprehend them; but experience has taught us that we may meet them, and perhaps, as in the case of the cattle plague, minimize their energy. Charles Kingsley speaks of two of our great staples as—

> "Water and sunshine, the heirdom of all,"

How essential that they both shall be admitted into these aforesaid slums in a pure and unadulterated condition.

These slums must be our point of departure; it is here we must contend with the enemy, for no chain is stronger than its weakest link. As for sunshine we have yet to learn how to introduce this life and happiness-bestowing commodity into our alleys, but as for the water our course is clear; we see where and how to obtain this facile vehicle of health (as it may be rendered by our apathy one of death) in its virgin purity. Nature specially rectifies and distils it for our benefit. If we are to receive it from her in its perfection we must go and collect it in the highest zones of the country, and introduce it from thence into our centres of human existence, before it can become vitiated by contact with the filth of the earth, artificially and in a hundred different shapes cast out upon it. Some persons have spoken of the almost impossibility of distributing it when obtained. As far as the better class of houses are concerned this remark will not apply; as for the other classes, those barracks in which we find their occupants crowded at the rate of one individual to every cube of 200ft. of space, and which are the foci of dirt and disease, the most summary legislation may be righteously enforced. The cistern, with its infusoria and foul precipitate, should be abolished; the water to be simply supplied through pipes laid beside the footways furnished with taps at intervals, placed in cast-iron pillars, something like the street letter-boxes, from which the liquid may be drawn off as required. The waste from these pillars would run along the storm water tables, and thus carry off to the sewers much impurity that now rests where it fell.

The great water schemes so long before the public, notwithstanding all this, hang fire. The adverse condition of the money market will sufficiently account for this state of affairs. It may be that we shall not be brought to a sense of our duty in the matter until some new and withering sickness shall attack us, carrying death in its train, and staggering the population of the modern Babylon by the weight and violence of its onset.

We are indeed puzzled to find the city as healthy as it is, considering its wretched stated state of sanatory preparation for the attacks of epidemic and malaria. This may perhaps be accounted for by its freedom from damp, the excellent quality of its food supply and the antiseptic effect of the large quantity of carbon continually held in suspension by the atmosphere, the latter at the same tending to deteriorate the *physique* of the masses. It may be answered that London is the healthiest city in the world—so it is—still its immense numbers, continually brought into contact with all classes of travellers through its locomotive habits and by reason of its great foreign trade, introduce into the calculation an equation of the city that has not yet been measured, and that must be respected.

We may flatter ourselves that our water supply is excellent, because it sparkles in the tumbler, or because we can see, as we did at the East London Waterworks, a white pebble in its whole course to the bottom, when dropped into a cistern 9ft. deep; we are informed, however, on the best authorities that such a reasoning is fallacious, and that so long as one-half the supply is drawn from the Thames—which acts as a common sewer for a population of 1,500,000 persons, and their accompanying animals, who exist within the area of its catchment—we are drinking a *contaminated* liquid, which filtering on the most scientific principles cannot ultimately purify.

Sewage is the complement of water supply and demands a few words.

The sewage of London is now, perhaps, in as perfect a condition as it can or ever will be; and this is a great sanatory point gained, but its utilization is still to be effected. It debouches on each side the Thames at Barking, at 10 miles or thereabouts, below London Bridge, not sufficiently far away, nevertheless, to give us what the Thames ought to be, a crystal stream. A company was formed some time ago for the purpose of conveying it for utilization to the Maplin Sands, and experiments on a large scale have been made at the Barking Farm of 300 acres, which has been visited by this society within the year. I have been informed within the past week that the project has fallen through, and that an order has been issued for the winding up of the whole concern. Here accordingly remains an important problem unsolved. In the meantime, as might have been expected, a bank of sewage deposit is being formed in the bed of the river, opposite to the outfalls, which does not tend to the tranquility of the inhabitants of the neighbourhood, and which the Conservancy Board will doubtless have to deal with shortly, as being an impediment to navigation.

Glasgow having provided for herself a supply of water unequalled in its perfection at all points, goes in boldly for a combined scheme of sewage and utilization. A distinguished honorary member of the Society, Mr. Bateman, F.R.S., is associated with Mr. Bazalgette in preparing designs with the object named.

During several visits made to Scotland of late, I am forced to the conclusion that our brothers there, who, according to Sidney Smith, "breathe their air in the uncooked state," are superior to us in their power to grapple with those difficult social questions which constantly arise in the history of all town assemblages, as they also are in the cultivation of those arts which contribute at once to the grace and utility of existence.

Edinburgh is in truth what it pretends to be, a modern Athens; while Glasgow is a miracle of manufacturing effort and success—both one and the other of them straining every nerve to ensure those conditions of existence which may be expected to bring with them a maximum of human happiness. I may add that their railway system appears to be in excellent order and developed to an incredible extent, while greater attention is paid to appearances in it than in England, in which respect the Highland Railway is prominent, its buildings and bridges are in many instances remarkable for their elegance.

A sewage experiment is being made by the Local Board of Harrow-on-the-Hill, under the direction of a member of this Society, Mr. Augustus Hamilton Jacob, B.A., which will be of interest on account of its vicinity to London. He will no doubt be very pleased to exhibit his performances there to the Civil and Mechanical Engineers' Society, as soon as the works shall be in a more forward state.

The Irish Railway Commission has published its report, which has met with general applause, for its completeness and the clear and intelligible system of its arrangement.

The Government are disposed to give the question of state intervention in the conduct of railways a trial in this case. It remains to be seen if they can come to terms with the proprietors of the 1,000 miles of line in operation there. A portion of the railway system of the sister island is amongst the most profitable and best managed of the United Kingdom; it will be easily dealt with, it exists subject to the Act of 1844, in common with the whole system (say parts of three lines not exceeding 70 miles in length), which gives the State compulsory powers of purchase, its precise market value is patent; in the case of the less remunerative lines, however, there will be the greater difficulty of arriving at a result, at once satisfactory to both the parties to the suggested contract. Some of them for example, at present, pay no dividend; the proprietors of these railways will find it hard lines to part with their shares at their apparent market value, they would naturally prefer holding their stock with the hope of better times, to disposing of it at a price that must be held by them to be ruinous, while the State will be naturally indisposed to use their compulsory powers under the circumstances.

The 1,900 miles of line have cost £28,000,000, while their present value is rated at about £19,000,000 by some of the leading Irish authorities of the day.

The project is supported by several railway theorists who assume that by a consolidation of management its cost may be greatly diminished, and its efficiency increased, so that as a result both passenger fares and goods freights may be lowered to a tariff of perhaps one half that now in force.

Centralization of management will doubtless do much, but it must be at the outset questioned if the result expected can be anything other than illusory. The experience on this side the Channel, as well as the actual practice going to prove that the opposite will be nearer the truth, and that, if Railways are to be placed in the category of other commercial enterprises, it is more likely that the present tariff is below its appropriate grade than above it. The *chevaux de bataille* of these doctrinaires are the experience of the new *regime* at the Post-Office, and that of Excursion Trains. Lower your railway charges, they argue, as you have done your postal rates, and the result will surprise you by its success; you prove your practical belief in our views by your encouragement of excursion traffic at rates considerably below your general tariff. The answer is this—and it will be admitted that this is as much a question of railway engineering as of management—first, as to the Post-office:—The number of letters to be carried from place to place may be increased *ad libitum* without much increase of weight—they are abstractions, they don't weigh; for example, a locomotive can practically pull through space 1,000,000 letters, at $\frac{3}{8}$ of an ounce each, equivalent to $10\frac{1}{2}$ tons, as cheaply as it can pull along 1,000, which at the same scale will weigh $46\frac{1}{2}$lbs. Every additional letter carried is, with a small deduction for the cost of sorting and distribution, an additional penny of revenue to the Post-office. Can it be said that every additional passenger carried adds the nett amount of his fare to the revenue of the Railway Company? No; the cost of carriage of a railway passenger will be found to increase in nearly the direct ratio of his numbers, for this reason that he weighs in the eyes of a traffic manager from 15 to 25 cwt.; increase his numbers as you please, and you must increase your train-pulling power in a like proportion. For example, we will take an average railway train at one engine, 35 tons, one tender, 25 tons, 2 break vans, 12 tons, 8 composite carriages of 4 compartments each, at 8 tons each, 64 tons, 224 passengers, at 28 to each carriage, less 25 per cent. for inevitable vacant space, at $2\frac{1}{2}$ cwt. each including their luggage, 28 tons, 4 train attendants, 6 cwt.; total 164 tons, 6 cwt. We have thus 224 passengers, less 25 per cent. for vacant space, as before—viz., 168 passengers, weighing practically 164 tons; that is to say, in order to convey by railway 168 passengers over a given distance, a weight of 164 tons must be pulled by steam power through the aforesaid given space. I have not here taken account of the occasional pulling back over the same space a portion of the same batch of carriages as "empties," which condition often arises, in consequence of their being at times a greater flux in one direction than in its opposite; as, for instance, at the commencement of the London season, and at its termination, on the occasion of a city or town *fête* of some duration, as in the case of a royal visit, a race meeting, an agricultural show, and so forth, which element will increase the passenger's weight still further than the 20 cwt. at which I have rated him; increase his numbers as you will by attractive tariffs, &c., &c., you still will be obliged to treat him as a log of 20 cwt.

To pull this weight through space at a speed of forty miles an hour, and with strict punctuality—nothing less will satisfy the Briton of the period—is a problem which the experienced railway Engineer can readily solve. It means coal, oil, tallow, cotton waste, wages, wear and tear of engines, carriages, rails, sleepers, ballast, bridges, embankments, cuttings, stations, and all the other belongings of railways, effected, not under cover, but in the open air, exposed to the sundry and manifold changes of the weather, for which our climate is noted.

To make a comparison between two such incomparable institutions as the Railway and the Post-office, for the purposes named, is absurd in the eye of the Engineer, as I believe it is also in the eye of the Railway Manager, for these reasons which, summed up, mean this: that a letter weighs *nil* while a passenger weighs a ton twist him and turn him as you may. In the matter of goods, likewise, a misconception exists in the public mind. Take, for instance, coal. A ton of coal, in the consumer's eye, is simply a ton, and nothing more; in the eye of the manager, however, it is $2\frac{1}{4}$ tons; for example, a train of 30 trucks weighs as under:—engine and tender, 60 tons; 30 trucks, at 4 tons each as empties, and containing 10 tons each of coal, 420 tons; 2 break vans, 10 tons; total, 490 tons. The whole of this weight, minus the coal, to be carried back to the pit's mouth, 190 tons; total weight to be pulled along, 680 tons, in order to convey 300 tons of coal from the pit's mouth to market, or $2\frac{1}{4}$ tons dead weight per 1 ton of coal carried.

These are considerations which an unreasoning public do not consider in their estimate of what they ought to pay for the conveyance by railway of themselves and their goods.

As for Excursion trains, companies tolerate them; they are concessions to popular clamour; they seriously derange the ordinary traffic of the line; they are fertile sources of accident; they are cumbrous unmanageable things; strict punctuality at starting and arriving is not enforced; vacant space in the trains is not a necessity, their occupants are packed together as thick as leaves in Valambrosa; every living unit who goes in the outward direction returns in the homeward one. These conditions are the reverse of those which must obtain in general traffic trains. In short, they are an exceptional institution, and when debited with their fair per centage of wear and tear of rolling stock and permanent way, &c., &c., they do not pay, consequently cannot be taken as a precedent for the conduct of the common traffic trains of the country.

It matters not what the outside opinion of the country is upon the subject, for natural and economic laws will ultimately assert themselves; but it may help to diminish the muddle and worry of existence, and to lubricate its wheels which evidently jar on the matter of railway charges at present, if railway reformers will condescend to examine the case from an engineering point of view.

## SOCIETY OF ENGINEERS.

### MODERN GASWORKS AT HOME AND ABROAD.

By Henry Gore, Consulting Engineer.

Among the varied applications of scientific discovery to the purposes of daily life during the last century, few, if any, have attained greater importance than that which relates to the manufacture and application of coal gas. Scarcely a city, town, or village of considerable size, in this country, or on the Continent, or even in the United States of America, remains unsupplied with this almost indispensable agent in our industrial and social existence. Its use is rapidly extending in more remote regions; for strange as it may appear there are many peoples and communities who, though persistently resisting useful applications of practical science as dangerous innovations, are yet eager to avail themselves of the use of gas as a source of artificial light and heat, even religious prejudices of the most obstinate character have succumbed to this desire, and we now behold the Christian Church, the Mosque of the Mahometan, the Hindu, Budhist, and even the Chinese Temple, each illuminated by this simple and beautiful light.

It is not the intention of the present paper to enter into an elaborate description of the dimensions or plan of the buildings, or the character and arrangements of the machinery and apparatus that constitutes a modern gasworks. The author proposes to deal rather with those leading principles of construction essential to the production of the greatest amount of light, from a given quantity of materials employed; and to the situation in which the manufacture may be most successfully conducted.

Adopting this plan, it will be requisite, at the outset, to consider briefly the important question, "What is the chemical constitution of coal gas?" In the absence of any other well-supported theory, it is the generally received opinion that the light afforded by this gas is due to the amount of solid carbon incandescent in the flame at the moment of combustion. The two most important gaseous compounds of hydrogen and carbon, are marsh gas, or light carburetted hydrogen, and the other olefiant gas. The composition of the first is represented by the symbols $C\ H$, and consists, by weight, of 75.4 of carbon, and 24.6 of hydrogen.

The composition of the second is represented by the symbols, $C_2\ H_2$, and consists of 86 parts of carbon and 12 of hydrogen. The permanently gaseous constituents of all coal gas consist essentially of combinations of these two fluids or compound gases; but experiment shows that it is not a chemical union that is formed between them, but simply a mechanical mixture that takes place. Thus some coal gas of low illuminating power consists principally of marsh gas, with a very slight proportion of olefiant gas; other gas, of high illuminating power, contains an excess of olefiant gas. But the value of gas as a source of light is not due entirely to its gaseous constituents, for it almost always contains a certain quantity of vapours, more or less rich in carbon, and therefore extremely valuable as light-giving agents. It should be the great object of the gas manufacturer to produce and retain the richer gas and light-forming vapours up to the moment of combustion in the burner. In endeavouring to accomplish this he meets with many difficulties. An important element in the chemical character, and the light-giving capabilities of coal gas, depends on the materials used for its generation, and the obstructions it meets with in its passage from the place of manufacture to the point where it is to be consumed. What is technically called a poor gas coal always yields gas of the most permanent character, and is the most uniform in its amount of illuminating power. With a coal rich in the constituents of olefiant gas, the illuminating power, though actually much greater, is still liable to more variation than is the case with the poorer gas; but the greatest instabilitity is experienced when a mixture of poor and rich coals is used. That this should be the case is very natural. In gas made from the character of material first referred to, we have the least amount of mechanical mixture, owing to the small quantity of olefiant gas or hydrocarbon vapours present. With the use of coals, on the other hand, rich in volatile hydrocarbons, as referred to secondly, we have a greater mixture of poor and rich gas, and likewise an increased quantity of hydrocarbon vapours present; the absolute illuminating power of the compound gas is, therefore, liable to greater deterioration by the disposition of some of its light-giving constituents. But with the description of material referred to thirdly, the greatest depreciation may be looked for. The gases generated from the mixture of poor and rich coal form but a feeble combination, the one with the other. The hydrocarbon vapours are merely held in suspension, and do not enter into union with either of the gases; the slightest obstruction, or the lowering of the temperature, soon destroys this slender connexion, and the result is the loss of a very considerable portion of the illuminating elements of such gas. It is strange yet true that this last process of manufacturing by mixed material is the one very generally adopted to meet the requirements imposed by the Legislature as to the quality of gas. Judging from recent proceedings in Parliament, it appears very probable that a higher standard of illuminating power will be imposed upon a number of gas companies, especially those which supply the metropolis.

In the earlier years of gas lighting, the illuminating power of gas was not regarded as a qestion of any great importance; the coal or material most easily or cheaply obtained was used, so that rich or poor gas was produced, just as the works happened to be nearest to ordinary or cannel coal. And when opposition was raised against these existing companies, it was almost always on the ground of price. The most important movement in this direction was that which led to the establishment of the Great Central Company for the supply of the City of London. The two fundamental principles upon which this undertaking started were a low price and a low standard of illuminating power. To carry these proposals into practice, required that the works should be constructed upon a system involving some important modifications, and changes in the machinery and apparatus; and a process of manufacture was adopted, the main feature of which was to obtain quantity, quality being only a secondary consideration. The principle laid down in the case of the Great Central Company has been more or less applied throughout the country, and the result has been that the constructive details of gasworks have been carried out almost exclusively with a view to obtain the largest possible quantity of gas from the materials used for its production. Furnaces affording the greatest heat, retorts exposing the largest carbonising surface, condensers and scrubbers making the strongest ammoniacal liquor, purifiers of large capacity and surface for the oxide system of purification, monster gasholders, and last, though not least, street mains of the dimension of small tunnels; these, and perhaps some other matters, are the concomitants of cheap gas, as inaugurated at the period above referred to. Subsequent events, however, have shown that at least one of the parties to the arrangement (the gas consumers) have become dissatisfied with their bargain. An agitation which originated some years ago still continues for a repeal of the condition as to quality, and the legislature has so far interfered as to raise considerably the standard of illuminating power; the important question presents itself whether, in meeting this change, it may not be requisite to modify the present mode of constructing gasworks, especially in those localities where mixed coals are used for producing gas of the quality required by these new regulations.

FIG. 1.

FIG. 2.

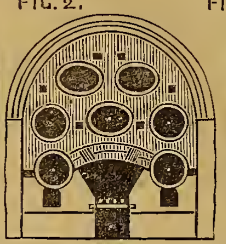


FIG. 3.

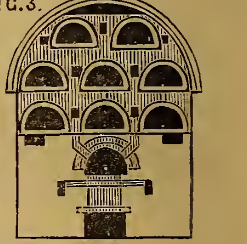


FIG. 4.

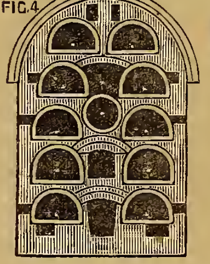


FIG. 5.

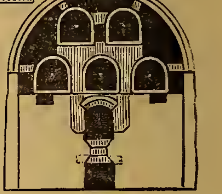


FIG. 6.

A glance at the several sections of the retort settings will show the form and arrangements at present generally adopted. Fig. shows Lowe's (Chartered) setting; Fig. 2, is Jones' (Commercial); Fig. 3, is Evans' (Westminster Chartered); Fig. 4, is Methven's (Imperial, St. Pancras); Fig. 5, is Gore's (Valparaiso) and Fig. 6, is Henderson's superheated steam retort. In large works, and with clay retorts, the system of through setting, with double mouth-pieces, is unquestionably the most economical, both as regards fuel and durability. But this arrangement is open to grave objections. If the retorts are use for the generation of gas of high illuminating power, the increased surface over which the gas passes after it is eliminated from the coal exposes it to the chance of decomposition, and the consequent deposition of its carbon. That this goes on to a very great extent is evident from the amount of solid carbon, or graphite, found on the inner surface of the retorts. In through retorts this deposition is due mainly to two causes; in the first place in charging the retort with coals either by the scoop or shovel, the centre of the retort scarcely ever receives its due portion of coal, and as this part is always the hottest it follows that the gas generated from the thinner stratum of coal is exposed to intense heat, and a portion of it is speedily decomposed, liberating the hydrogen and depositing the carbon, thus forming a deposit which rapidly increases and soon renders the retort useless, unless precautions are taken from time to time to remove the carbon. Another cause of this deposit is the want of uniformity in the pressure in the two hydraulic mains; a slight resistance in one main or the other causes the gas to take the course offering least obstruction, and as the particles of gas thus pass over a larger amount of heated surface, they are exposed to the greater risk of decomposition. Several expedients have been suggested to remedy this evil; one is to use a valve to each ascension pipe so as to dispense with the dip pipe when the retort is working; another is to have only one hydraulic main, placed over the centre of the ovens, and both mouth-pieces connected to it by a single dip pipe.

The material of which the retort is made will exert a very important influence on the production of gas of high illuminating power. The high temperature at which clay retorts are worked tends to produce a very large quantity of carbonic oxide and hydrogen, by the decomposition of the olefiant gas and hydrocarbon vapours. It is frequently asserted that by the use of richer cannel coals, the excess of non-illuminating gas is rendered highly luminous by becoming saturated with the hydrocarbons given off from the richer coal; but this is only true to a limited extent, inasmuch as the mixture undergoes rapid deterioration consequent on the liquefaction of a large portion of these hydrocarbon vapours.

We now proceed to consider the operation of the condenser, in the process of gas manufacture. By the term condenser, we usually understand the apparatus acting as a means of cooling or refrigeration, but this is only true in reference to its use where the gas is of poor quality and of low specific gravity. In treating gases which are to possess high illuminating power, it is not desirable to reduce their temperature below 60°. Under these circumstances, therefore, we must look upon the condenser as a separator and not simply as a refrigerator. The two forms of condensers most generally in use are the tubular, or a series of pipes, and the annular. Whichever of these forms is adopted, a large extent of surface is indispensable, in order that the separation of the mechanical and non-chemical impurities contained in the crude gas may be gradual. The existence of naptbaline may in many cases no doubt be traced, first, to the high temperature at which the gas is generated, and again to the too sudden reduction of the temperature by rapid and excessive refrigeration. It is a strange anomaly that so much care and labour should be applied to remove so many of the light-giving constituents from the gas, and then to give back these elements by the use of costly, and in some cases dangerous, appliances, in naphthalisers, carburetters, and other high sounding and wonderful specifics.

In the generality of works as now constructed, the gas, after leaving the condenser, is subjected to the process of washing, either by means of the old-fashioned wash vessel, or the more modern contrivance called the scrubber; the object in either case is still further to purify the gas from any remaining particles of tar, heavy oils, and ammonia. As the use of the washer has become almost obsolete, we shall confine ourselves to a few remarks on the action of the scrubber. Many very conflicting statements have been made in reference to the effect of water in removing some of the light-giving constituents from coal gas. Several chemists, who have the reputation of being oracles in these matters, have asserted that water exerts but a small influence in diminishing the illuminating power of coal gas. Some engineers, who certainly have an equal claim to consideration from their great practical experience, say, on the contrary, that water produces a very injurious effect. In the year 1860, the author of this paper, in his capacity of engineer to the Valparaiso Gas Company, was obliged to economise the use of cannel coal on those works, and yet maintain an illuminating power of nineteen candles. To effect this a series of experiments were made gradually reducing the proportion of Boghead cannel from 30 per cent. to 20 per cent. of the coal used in making the gas; the proportions of coal ultimately decided upon, being 60 per cent. of native Chile, 20 per cent. of New Pelton, or Australian bituminous coal, and 20 per cent. of Boghead. The average quantity of gas produced per ton of this mixture was about 10,300 English cubic feet. The condensers were of the annular form, as introduced by Mr. Kirkham; the scrubber was 6ft. diameter and 14ft. high, filled in the usual manner with four tiers of coke and breeze; the water was supplied by a coil of perforated pipe, and a conical dash plate. A water cistern was so placed as to give a 3ft. head above the coil; the flow of water through the scrubber was continuous; the mean temperature of the air during the experiments was 17° Cent. or about 62°.6 Fahr. With the apparatus working in its normal condition, and with 30 per cent. of cannel the average illuminating power of the gas was from 23·70 to 24·50 standard candles; on reducing the proportion of cannel to 20 per cent., the light fell to 18 and 18·50; the flow of water through the scrubber was diminished, and a slight improvement in the light was observed. After a series of trials a system was adopted of allowing the water to flow for ten minutes, at intervals of two hours. By this arrangement it was found that the gas was sufficiently freed from tarry matter, and the illuminating power of nineteen candles was always maintained, the average being twenty-one candles at the works.

The difficulty of getting rid of the residual products from gas manufacture, particularly ammoniacal liquor, has led to the plan of obtaining a stronger solution of the salts by passing the liquor over and over again through the scrubber. The advocates of this process claim for it among other advantages that more of the hydrocarbon vapours are retained than when the gas comes in contact with pure water; and it is possible that this may be to some extent true, because, although each time the liquor comes in contact with the gas, it takes up some particles of hydrocarbon vapour, or it may be some portion of the olefiant gas, yet as in the succeeding stages of its passage it absorbs more of the ammoniacal gas, the hydrocarbons are to some extent liberated, and are taken hold of by the gas in exchange for the particles of ammonia it has given up; but whether this latter supposition is correct or not, it is certain that the use of a large quantity of water, in any form, is prejudicial to the light-giving elements of coal gas.

In removing from gas its chemical impurities lime is unquestionably the most appropriate agent, and, in all situations where it is possible to employ it, it should be used to the exclusion of all other substances. Considerations of economy, and certain sanitary regulations have induced chemists and engineers to turn their attention to some of the metallic oxides as substances adapted for the purposes of gas purification, and now by common consent certain oxides of iron are used as a substitute for lime in most of our important gasworks. The action of this material is to remove the sulphuretted hydrogen, by the union of the sulphur with the iron, forming the black sulphuret or sulphide of iron. When the material is fully saturated it is removed from the purifier, and on exposure to the atmosphere undergoes a series of chemical changes, which result in the precipitation of the sulphur and the re-oxidation of the iron, which again becomes fitted to act as a purifying agent; in fact the process of revivification may be carried on for months before the purifying power of the material is entirely exhausted. In constructing purifiers for the oxide of iron process a much larger superficial area is necessary than when hydrate of lime is employed. It is very questionable, the author ventures to think whether the practice of increasing the thickness of the layers of the oxide is in all respects good, especially when the material is partially spent. A very objectionable system is now pursued in gas manufacture of disregarding the existence of carbonic acid in gas. The reason assigned for this practice is that the quantity is so small that its interference with the illuminating power of the gas is easily compensated for by adding a little more cannel in the process of manufacture. These petty adulterations for the sake of a paltry economy are unworthy the position of those who have the control of such important undertakings as our modern gasworks. Another economic suggestion has been made, namely, the revivification of the oxide in the purifier itself, by allowing a portion of atmospheric air to be driven through the material along with the gas, thus causing a constant decomposition of the sulphuret as fast as it is formed; the injury resulting to the illuminating power of the gas is to be remedied by that panacea for most, if not all, of the ills attendant on gas lighting—"a little more cannel"—but any admixture of atmospheric air should certainly be avoided, first, because it is a dishonest adulteration of the gas, and, secondly, because it is unsafe, and may lead to the most disastrous consequences.

In the arrangement of the apparatus of a gasworks, the next in order to the purifiers is the station meter, but as this machine exerts no direct influence on the process or products of manufacture, the author passes on to consider the means adopted for the storage of gas. On the first establishment of gasworks some very absurd opinions were expressed as to the form, construction, and capacity of gasholders. The restrictions proposed as to the dimensions of these vessels are certainly very amusing when recalled and contrasted with the monster creations of the present day. The demand for gas, consequent on the reduction of price, has led engineers to construct gasholders, the capacities of which are measured by millions, instead of hundreds of thousands of feet, as was the case formerly; attempting to answer satisfactorily the ever recurring question of economy. It must be admitted that the larger the gasholder the cheaper its cost at per thousand feet of its contents; but it is a question for serious consideration whether, as a matter of safety, these enormous depositories are not open to grave objections. So long as the quantity produced in the course of manufacture was the essential object of our manipulations, the effect on the quality of gas by its storage was only of secondary importance; but if, as we are by recent events led to believe, a much higher standard of illuminating power is to be imposed on gas manufacturers, the advantages of these enormous gasholders may not prove so obvious in the future as they appear at present; for, besides other reasons that will suggest themselves to the mind of every competent gas engineer, the fact that the storing of gas (especially such as contains any considerable amount of hydrocarbon vapours), is sure to result in an appreciable diminution of its illuminating effect is, of itself, a good ground for objection against the construction of what the author cannot help calling, injudiciously large gasholders. Before leaving this part of his paper, the author might have been expected to say a word or two in reference to the mode in which some of these vessels are constructed, but as these are purely mechanical details, and do not in any way effect the condition or quality of the gas, he will reserve his remarks upon this subject, until offering a few observations upon the peculiarities necessary in the construction and arrangements of gasworks in foreign countries.

Before concluding the first section of this paper, the author desires to say a few words on the most favourable localities for gasworks, and the means of distribution. In selecting a site for works, the following are among the most essential desiderata: Sufficiency of area, a low level, a good supply of water, good drainage and easy access. Even in some modern works these important conditions are sometimes most palpably neglected; as a general rule, however, they are complied with. In the earlier times of gas engineering it was thought desirable that the supply should be as near as possible to the centre of the consumption, but modern practice removes our gasworks to remote distances, and some enthusiastic persons have even suggested the removal of the manufactories to the centres of our coal districts. Wild as this proposal seems, it might possibly be realised, if gas and not light was the product to be supplied; but if the public demand gas light, and not light gas, then the proximity of the works to the locality of the consumption must be a vital element in the economy of gas manufacture. The longer the distance through which the gas has to travel before reaching the burner of the consumer the greater will be the loss of illuminating power; hence it follows that a company supplying gas three or four miles from the district or place where the gas is to be consumed will have to use a much larger proportion of cannel, or other light-producing material, to produce and supply gas of equal quality with a company only a mile from its consumers. It is very questionable if the advantages said to be gained in a sanitary point of view, or the greater economy effected in the delivery of raw materials, and the distribution of residual products, as coke, tar, liquor, &c., will at all compensate for the increased outlay in mains and the attendant loss of illuminating power.

Having thus touched upon some of the leading principles in the construction of modern gasworks, viewed in relation to their adaptation for the production of light, and not simply the generation of gas, the author now proposes to offer a few remarks on the construction of gasworks in new and less advanced countries than England, such, for instance, as the continent of South America, the field in which this branch of engineering practice has been most recently introduced. As it is a continent for a great part difficult of access, it may be presumed to afford a very fit illustration of the difficulties which attend the practice of the gas engineer in remote countries.

The principal gas establishments on the east or Atlantic coast of South America are those of Para, Ciara, Pernambuco, Bahia, Rio de Janeiro, Monte Video, and Buenos Ayres. There are also works in course of erection at several of the chief cities and towns on the banks of the rivers La Plata and Parana; but the recent war with Paraguay has caused a temporary suspension of these works. On the Pacific, or west coast, there are works at Guayaquil, Callao, Lima, Tacna, Copiapo, Valparaiso, and Santiago de Chile. The works on the east, or Atlantic coast, with the exception of those at Rio de Janeiro, are constructed on the English model, to use ordinary English gas coal, with a small admixture of Wigan or Scotch cannel.

In Rio de Janeiro the works were originally intended for a modification of White's hydrocarbon process, using American resin as the source of illuminating power; but the works, after undergoing several modifications, are now virtually adapted for coal. On the Pacific coast, with the exception of Guayaquil, all the works are of English construction; but all of them use a considerable quantity of native Chile coal in the production of the gas, mixed with English or Australian coking coal, and more or less of Wigan or Scotch cannel. The principal coal basin of Chile is situated between 36° and 41° of south latitude; it contains several varieties of coal, but that best adapted for gas is obtained from Lota, Coronel, and Pachoco. It yields, at fair working heats, about 8,000 English cubic feet to the ton, of an average illuminating power of 14·30 standard candles. The coke is light and friable, but as the natives employ charcoal for all culinary and heating purposes, the coke meets with a ready sale, being a good substitute for the charcoal. The proportions of tar and ammoniacal liquor are somewhat different from those resulting from the use of English coal, the quantity of tar being much less, but of ammonia much in excess averaging 190lb. to 200lb. to the ton. The percentage of sulphur is high, and found principally in the form of sulphate of lime, with some curious nodules of pyrites. The first gasworks erected on this coast were those of Lima and Valparaiso; these were of purely English type, and not the best adapted for the climate or peculiar nature of those countries. The retorts are set in beds of five and seven to a furnace. The retort house in Lima is constructed with a raised charging stage, and a coke depository below; in Valparaiso the charging floor is on the ground level. In both establishments the retorts are charged with the scoop. In consequence of the prevalence of earthquakes, chimneys, of even moderate altitude, are inadmissible; it was therefore found that beds of seven retorts could not be worked advantageously. In the works at Valparaiso the form of setting ultimately adopted was that of five, set in tiers of three and two. The retorts are 14in. by 14in., D shaped, and 8ft. long inside; the furnace is 2ft. 3in. long and 7in. wide at the bars, and 5ft. 6in. long and 1ft. 4in. wide in the body. The heat is conveyed into the retorts by a row of apertures or nostrils on each side of the arch of the furnace; from these it rises between the centre and outside retorts, and, after circulating round the two upper retorts, escapes to the chimney by flues under the two outside lower retorts. The average duration of the clay retorts is about two years and of iron retorts thirteen to fourteen months. The mean yield per mouthpiece is 3,200 cubic feet each twenty-four hours; the absence of sufficient draught is a serious drawback to the efficient working of the furnaces, but this has been obviated recently by converting the horizontal main flue into a series of short chimneys. This plan is now in successful operation at the magnificent new station of the New York and Manhattan Gas Company. There each double setting of ten retorts, set back to back, is furnished with a small separate chimney, the products of combustion being carried through the roof of the retort house by an iron tube. The author, in constructing the new works for the city of Mexico, has adopted this plan, and has found that, even with wood fuel, clay retorts can be maintained at a good carbonising heat, adopting, it should be noted, the necessary precaution of increasing the width of the body of the furnace. In designing gasworks for new countries it is a great error to be guided solely by home practice, especially in reference to retorts and furnaces. The number of retorts in, a setting should never exceed five, and, even in the largest works, settings of threes should always be provided. The demand for gas in some of these countries is not at all uniform, especially in the case of public lighting; special festivals, and the exercise of police and municipal authority frequently interfere to affect in an important degree the quantity of gas required. To meet such exigencies, it often happens that it would be better to light up two beds of threes than one bed of fives, or *vice versâ*. Simplicity of arrangement in the setting of retorts is also of the utmost importance, so that the bricklayers' and other work may be performed by comparatively unskilled operatives. The employment of native labour is an essential element in the success of all gasworks abroad.

The condenser, scrubbers, and purifiers at Valparaiso are of the form and description usually found in gasworks at home. In the original design arrangements had been made for cooling and refrigeration by using a large quantity of water, but this was found unnecessary. The purification of the gas is effected by the use of oxide of iron and lime. There are four purifiers each 10ft. square, and 3ft. 6in. deep, with five tiers or sieves. On the four lower tiers the oxide is placed in layers from 6in. to 7in. thick, on the top tier the layer of lime is 4in. thick. In consequence of a very large portion of the gas being supplied to private consumers, and from the peculiar construction of the rooms in Spanish-American houses, it was necessary to pay particular attention to the purification. The purifiers are worked in a series of three; the third one is always kept free from sulphur by putting a clean purifier in action as soon as the second of the series discolours the acetate of lead test.

The site of the works being close to the sea rendered the construction of a brick tank impracticable; the tank and gasholder are therefore of iron. The gasholder is 80ft. diameter, and 24ft. deep, in a single lift. The roof is flat and without trussing. The outside, or guide framing, consists of eight cast-iron tripods, with wrought T iron braces and girders. The gasholder gives a working pressure of $3\frac{2}{10}$in.; it was designed at the period when non-trussed gasholders were considered the *ne plus ultra* of economical construction; but we must not always estimate the value of a machine or apparatus by its prime cost, and it is very questionable if it is prudent to sacrifice safety and efficiency for economy. The gasholder at Valparaiso has been a constant source of anxiety from the upper ring or flange geting out of shape. If a gust of wind caught the holder when it was full, the strain on the outer row of roof sheets often caused the rivets to strip, and produce leakage. But the greatest drawback to the use of untrussed gasholders abroad is, the risk of bad workmanship in rivetting up the top flange and rows of boiler plate: this is a difficulty often experienced at home, but the risk is tenfold greater abroad. Before concluding his remarks on the gasholder, the author would refer to what may appear a very simple matter, but really one of very great importance in hot dry climates, namely, the means of keeping the gasholder cool during the hottest part of the day. It is the universal stipulation on the part of the gas companies that the public lamps shall not be lighted when the moon is visible, and the practice is to reduce the stock of gas in the gasholder at such times as low as possible, consistently with safety, relying on the retorts to meet any sudden extra demand. During the summer, or dry season, the evaporation caused by the heat of the sun's rays is so great that an immense quantity of aqueous vapour is formed in the gasholder, which is carried forward by the gas into the mains and fittings, causing great annoyance and trouble. Painting the roof of the gasholder white, and several other expedients have been tried to get over this difficulty, but the only one attended with any success has been sprinkling the roof with water by means of a rose jet. Notwithstanding all that could be done, a very considerable amount of water is from time to time deposited in the mains and fittings, and it requires constant and careful attention to avoid inconvenience to the consumer.

The distribution of the gas is controlled by governors at the works, and by regulating valves in the streets; these valves are necessary in consequence of the sudden elevation of the mains used for lighting a portion of the city built on a plateau at the height of several hundred feet above the main streets that surround the bay. An error frequently committed in this country is to suppose that the quality and illuminating power of the gas are matters of no moment in countries such as are now referred to; it is impossible to make a greater mistake, and for these reasons; those who would burn light at all, or at least those who would burn gas light, are exclusively those of the class who have been in habit of using either sperm oil, camphine, or wax or spermaceti candles; any new source of illumination must be at least equal or superior in brilliancy to each of these, and not more costly. Again, the rooms are generally very lofty, especially in the best class of houses, and to light such apartments well, requires that the gas should be of superior quality; it should not, therefore, be surprising that the average illuminating power of the gas in Valparaiso is twenty standard candles, the minimum being nineteen candles. The failure, at a certain juncture, to maintain this quality by the company whose works have been described, caused so much dissatisfaction as to lead ultimately to the establishment of a competing company for the exclusive supply of private consumers. Their works are placed in the centre of their consumption which averages 80,000 cubic feet per night, and their average annual loss of gas unaccounted for is scarcely 6 per cent. It may not be out of place to mention here the cause of the reduction of the illuminating power of the gas on the occasion alluded to. The company had been in the habit of keeping a large stock of Boghead cannel, but became unwilling to continue this system, and arranged to receive periodical supplies of a few hundred tons, as ships could be found to take it as dead weight cargo. Trusting to the arrival of one or more such shipments, the stock became exhausted, and by a strange fatality two ships conveying cannel met with accidents, so that no cannel arrived for several months. To improve the quality of the gas a large quantity of American resin was bought, and used in conjunction with common coal. The gas produced from this mixture, when used in the vicinity of the works, appeared of tolerably good quality, but the consumers in the district most remote from the works soon had grave cause for complaints, first, for want of light, arising from the depreciated state of the gas; and, secondly, for a still greater source of annoyance from their fittings becoming stopped up by a viscid tarry deposit that collected at every angle, bend, or tap. The irritation caused by this unlooked-for difficulty, as already stated, laid the foundation of the new company.

As a set off to these misfortunes, several very useful practical lessons were learned in respect to the department of gases generated from different substances in the same retorts, and subjected to the same processes of purification. In the course of the experiments made when the coal supply failed, the following materials were used:—rosin, dregs of whale oil, several varieties of vegetable oil, asphalte, refuse of sugar-cane, wine lees, and creosote, or dead oil. In using the resin, oils, and asphalte, the best results for enriching the gas were obtained by mixing the gases after the coal gas had been passed through the purifier, and allowing the mixed gas to pass through a dry scrubber before entering the gasholder. In experimenting with the dead oil, or creosote, a very ingenious modification of White's hydrocarbon apparatus was designed by a gentleman connected with the Valparaiso Railway. The agent employed was superheated steam, the object sought to be obtained the decomposition of the tarry vapours. The retorts (Fig. 6) were of iron, cast with a double bottom, so as to leave a space of about 1½in. to 2in. between the bottom on which the coal and the creosote were placed and that exposed to the fire. In this space an iron steam pipe was placed, ¾in. in diameter, screwed into the bottom of the mouthpiece, and extending nearly to the back of the retort. A similar pipe was connected with the boiler of the steam engine, but was placed in the upper part of the main flue, so as to be exposed to the waste heat from the retort furnaces; by this means the steam became highly heated before entering the retort. The steam, on issuing from the open end of the pipe at the back of the retort, acquired additional heat by passing over the surfaces of the bottom of the retort. On reaching the front it came in contact with the vapours and gases generated from the mixture of coal and creosote, which were carried away by a pipe at the back of the retort. A very large quantity of gas was produced by this process, with an average of illuminating power of thirteen and a half to fourteen candles. The object of all the experiments was to find a substitute for Boghead or other cannel coal to produce gas of at least twenty candles quality; as none of the results met this requirement, the several processes were soon all abandoned.

In the management of gasworks in remote countries, it frequently occurs that the engineer is called upon to purchase or use coal of a character and quality of which he is entirely ignorant; it is therefore highly important he should be able to make one or more commercial experiments before committing himself to the use of the strange coal. All coal, except some of the varieties of Scotch cannel, undergo a marked deterioration in their gas-making qualities when exposed to a long voyage, and especially in passing through the tropics. Another source of trouble and annoyance, particularly on the west coast of South America, is the gross frauds practised in the use of false certificates as to the names and descriptions of coals offered for sale. All foreign gasworks should be fitted up with an experimental arrangement of retort, purifier, meter, &c., and the retort should, if possible, form one of the ordinary sets charged by the stokers in their usual course of work. It frequently happens, however, that the results obtained by special manipulation are far from realised by ordinary commercial practice, and in no branch, probably, of what may be called chemical manufacture, has this experience been more frequently manifested than in gas-making. The greatest discrepancies between laboratory experiments and practical working are of the most common occurrence, and the most disastrous losses, as well as painful disappointments, have often resulted from the attempt to carry into practice processes founded upon chamber investigations.

In concluding these remarks on foreign gasworks, especially for warm or tropical climates, the author would suggest the desirability of the greatest simplicity in the design and construction of the requisite buildings, and the absence of all complication in the machinery and apparatus. The buildings, if not used as store-rooms for valuable goods, should be merely roofed sheds, supported on iron or even wooden pillars. All enclosing walls walls should, as far as practicable, be avoided. Care should be taken to provide ample covering for coals, but with sufficient ventilation. An abundant supply of water is essential, with appliances for raising streams or jets to a considerable altitude. In all cases where hydraulic valves, self-acting seals, or lutes, and especially in the lutes to purifiers, the depth of the sealing fluid should be greatly increased. The tanks of gasholders, if required to be made of iron, are better of wrought iron than of cast, particularly in countries exposed to earthquakes. If the engineer is not well aware of the nature of the ground, either by personal inspection, or very reliable information, he should shrink from designing a brick or stone tank for such countries. In laying street mains especial care should be taken to ensure a more than average depth below the surface, and a sufficient, but not too great, inclination or fall. It is also a wise precaution to make the capacity of syphons of tar wells greater than those usually employed in this country.

In carrying on the operations of a gas establishment in countries similar to those just described, the engineer will find his duties and responsibilities infinitely more arduous and onerous than those he would be called upon to discharge in the situation of a manager and engineer at home; it is therefore of the utmost importance to him that his works and apparatus should be as simple as possible, consistently with due efficiency.

Above all, let him employ to the utmost extent to which they are available the labour and the materials of the country. In doing this he may have to pluck up deeply rooted prejudices, probably to place in abeyance well grounded opinions, the soundness of which he may have thoroughly proved, under other but widely different circumstances; this he should be ready to do with cheerful alacrity and unreserve. Assuredly he is most certain in a foreign country to achieve success in engineering and manufacturing enterprises who acquires the most thorough knowledge of, and influence over, the inhabitants of the country, and masters most completely an acquaintance with the character and capabilities of its productions; who can enlist the hearty co-operation of the people, and lay the native products under contribution to subserve his purposes; who, in a word, most completely adapts himself to the peculiarities of the circumstances, influences, and objects, which surround him in the New World in which he is placed.

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## ON THE SCREW PROPELLER.

By Arthur Rigg, Jun.

(*Concluded from Page* 259.)

By the system of construction explained in Fig. 1, it is clear that different angles of the screw blade will produce a different length of the line X, Z as compared with F, E. For the sake of comparing the first figure with those that follow, it will be assumed that the line X, Z, be divided into three parts, of which two-thirds are given to the ship forwards, and one-third to the reverse current.

Let Fig. 4 be a diagram similarly constructed for a screw 23ft. 6in. diameter and 13ft. 4½in. pitch; R, T is the ship's progress during one revolution, and R, S the reverse current.

Fig. 5 is a similar diagram for a screw 23ft. 6in. diameter and 21ft. 8¼in. pitch. This is the first screw made for the Bellerophon, and is a good example of "negative slip." V, X is the ship's progress, and V, W the reverse current, during one revolution of the screw.

In order to show how clear an insight these diagrams give into the working of a screw-propeller, it will be most suitable to compare the three examples already given with the theory now generally acknowledged. Let F, E be the circumference, and E, H the "pitch," and continue A, B to the intersection at H. If water were a solid body every screw ought to advance the distance E, H (the "pitch") in one revolution; but really Fig. 1 advances less than the pitch in one revolution, Fig. 4 advances equal to the pitch in one revolution, Fig. 5 advances more than the pitch in one revolution being examples of "positive slip," "no slip," and of "negative slip," but when examined by the system of the diagrams, and according to the principles already enunciated, it proves to be that in each case a corresponding proportion of water is driven backwards for each advance of the ship. In order to show how closely alike are the diagram results, there follows a table of certain ships in her Majesty's navy, all of which give "negative slip" according to the usual theory, but which really have reverse currents much alike:—

| Her Majesty's steamships supposed to illustrate "negative slip." | | | | | | | Reverse currents according to foregoing principles. | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Ship's name. | Diameter of screw. | | Pitch of screw. | | Number of revolutions per minute. | Ship's rate, knots per hour. | Ship's rate per revolution of screw. | Total currents through screw per revolution. | Reverse currents at circumference per revolution. | Reverse currents at circumference per foot of ship's advance. |
| | ft. | in. | ft. | in. | | | ft: | ft. | ft. | in. |
| Archer ........... | 12 | 6 | 7 | 9 | 71·0 | 6·391 | 9·118 | 14·955 | 5·837 | 7·681 |
| ——— | 11 | 7 | 7 | 9 | 73·0 | 6·151 | 8·53 | 14·793 | 6·263 | 8·810 |
| Arrogant ......... | 15 | 6 | 15 | 0 | 55·5 | 8·295 | 15·14 | 27·923 | 12·738 | 10·131 |
| Cygnet ........... | 9 | 0 | 10 | 6 | 104·0 | 10·827 | 10·54 | 18·912 | 8·372 | 9·531 |
| Flying Fish ...... | 13 | 1½ | 15 | 0 | 62· 0 | 9·731 | 15·89 | 26·469 | 10·579 | 7·989 |
| Hannibal ......... | 17 | 0 | 12 | 6 | 64·87 | 8·6 | 13·42 | 24·243 | 10·823 | 9·677 |
| Miranda ......... | 12 | 0 | 11 | 6 | 87·87 | 10·75 | 12·39 | 21 602 | 9·212 | 8·921 |
| Plumper ......... | 8 | 9¼ | 4 | 6½ | 136·25 | Negative slip 18·43 per cent, | 5·37 | 8·937 | 3·567 | 7·970 |
| Simoon ........... | 15 | 11½ | 16 | 6 | 52·5 | 8 447 | 16·87 | 30·826 | 13·956 | 9·926 |

Perhaps the most instructive example in the above series is the *Archer*, whose screw was originally 12ft. 6in. diameter, and gave a reverse current of 7.681in. per foot of the ship's advance; but when the tips of the blades of this screw were cut off, and its diameter reduced to 11ft. 7in., the reverse current per foot became 8·81in.; and this is within one decimal of being exactly in the inverse proportion of the diminution of the area of the reverse column: *i.e.* if it were exactly in proportion to the areas the second figure ought to be 8·9in. instead of 8·81in. In fact, however closely this system of diagrams be examined, it seems to throw a new and clearer light upon the complicated phenomena attendant upon screw propulsion.

There is a singular and somewhat obscure result in the experiments made on the steam-tug *Dagmar*, given in the first table; and this is the remarkable diminution in the pressures of the currents as the angles of deflection becomes greater. For example:—With 35 deg. deflection the pressure per square inch is 2·1lb.; with the 45 deg. deflection the pressure per square inch is 1·0lb.; with 72½ deg. deflection the pressure per square inch is 0·4lb., and it may be safely assumed that with 90 deg. deflection the pressure would be 0.

It will be remembered that these pressures are taken at right angles to the currents, and not to the course of the ship; so they represent the real pressure of the water as driven away from the screw, and it would seem that all the power of the engines is consumed by turning the current at right angles to its original course.

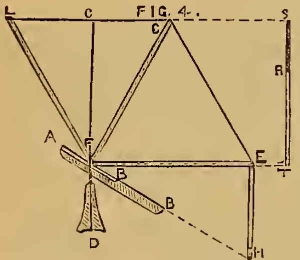
FIG. 4.

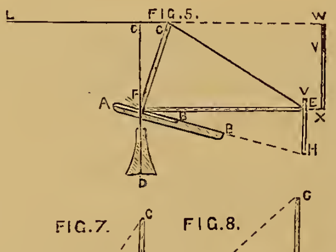
FIG. 5.

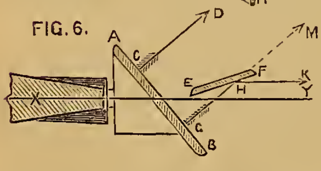
FIG. 6.

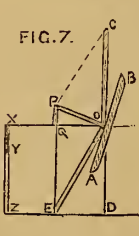
FIG. 7.

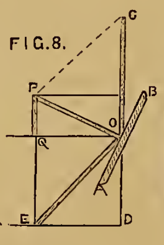
FIG. 8.

Certainly the converse operation takes place with a turbine; for when a stream enters this hydraulic machine, and passes away at right angles to its original direction, having meanwhile turned the wheel, it is certain that all the power has been transmitted; but if the current has not been diverted so far as a right angle, then unconsumed power passes away.

This example shows that power is given out by a mere change in the direction of a current, and no doubt in the same manner power is consumed in changing the direction of the reverse current behind the screw; that is, in other words, giving it a rotation. It is not easy to follow this action, and the illustration of the turbine is rather suggestive than explanatory.

As there is so great a loss of power it ought to be possible to recover the greater part and apply it usefully to propelling the vessel. This has been accomplished by placing deflectors in the reverse current, so adjusted as to restore its course into a line due aft by the latent power already received from the engine.

The diagram, Fig. 6, explains the principle more fully:—X, Y being the line of axis of the screw; A, B represents a section of the blade; E, F a fixed blade or deflector; C, D and G, M the reverse current as it leaves the screw, A, B.

The current, G, M, is supposed to strike on the surface of E, F; and is thus diverted along the line, H, K; giving a resultant pressure perpendicular to E, F.

Fig. 7 shows the effect of this pressure with a deflection of 30 deg., and Fig. 8 with a deflection of 45 deg. Similar letters correspond in both diagrams.

A, B is the fixed deflector plate; E, O the current's direction and force; O, C the direction and force with which it leaves the deflector and passes away in line with the axis of the screw. The angles E, O, A and B, O, C will be equal. By drawing E, P and P, C parallel to O, C and E, O, and joining the points O and P, the line O, P will be the resultant pressure perpendicularly upon the surface of the deflector.

In making use of this force it may either be taken as Q, O along the line at right angles to the vessel's course (C, D), or as P, Q in the direction C, D, and this latter being the direction really wanted, P, Q will be the useful effect extracted from the oblique reverse current.

The truth of these principles have been fully proved by some hundreds of experiments; one of the number will be sufficient; it was tried on a tug boat belonging to the Grand Junction Canal Company. The screw had three blades, and was 3ft. diameter. The boat was arranged to show its hauling power by a dynamometer, and was tried at first with the screw alone; then lifted out of the water by a crane, and the deflectors attached behind the propeller. The following results were obtained:—

*Experiments to Determine the Latent Power in the Reverse Currents.*

| Description. | Steam pressure. | Revolution of screw per minute. | Tension on dynamometer. |
|---|---|---|---|
| | lb. | Revs. | cwt. |
| Screw alone ................................ | 70 | 240 | 6¼ to 6½ |
| Screw and deflectors ...................... | 65 | 230 | 7¾ to 8 |

Thus it may be considered as proved, 1, that the propeller drives a column of water backwards; 2, that this column possesses a certain rotary motion; and, 3, that hereby ensues a loss of useful effect.

The Figs. 1, 4, and 5, give the theoretical effect of the action of one portion of a screw-blade only; but as ordinarily constructed a great variety of inclinations exist in one and the same propeller, it will be necessary to examine how this system will elucidate practical questions connected with the proper form of blade, &c.

Fig. 9 is a side and end elevation of a true screw 10ft. diameter and 17ft. pitch, making 65 revolutions per minute, and propelling a ship at 7½ knots per hour, or 11·7ft. in each revolution of the screw, being what would be called a positive slip of 31·2 per cent.

Fig. 11 is a diagram constructed to show the action of the extremity of the screw blade; F, C being the circumference to a scale, E, H the pitch, V, N the advance of the ship in one revolution = 11·7ft., and M, V, the reverse current = 14·8ft. measured straight backwards.

As the water moves backwards, M, V, and the ship forward, V, N, clearly the current which would pass through the screw, supposing there to be no loss by friction, would be M, N, while the blade moves from F to E = 26·5ft. in the present example. While the current is moving a distance, M, N, in consequence of the impulse given by the screw-blade, a revolution has taken place, and the same blade re-enters, this current having passed a distance, E, H, forwards; consequently the water would travel a greater distance backwards than the screw moves forward, and there must therefore be a check given to its progress. In the case of such a screw as the one illustrated in Fig. 5, this check is a very serious hindrance, and shows itself by the very deep honey-combing upon the back of the leading corners of the blade. This is caused by the blow given by the current moving faster backwards than the screw allows it to do.

Fig. 12 is a similar diagram at the diameter 5ft. 4in., V, X is the advance of the ship = 11·7ft., W, V the reverse current = 5·3ft., and E, H the pitch = 17ft. In this case the sum of the ship's progress and the reverse current are exactly equal to the clearance given by that blade, namely, 17ft., and the honey-combed appearance above named could never be seen on a screw set as so great an angle as this portion of the blade.

It is evident that there can be very little diminution in the speed of the currents between the times that one blade leaves and the succeeding one enters, otherwise a great number of blades would give a better result, so far as speed is concerned, than two blades, but this is not the case; and, indeed, one blade is sufficient to propel, though somewhat unsteadily.

A succession of diagrams may be taken at different radii of this screw, and it will be found that at a diameter of 3ft. 8¾in. there will be no reverse currents whatever, and, therefore, no propelling power; but of course upon another ship this circle would probably be larger or smaller. As there is no propelling power within this space, it only remains to contrive this part of the screw so as to give the minimum of resistances to the current flowing through, and the circumstances of any particular ship decide the best means of accomplishing this object.

The angle of the blade in the outer portion of the screw will have to be set in such a manner that the total current, M, N, (Fig. 11) shall have passed over a distance neither more nor less than E, H, by the time that the blade returns into the current it has already impelled. Where the reverse current bears a high proportion to the ship's progress it is evident that there may be a greater diminution of speed than where M, V bears a low proportion to V, N, because M, V is the variable element and V, N, the ship's progress, is constant. Still further experiments are wanted to make this question more clear, and to establish reliable data. The influences due to the slip upon the currents are, first, the deviations which take place owing to the water closing in behind, and entering into the area swept over by the screw; and, secondly, the effect produced by the currents as they pass away from the screw. The action of the rudder is in the main detrimental, because it summarily checks the rotation of the currents, without absorbing the power that has been expended in producing this rotation.

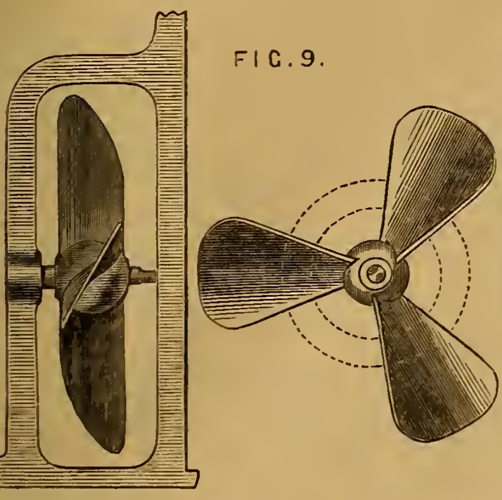

FIG. 9.

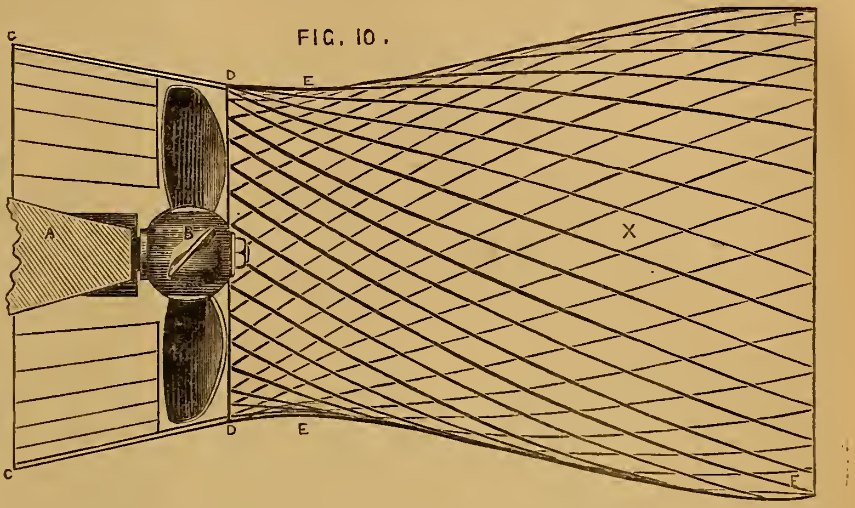

FIG. 10.

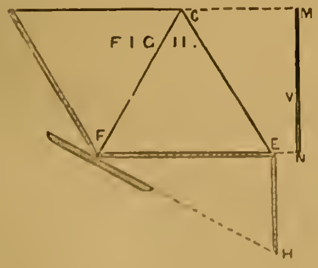

FIG. 11.

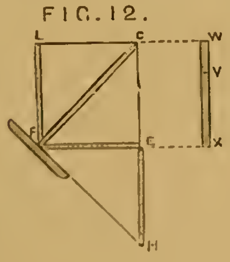

FIG. 12.

A (Fig. 10) is the stern of a ship in plan, and B a screw-propeller giving a deflection of 35 deg. to the reverse current at its extreme radius. As the ship makes progress through the water the currents close in behind it, as C, D, converging, and joining together somewhere about the point X, forming what may be aptly described as a wedge of water, of which the portion from B to X is only partially filled.

The first effect of motion being given to the screw will be to suck a considerably greater quantity of water along C, D, and (particularly if the ship have a full stern) this will make the currents to converge still more; and render the space between B and X almost empty. Indeed, in some ships this space may be seen as a sort of whirlpool, close behind the screw. When the pressure of the blade comes upon the water it will naturally flow in the direction where it encounters the least resistance; and when this vacant space is conveniently at hand much of the current which ought to run backwards really enters herein and performs no useful work. Now if the screw have a large boss, as shown in Fig. 10, there is no vacant space into which the water can enter, and it is driven backwards and set in rotation by the blades of the screw. When a ship has a full stern the converging currents leave a very large vacant space, and it has been noticed experimentally that in such cases the large boss is peculiarly advantageous.

Even with this large boss there is still nothing to prevent the currents converging behind it; but a very simple expedient removes this difficulty. By bending the blades or curving them forward towards the ship, a centrifugal tendency is imparted to the current as it leaves the screw, which exactly balances the centripetal tendency of the column of water, and it passes backwards in a parallel twisted column. As this reverse current passes backwards, it gradually draws into motion the adjacent particles of water, it spreads wider, and at last loses all its motion and returns to a state of rest.

The well known fact that a screw propeller works best when deeply immersed, has often been brought forward as a convincing proof that water must resist the screw just as if it were a solid body; and that where the density is greatest there the resistance is greatest also. This argument, however, is quite fallacious and the real advantage gained by deep immersion is the opening of an additional source of supply for the screw, because water can now come from above in addition to the side supply; and the pressure materially assists in preventing the great evil of a semi-vacant space within and behind the screw; so long as there is an abundant supply of water in front, the screw will propel perfectly well if there be no water at all behind it. This can be seen with the hydraulic propeller, when the discharge pipes are above the surface; and when once sufficient water is forthcoming no further depression below the surface will be of the slightest benefit to the propelling power. It is also an utterly baseless assumption to suppose that water is less mobile at a little distance below the surface than it is on the surface; for in the experiments to ascertain the deflections of the currents mentioned in the earlier part of this paper, it was found that they were just as great below the the centre of the screw, and some distance under the surface, as within a few inches.

The foregoing considerations will show that there are many points to be considered in arranging the best screw-propeller for any particular example. The form of the stern will determine the inclination of the currents running into the screw, and its blades must be bent forward so as exactly to balance the centripetal tendency of the incoming water. The speed of the ship will determine the diameter of the circle within which propelling ceases, and it may be desirable wholly or partially to fill this area with a large boss. The form of the blades and their number will be adapted to the special character of the work required for the screw. And there are many other points which the foregoing principles make more clear. There is no question that the screws of many ships are not at all adapted to the work to be done; and the most common defect is having too fine a "pitch," perhaps with the idea of gaining power, by running a smaller engine quickly or obtaining a certain empirical number of revolutions per minute.

The principles that regulate the true proportions of a screw-propeller are not complicated if taken one at a time; but there are so many that work into and influence each other that the final result is often obscure; and after all that has been done to investigate the subject there is still much want for extended general practical knowledge; and it may be hoped that the foregoing investigation and experiments may be of some assistance to those who are specially interested in the subject, and even if they are of no further use than to get rid of some of the venerable theories which now obscure the action of the screw-propeller they will have been of no small service; for the existing theories can no more explain all the observed facts than can the ancient systems of astronomy explain the movements of the planets and stars.

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The extraction of oils by means of bisulphide of carbon is now carried on at Moabit, near Berlin, upon a very large scale. In the manufactory of M. Heyl 2,570 kilogrammes of oil, of sufficiently good quality to be employed in lubricating machinery, are manufactured daily. Colza and linseed are the materials chiefly operated upon, and the residues serve to feed cattle. The seeds are first crushed, and dried by heating. For the daily fabrication of 2,570 kilogrammes of oil only six men are required. Analysis has shown the residues to contain only 2 per cent. of oil and 7 per cent. of water, while the residues of the ordinary pressure process contain 9 per cent. of oil and 15 per cent. of water. In the extraction of the oil 7,000 kilogrammes of bisulphide of carbon are used daily, and the amount lost is 28 kilogrammes.

## MANCHESTER ASSOCIATION FOR THE PREVENTION OF STEAM BOILER EXPLOSIONS.

The last ordinary monthly meeting of the executive committee of this association was held at the offices, 41, Corporation-street, Manchester, on Tuesday, September 29th, 1868, Samuel Rigby, Esq., of Warrington, in the chair, when Mr. L. E. Fletcher, chief engineer, presented his report, of which the following is an abstract:—

During the past month 266 visits of inspection have been made, and 564 boilers examined, 402 externally, 12 internally, 4 in the flues, and 145 entirely, while in addition 4 have been tested by hydraulic pressure. In these boilers 95 defects were discovered, 2 of them being dangerous. Furnaces out of shape, 2—1 dangerous; fractures, 19; blistered plates, 6; internal corrosion, 24 external ditto, 5—1 dangerous; internal grooving, 7; external ditto, 7; water gauges out of order, 3; blow-out apparatus ditto, 2; pressure guages ditto, 3; without feed pressure valves, 17.

The case of external corrosion referred to in the preceding list, was met with in a boiler set on side walls with sheets of copper placed between the plates and the brickwork seating, the corrosion occurring where the boiler was in contact with the copper plates. The boiler was set near to a tidal river and below high water mark, in consequence of which the brickwork was damp. The external brickwork flues were scarcely large enough to admit of complete examination, but on suspicion being aroused the boiler was raised from its seat and drilled in the thinnest parts, when the plates were found to be considerably reduced, and in places little more than one-eighth of an inch in thickness.

In another case met with a short time since, a boiler set on side walls of the unnecessary width of 10in. was seen to be corroded at the seatings; but as the plates were not bared for inspection, the extent could not be ascertained. A request was consequently forwarded to the owners for facilities for making a complete examination, and the guarantee withheld meanwhile. On our inspector's next visit to the works he found that the suspected plates had been laid bare, and serious corrosion ascertained to extend almost from one end of the boiler to the other. A hole had been knocked through nearly every plate, one of them being reduced to the thickness of one-sixteenth of an inch, in consequence of which the owners thought it prudent to condemn the boiler, and a new one was in process of manufacture and shortly expected at the works.

### EXPLOSIONS.

During the past month, two explosions have occurred, by which two lives were lost, but neither of the exploded boilers were under the inspection of this association. The scene of the catastrophe has been visited by officers of this association, and minute details obtained, but on account of want of space on the present occasion, reference to these is deferred to a future report.

TABULAR STATEMENT OF EXPLOSIONS, FROM AUGUST 22ND, 1868, TO SEPTEMBER 25TH, 1868, INCLUSIVE.

| Progressive Number for 1868. | Date. | General Description of Boiler. | Persons Killed. | Persons Injured. | Total. |
|---|---|---|---|---|---|
| 34 | Aug. 31 | Bleaching Kier, Cylindrical, camber-ended ......... | 1 | 0 | 1 |
| 35 | Sept. 17 | Vertical Furnace, Externally-fired ...... | 1 | 0 | 1 |
| | | Total.................. | 2 | 0 | 2 |

## MEETING OF THE BRITISH ASSOCIATION AT NORWICH.

### DYNAMITE.

By M. NOBEL.

(*Concluded from page* 256.)

Another sterling advantage of dynamite is that it needs no tamping, and consequently does away with a great number of minor accidents, which are little thought of in general, being too common to be reported in the daily papers, but form nevertheless a very long and sad list of continued calamities. I was told in Cornwall that by far the greater number of accidents, occurring in the mines of that country, are due to the act of tamping. It is abuse, I admit, for a hole may be tamped without firing the charge; still, it is very desirable to provide against a source of accidents which, after centuries of experience, still continue to exact such numerous victims. It would be a great drawback on the advantages here set forth if, as has been sometimes asserted, the fumes of nitroglycerine or dynamite were of a noxious nature. The best answer, perhaps, to those who maintain that opinion, is that a great number of mines are daily using it for underground work, and that the miners do not at all complain. The truth is that when nitro-glycerine is allowed to leak into the crevices of a borehole, it does not all explode, and being dispersed in the atmosphere causes a very severe headache. It is, however, easily remedied by using cartridges, which prevent leakage, and in the case of dynamite, which is a solid, that inconvenience falls away entirely. Since that explosive became introduced no complaints have been made, and the workmen in many mines assert that dynamite cannot be nitro-glycerine, because the fumes are so different.

So far its properties, and now we will examine the practical results. The introduction of dynamite is so recent that its advantages over other blasting agents cannot be proved by statistics. But in all except danger it is so analagous to nitro-glycerine, that the results obtained with the latter will allow us to form a clear estimate of its commercial value. Sweden is the only country where nitro-glycerine has been in use ever since 1865; it is therefore the most conclusive example. The sales in that country, as estimated from the books of the Nitro-glycerine Company at Stockholm, were, in 1865, 32,258lbs.; in 1866, 48,785lbs.; in 1867, 76,575lbs.; and during the first six months of the present year reached 64,293lbs. These figures show a steady and rapid increase. The quantities are not enormous, but it should be borne in mind that Sweden, although an extensive country, is not a very productive one, and that Cornwall alone consumes three times as much gunpowder as the whole of Sweden. The sale of 221,900lbs. of nitro-glycerine in that country, equal to at least 2½ million pounds of gunpowder is therefore a proof of decided success. If the material had, over gunpowder, the advantage of cheapness, weight for weight, the demand might possibly be ascribed to futile and mistaken economy; but as 1lb. of nitro-glycerine costs the miner as much as 8lb. of gunpowder, it is evident that it must do some work or he would not have it.

It has no doubt greatly facilitated the introduction of nitro-glycerine into Sweden that the transportation, storage, and use of the quantity above mention, has caused no accident of any serious nature: and positively a less total of minor accidents than if gunpowder had been used in its stead. That immunity from danger is, in all probability, due to the colder climate of Sweden, which allows of nitro-glycerine being transported, nearly all the year round, in a congealed state, its freezing point being as high as 50°. In this country nitro-glycerine, notwithstanding the strong dislike which generally prevails against it, has been constantly used in the quarries of North Wales since 1866, and is in high favour with the miners. Two quarries alone (Brynderven and Driwrwick) have up to this time consumed about £3,000 worth of the material or about nine tons; and its remaining stationary in North Wales is owing only to the circumstance that the manufacture and sale of the article has not been in this country as in Sweden—an organised business. The workmen in Wales pay for the material, which they consume, the price of 3s. 3d. per pound, while gunpowder costs only 4½d., and if they continue to do so for years it proves that they derive a benefit from its use. Still a slate quarry is far from showing it at its greatest advantage, which can only become prominent in hard rock.

Whatever success nitro-glycerine has realised it will certainly be admitted that it is not due to popular favour. No improvement has ever worked its way under a more crushing weight of opposition, and the very fact of its having stood it, is perhaps the best proof of its valuable properties. Guncotton, which has been repeatedly pushed for more than twenty years, has not beeen used for blasting in all that time as much as nitro-glycerine in six months. Why? because the miners had no advantage at all in using it.

In mentioning guncotton, it is but just to state that it has been highly improved of late by Professer Abel, I believe, and is sold now in a condensed state, in which it forms a good blasting agent, and ranks as such next to dynamite. Only a few years ago the attempts which I witnessed to make guncotton take the place of gunpowder appeared to me to be perfectly fruitless Bulk for bulk it had less power, and that power was even more expensive than the powder which it was meant to supersede. A new explosive cannot be introduced when the economical advantages are on the wrong side; and is next to impossible to get adopted by miners unless the advantages are very great and of a payable nature. But compressed guncotton is decidely superior to gunpowder as a blasting agent, and if it cannot compete with dynamite it is only because the manufacturing cost of the latter is less, while it possesses at least three times more power, and effects a far greater saving of labour. Details are only a matter of time and improvement, while the intrinsic merits of a substance decide the place which it is to occupy.

Nitro-glycerine has of late been prohibited in Belgium. It is of no consequence now that a substitute of equal power and greater safety has been found, but, as a legislative measure, it is remarkable for its absurdity. It was issued by the Minister of Commerce immediately after the late accident at Quenast. The cause of that accident is unknown, and even if it should have been of such a nature as to render a prohibition desirable, it is quite unwarrantable to proceed without careful inquiry. Steam has caused plenty of accidents, and it is a wonder that philanthropic governments have not prohibited its use. They seem entirely to forget that every article, if it has some drawbacks, is capable of improvement, which is necessarily stopped by giving it the deathblow of prohibition. It is entirely opposed to the spirit of our age, and can only be looked upon as a useless and troublesome muzzle on our liberty of action.

In Sweden, also, a prohibition has lately been issued against nitro-glycerine, which, by many persons in this country, I understand, has been mistaken as referring also to dynamite. Such is not the case. The latter substance has simply been subjected to the same regulation as gunpowder, and that only, as it is plainly stated, until its properties have become better known, so as fully to warrant a more liberal legislation. Prohibitions, as a rule, are as little liked in Sweden as here, but in this instance it was issued at the instigation of the Stockholm Nitro-glycerine Company, and only with a view to greater safety, since the new explosive, dynamite, is considered fully equal to take its place. For my part, I would never have petitioned for such a prohibition, there being something revolting to me in these forced leading strings. It is very likely that the miners who have got used to nitro-glycerine, and have yet a little schooling to go through before they find out that dynamite is fully its equal, will raise a strong opposition against the measure, and I should not wonder if the Government was forced to withdraw it. I know nothing, with the exception of, perhaps, a liability to spontaneous combustion, which could possibly warrant the absolute prohibition of a substance. Now as for nitrated organic compounds in general, it is a decidedly erroneous notion that there is any such drawback attached to them. That notion has sprung up in laboratories because the chemist has no suitable means at hand for thoroughly neutralising the adhering acid. It is well known that the continued action of nitric acid decomposes nearly every organic compound. It is therefore clear that unless nitrated compounds are rid of adhering nitric acid they will decompose in course of time. Hence we read in nearly every chemical work that nitro-glycerine is gradually decomposed, deposing oxalic acid, while such a change has never occured in the same article manufactured on a large scale. With suitable apparatus it takes less than one hour to completely neutralise a ton of nitro-glycerine, and as a further control a small quantity of every day's produce after it has been well mixed, so as to be fully uniform, is sealed and kept for inspection. That practice has now been carried on for eighteen months, and shows not the slightest vestige of decomposition in any of the numerous samples.

Having to store large quantities, not only in six factories, but also in numerous depôts, it is but natural that I should have been anxious myself to investigate the matter. In the case of dynamite it is true that spontaneous combustion could mean only its catching fire and burning without explosion, since internal or external heating must naturally have the same effect; still spontaneous combustion, even where no explosion can ensue, is a serious evil. Fortunately the tendency of organic compounds to decompose under divers influences increases so rapidly with the increase of temperature, as to render an investigation very easy without having to rely on the tedious experience of years. I kept a small quantity of dynamite for forty days and nights exposed in a current of heated air, the temperature of which varied between 140° and 203°, after which time it was found perfectly unaltered, only there was a loss in weight of about 2½ per cent. due to a slight evaporation of nitro-glycerine at that high temperature. Adding to safety tests like this the circumstance that nitro-glycerine has now been stored in many factories and depots for about four years, and in large quantities, without ever causing an accident or having been found to deteriorate, I think that there is ample proof of its stability. Nature indeed, is not so treacherous as she is sometimes accused of being, and there are few substances, except those of a very complex composition, which cannot be stored without deterioration.

## THE INSTITUTION OF CIVIL ENGINEERS.

This was the first meeting of the Session 1868-69, and it was held in the New Building, erected during the recess, and upon the completion of which, according to the promise made by the Council, the President congratulated the Members; taking occasion to remark, that the Council had placed upon their private minutes a unanimous vote of thanks to the architect, Mr. T. H. Wyatt. The President observed that the contractors, Messrs. Holland and Hannon, were also entitled to commendation, for the manner in which they had carried out the works, within the time specified in the contract—a result to which the personal care of the Secretaries had largely contributed.

## ON LIGHTHOUSE APPARATUS AND LANTERNS.

By Mr. David M. Henderson, Assoc. Inst. C.E.

It was stated that this communication might be regarded as a sequel to the paper "On the Optical Apparatus of Lighthouses," by Mr. James T. Chance, M.A., Assoc. Inst. C.E., read during the Session 1866-67.

The glass used in lighthouse apparatus was nearly all made at Saint-Gobain or Birmingham, and was of the kind known by the name of crown glass. Different mixtures had been employed for the purpose; but M. Raynaud, the Director of the French lighthouse service, now gave the composition as—

| | |
|---|---|
| Silica | 72·1 |
| Soda | 12·2 |
| Lime | 15·7 |
| Alumina and Oxide of Iron | traces. |
| | 100.0 |

At Birmingham various mixtures had been tried, of which several examples were given, the following being about an average:—

| | cwt. | qrs. | lbs. |
|---|---|---|---|
| French Sand | 5 | 0 | 0 |
| Carbonate of Soda | 1 | 3 | 7 |
| Lime | 0 | 2 | 7 |
| Nitrate of Soda | 0 | 1 | 0 |
| Arsenic | 0 | 0 | 3 |

English glass was supposed to be of the refractive index of 1.51. That produced at Saint-Gobain had formerly an index of refraction as low as 1·50, but now it was 1·54, and frequent experiments were made to ascertain that the standard was maintained.

The furnace for melting glass was generally rectangular in plan, and was constructed of the most refractory materials; and the sides were arranged so as to allow of the easy withdrawal of the pots. Six, and sometimes eight, pots were placed in the furnace, arranged in pairs with a firegrate at each end. The flame filled the whole interior of the furnace, and after circulating round the pots, which were covered to prevent the colour of the glass being injured by dust, or impurities from the coal, found its exit by flues. Great care was necessary in the preparation of the pots, which were made of about one-half new fire-clay, and one-half old pot-sherds finely ground. The length of time a pot would last depended upon (1) the quality of its manufacture; (2) its being slowly and thoroughly dried—a process occupying about six months; and (3) the care bestowed upon it in the furnace, and whilst withdrawn for casting. The average number of castings from each pot was about twenty; and the time the pot was out of the furnace at each casting was about three minutes. It was mentioned that Mr. Siemens' Regenerative Furnaces were now in use for the manufacture of lighthouse glass with perfect success. When the metal was ready for casting, each pot was lifted from its seat, withdrawn from the furnace, and carried to the foot of a crane, the lifting chain of which had attached to its end a clip to embrace the pot. A mouth-piece of wrought iron was fitted to the pot before casting, to facilitate the pouring, and the workmen tipped over the pot, by means of long handles.

The casting table was circular, and was mounted on a frame, so that by means of a handle it could be turned round, and each part of its outer circumference brought consecutively under the pot of molten metal. The moulds into which the glass was to be cast were arranged round the outside of this table, and were caused to revolve slowly under the continuous stream of liquid glass flowing from the melting pot, so that each mould was filled in succession, thereby enabling the immediate return of the empty pot to the furnace. The moulds were of cast iron, of a uniform thickness of ⅝in., and were supported on feet cast on, the size being such as to allow ⅛in. thickness of glass all round for the grinding process. The small lens-rings and prisms were cast in one piece, but the larger ones were cast in segments. The large belts, or central lenses for fixed lights, were generally cast flat, and were afterwards bent on a saddle to the required curve in a kiln.

Sand, emery, rouge and water were the four necessaries for glass grinding and polishing. The sand had to be applied, with abundance of water, until it lost its cutting qualities. The emery, after being ground to a fine powder, was agitated in water, and the mixture was passed through a series of vats or tubs, so that the emery was divided into as many qualities as there were tubs, the coarsest being deposited in the first tub, the finest in that furthest from the supply. The rouge, which was an oxide of iron, was prepared from the sulphate, and was separated into qualities by means of water tubs, as in the case of the emery. The glass of optical apparatus was ground on horizontal circular tables, securely fastened to the tops of wrought iron vertical spindles, which received motion from the main shafting in various ways. The surfaces of these tables were divided out, like the face plate of a lathe, to receive the different sizes of 'carriers,' or supports of cast iron, which were bolted to them, and were arranged to hold the lenses or prisms to be ground. Plaster of Paris was then laid on the "carriers' in bands, the bands being reduced to the exact size by turning the table round under a gauge secured to the framing of the machine. The glass was laid on those strips, and was secured in place by means of pitch, care being taken in the larger sizes, which were ground in segments, to place a thickness of pitch between each joint, so that the glass did not touch glass. A detailed account was given of the method of grinding a belt, or central lens, of a fixed light, and also of grinding a bull's eye or central piece of an annular lens.

The various sizes of catadioptric lights were next given in detail; and it was stated that, in order to produce a distinction between different lights, some were fixed and others revolving, while there were many combinations of the two classes. Again, there were modifications to render fixed lights intermittent, and colours had also been employed, to both fixed and revolving lights.

In reference to the method of mounting the lenses and prisms, it was remarked that sea-lights on account of their size and weight, were necessarily divided into several portions. The section of the apparatus, consisting of lower prisms, lenses, and upper prisms, gave a convenient division into three tiers, each of which was sub-divided into eight panels of 45° each, which were made of gun-metal racks, or side pieces, formed to receive the lenses or prisms, these side pieces being connected together by gun-metal segments of rings at the top and bottom. The author then proceed to describe minutely (1) one segment of a first order light, in which all the joints of the panels were vertically over each other; (2) an arrangement with inclined lens-panels, the upper prism panels being so placed that their joints did not come vertically over those of the lower prism panels; (3) a first order apparatus, where the upper and lower prisms were fixed; (4) an eight-sided revolving light, collecting the whole light into eight beams of parallel rays; and (5) a first order apparatus, commonly called a 'Fixed Light varied by short Eclipses,' a title which did not convey the actual effect, as the fixed light was followed by an eclipse, then a flash, and next an eclipse, the same phases being continually repeated.

The construction of the panels are referred to in detail; and it was observed that, when the fitting was finished, the panels were taken to the erecting shed, when they were erected on their pedestals, or on, what was more convenient, a revolving table, specially constructed so that each panel, or part of a panel, could be brought in succession opposite the erecting post. The prisms were passed into their places, one end covering plate of the panel to be set being removed, and wooden wedges were used to support the glass and enable it to be accurately adjusted in its position by means of internal observation, as explained by Mr. Chance in his paper. When the prisms were adjusted, plaster of Paris was applied at all the corners, to retain the prisms in their correct position, and when fairly set, the wedges were removed and the remaining spaces filled in with best red lead putty.

The arrangement of panels generally adopted was that of placing one panel over the other, so that the joints should be vertically over each other. It had in its favour simplicity, a minimum loss of light, a minimum cost, and strong, convenient-shaped panels. These advantages had been considered of such importance, that in France this method was still adhered to, and all the lanterns were constructed with vertical standards placed in front of the obscuration caused by the sides of the panels. This plan, however, rendered as many points, on rather small arcs, on the sea as there were standards in the lantern, to be illuminated with a considerably weaker light. The late Mr. Alan Stevenson was the first to introduce inclined lens-panels, with a view to equalise the distribution of light on the sea, but he was no doubt well aware, that the total loss of light would be increased. Inclined standards bad been adopted in several instances, but without any alteration in the optical apparatus. The horizontal divergence, resulting from the size of the burner in a particular case alluded to, might be taken at 6°, and the standard was inclined over an angle of 7½° in plan, so that when an observer was placed in front of the standard, it nearly stopped off the light from him throughout its entire height commencing on one edge of the flame and finishing on the other, thus obstructing much light which had successfully passed through the apparatus. The lantern of Mr. Jas. N. Douglass, M. Inst. C.E., the Engineer to the Trinity House, was designed to render impossible a correspondence, or optical coincidence, between the framing of the apparatus and that of the lantern. In the author's opinion, this lantern was expensive, from the amount of workmanship of a costly class, and from the glass cut to waste.

An arrangement had been designed by the author, with a view to obviate the objections to previous methods. The first consideration was the optical apparatus, and it was apparent, that a minimum amount of light was stopped by vertical panels, and that it was possible to divide the previous large obscurations into a greater number of smaller ones, thus equalising the light without increasing the total observation. By excentering, or placing the various tiers of panels so that their joints did not come vertically over each other, each previous obscuration was divided into three. The amount of excentering necessary depended upon the size of the flame, so as to enable one obscuration to be completely passed before entering upon another. In a first order, for example, the panels were 45° each; and, as there was an intermediate rack in the prism panels, there was a space of 22½° between each obscuration. Each large obscuration could be divided into three small ones, which, if placed at intervals of 7½°, would never allow more than one obscuration to be visible at a time. The next consideration was the lantern, which, when arranged with excentered panels, was rendered less rigid, owing to its weight not being transmitted continuously downwards, as was the case with vertical continuous standards. This want of rigidity would be objectionable in a light illuminating the whole horizon, but in those illuminating from 180° to 270° (which were by far the most common), the dark arc could be filled in with solid iron plates, by which any amount of rigidity could be obtained. By the substitution of triangular frames in the central tier, it was still possible to retain the upper and lower panels excentered, and to render the framing perfectly rigid, in fact more so than with the vertical continuous bars of the old lanterns.

A detailed description was then given (1) of a first order lantern with inclined standards (2) of the lantern to which the French engineers adhered for all apparatus burning oil, and (3) of the lantern arranged by the author to ensure the most uniform distribution of light.

The three principal varieties of lamps in use for sea lights were the mechanical, the high reservoir, and the pressure. The mechanical were the most general, being used in Scotland, France, and many foreign countries. The oil was forced over the burner by pumps, which were worked by clockwork placed underneath and driven by a weight. One of the best high reservoir lamps was that designed by Captain Nisbet, of the Trinity House, and which had been applied to several English lighthouses. Lamps of this class were not, however, applicable to revolving lights, or those illuminating all the horizon, on account of the obstruction of light that would be caused by the reservoir. The pressure lamp of M. Degrand, of Paris, was next noticed. In it the oil was forced over the burner by means of a weight pressing directly on the surface of the oil. It was found that the large space between the piston and the cylinder in this lamp rendered the leather packing liable to turn over when the oil got heated, and softened the leather; added to this, there was no provisions for varying the weights on the piston. To meet these objections, M. Masselin designed a lamp with external weights which gave excellent results, and had the advantage, not possessed by the high reservoir lamps, of being equally well adapted for fixed and revolving lights, whether the whole horizon was illuminated or not. This lamp was minutely described, and in the next section of the paper an account was given of a first order clockwork, consisting of two trains of wheels, one for driving the apparatus, and the other for driving a fly wheel with adjustable vanes for regulating the speed.

In conclusion, the means adopted for lighting the entrance to Odessa harbour were described. At the extremity of one breakwater a tower was built, to contain a fourth order optical apparatus fixed for 270°, with a metallic reflector for the remaining 90°. At the extremity of the other breakwater a beacon was erected, but it was required that a light should be shown without there being a lamp, or any metallic reflector, at that place. Accordingly a sixth order holophote was placed in the tower, to collect all the light from its lamp into one beam of parallel rays, which was thrown across the entrance to the harbour to illuminate the beacon, producing thus what was called an apparent light. On account of the distance of the beacon from the holophote, 300ft., much light was lost, and the divergence of the beacon was small, but ample for what was required, as it was placed low, and a range of only about one mile was required.

The communication was accompanied by fifty-six large diagrams, and by six sheets of carefully executed drawings to a reduced scale.

A report was brought up from the council stating that, under the provisions of Section IV. of the by-laws, the following candidates had been admitted, since the last announcement, students of the institution:—Charles Toler Burke, George Ernest Faithfull, Henry James Samson, and Herbert de Symons Skipper.

## THE ROMAN ROCK LIGHTHOUSE, SIMON'S BAY, CAPE OF GOOD HOPE.

By Mr. John Frederick Bourne, M. Inst. C.E.

The object of this communication was to point out the causes of failure of the original structure, and to give an account of the mode of securing the tower against further injury.

The late Mr. Alexander Gordon, M. Inst. C.E., was intrusted with the design, and with the superintendence of the construction of the ironwork and lantern in England. The design was for a circular tower, 15ft. in diameter and 48ft. in height, of cast iron plates, with a central column, 16in. in diameter, as a well for the weight of the revolving machinery. There were eight plates in the circumference of the tower, and six plates, each 8ft. long, in the height. But to admit of the horizontal joints of each vertical sets of plates breaking joint with those of the contiguous vertical sets, there were four plates of 4ft. high each and four of 8ft. each in the first and last sets of plates. The door-sill and level of the first floor were 24ft. from the foundation; the whole interior up to that level being intended to be filled in with concrete. If the building, as designed, had been skilfully and carefully erected, and filled in with good material, there was no reason to doubt that it would have answered the required purpose, and have stood well. But it failed, and was condemned as being dangerous.

The first cause of trouble, and which led to immense additional expenditure of time and money, arose from the lowest portion of the rock being chosen for the site, on account of its being more level. The next error was cutting the foundation pits too deep into the rock, for the purpose of getting as much solid core as possible for the inside of the tower. In order to give a core of 6in. at the lowest spot, it was necessary to leave it 2ft. 9in. high at the highest point; and as the groove was formed by blasting, for the sake of saving labour and time, the rock was much injured. Every sea of course filled the annular foundation pit, rendering it difficult to work. Two channels were therefore made, by blasting, one on each side, to allow the water to run off; and these channels were very annoying at a later period. It was found impossible to cut the foundation pit true and level, or so difficult that the attempt was abandoned; and the holding-down bolts were so imperfectly secured, that some of them drew when screwed up. Nor was the circle true in plan. Not only had the bottom flanges of the plates to rest upon uneven bearings, being wedged up in some places with blocks of teak, but they were forced, when screwed together, to take a form to which they were not cast. When the plates were tightly bolted together, and the concrete was filled in to its full height of 24ft., the plates began to crack vertically in six different places, one crack extending 28ft. high; so that it became necessary to hoop the tower with wrought iron hoops. In this condition the lighthouse was completed and was used for some time. The erection occupied five years, and the cost was stated to have been about £17,000.

The lighthouse was built by the Imperial Government, and the arrangement was that, when completed to the satisfaction of the Colonial Government, it was to be maintained and lighted by the Colony. Owing to its patched-up state the Colony refused to undertake its maintenance, and consequently a long correspondence ensued, when a proposal, made by the author, was eventually adopted by the Board of Trade, that the tower, as it stood, should be surrounded to the level of the first floor, a height of 24ft. by a concentric ring wall of granite, 4ft. thick, with a backing between the wall and the iron plates of about 8in. of cement concrete.

The arrangements for conveying the stones to the rock, for landing them, and for setting them by means of a traveller running on a circle of fished railway bars fixed round the tower were described. Copious extracts from the Resident Engineer's journal of operations were also given, from which it appeared that, the foundation pit was cut by drilling holes, 1½in. in diameter, in concentric and radial lines, to the required depth, and breaking the pieces out with plug and feather. The bed was then dressed until it was perfectly true. The whole foundation was got out in two levels, the lower one not being so deep as the old foundation pit, or as the channels previously referred to. The journal shows that in 269 days after the work was commenced, in 1864, there were 102 days on which it was possible to do something on the rock, in 356¾ working hours, whilst in the same number of days in the year 1865, there were only 42 days when the work could be proceeded with, for 126½ working hours. But the year 1865 was exceptionably bad. The number of hands employed, all told, was generally 19. The four masons and two smiths received 6s. 6d. a day each, and the labourers who were employed in drilling, quarrying, and rough dressing, and pulling out to, and back from, and working on, the Rock, received 4s. 6d. a day each. It was satisfactory to be able to record, that the whole work was completed without any serious accident to the men. No difficulty was experienced in filling in the old pit and gullies in favourable weather, with Portland cement mixed with very little sea-water and chips of granite from the quarry. A temporary protection for each short length of pit, as it was about to be filled, was made with gunny bags, filled some with sand and some with clay. As the stiff cement and flakes of granite were laid, they were covered with tarpaulin and bags. Some time elapsed, owing to adverse weather, before the courses of stone could be laid. The work was commenced on the lee side of the tower, and carried round to windward on both sides for the first three courses, after which each course was commenced to windward, as, being 6ft. high, it was not so much exposed to the force of the sea, and it was more convenient in bringing round the stones. By the end of 1866 the work was at its proper height for putting on the coping. This was completed early in the following year, when the lighthouse was taken over by the Colonial Government.

## PREMIUMS.

### Session 1867-68.

The council of the Institution of Civil Engineers have awarded the following premiums :—

1. A Telford medal, and a Telford premium, in books, to George Higgin, M. Inst. C.E., for his paper "Irrigation in Spain, chiefly in reference to the construction of the Henares and the Esla canals in that country.

2. A Telford medal, and a Telford premium, in books, to Christer Peter Sandberg, Assoc. Inst. C.E., for his paper "On the Manufacture and Wear of Rails."

3. A Telford medal, and a Telford premium, in books, to Lieut.-Colonel Peter Pierce Lyons O'Connell, R.E., Assoc. Inst. C.E., for his paper "On the relation of the fresh water floods of rivers to the areas and physical features of their basins."

4. A Telford medal, and a Telford premium, in books, to William Wilson, M. Inst., C.E., for his "Description of the Victoria Bridge, on the line of the Victoria Station and Pimlico Railway."

5. A Telford medal, and a Telford premium, in books, to Charles Douglas Fox, M. Inst. C.E., for his paper "On new railways at Battersea; with the widening of the Victoria Bridge and approaches to the Victoria Station."

6. A Telford medal, and a Telford premium, in books, to John Wolfe Barry, M. Inst. C.E., for his paper "On the City terminus extension of the Charing Cross Railway."

*7. A Watt medal to Edwin Clark, M. Inst. C.E., for his paper "On engineering philosophy : the durability of materials."

8. A Telford medal to William Jarvis McAlpine, M. Inst. C.E., for his paper "On the supporting power of piles; and on the pneumatic process for sinking iron columns as practised in America."

9. A Telford premium, in books, to Thomas Login, M. Inst. C.E., for his paper "On the benefits of irrigation in India; and on the proper construction of irrigating canals."

10. A Telford premium, in books, to Allan Wilson, M. Inst. C.E., for his paper "On irrigation in India."

11. A Telford premium, in books, to Wilfrid Airy, Assoc. Inst. C.E., for his paper "On the experimental determination of the strains on the suspension ties of a bowstring girder.

12. The Manby premium, in books, to Andrew Cassels Howden, Assoc. Inst. C.E., for his paper "On floods in the Nerbudda Valley; with remarks on monsoon floods in India generally."

## SUBJECTS FOR PREMIUMS.

### Session 1868-69.

The council of the Institution of Civil Engineers invite communications on the subjects comprised in the following list, as well as upon others, such as 1° authentic details of the progress of any work in civil engineering as far as absolutely executed (Smeaton's account of the Edystone Lighthouse may be taken as an example); 2° Descriptions of engines and machines of various kinds; or 3° Practical essays on subjects connected with engineering, as, for instance, metallurgy. For improved original communications, the council will be prepared to award the premiums arising out of special funds devoted for the purpose.

1. On the present state of knowledge as to the strength of materials.

2. On steam cranes, and on the application of steam power in the execution of public works.

3. On the theory and details of construction of metal and timber arches.

4. On land slips, with the best means of preventing, or arresting them, with examples.

5. On the principles to be observed in laying out lines of railway through mountainous countries, with examples of their application in the Alps, the Pyrenees, the Indian Ghats, the Rocky Mountains of America, and similar cases.

6. On railway ferries, or the transmission of railway trains entire across rivers, estuaries, &c.

7. On the systems of fixed signals at present in use on railways.

8. Description of a modern English locomotive engine, designed with a view to cheapness of construction, durability, and facility of repair.

9. On the leading points of difference between the engines and carriages in use on railways in the United States and in Great Britain, and the reasons for any peculiarities in the American practice, with details of the cost of maintenance.

10. On the most suitable materials for, and the best mode of formation of, the surfaces of the streets of large towns.

11. On the construction of catch water reservoirs in mountain districts for the supply of towns, for irrigation, or for manufacturing purposes.

12. Accounts of existing water works; including the source of supply, a description of the different modes of collecting and filtering, the distribution throughout the streets of towns, and the general practical results.

13. On pumping machinery for raising water, both for high and low lifts.

14. On the drainage of towns, and the ultimate disposal of town refuse.

15. On the employment of steam power in agriculture.

16. On the ventilation and warming of public buildings.

17. On the design and construction of gas works, with a view to the manufacture of gas of high illuminating power; and on the most economical system of distribution of gas, and the best modes of illumination in streets and buildings.

18. Critical observations on estuary tides.

19. On the construction of tidal, or other dams, in a constant, or variable depth of water; and on the use of wrought iron in their construction.

20. On the arrangement and construction of floating landing stages, for passengers and other traffic, with existing examples.

21. On the different systems of swing, lifting, and other opening bridges, with existing examples.

22. On the measure of resistance to bodies passing through water at high velocities.

23. On the results of the best modern practice in ocean steam navigation, having regard particularly to economy of working expenses, by superheating, surface condensing, great expansion, high pressure, &c.,; and on the "life" and cost of maintenance of merchant steam ships.

24. On ships of war, with regard to their armour, ordnance, mode of propulsion, and machinery.

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* Has previously received a Telford medal.

25. On the measures to be adopted for protecting iron ships from corrosion.

26. On coal mining in deep workings, including machinery for dispensing with gunpowder in "getting" coal.

27. On the present systems of smelting iron ores; of the conversion of cast-iron into the malleable state, and of the manufacture of iron generally, comprising the distribution and arrangement of iron works.

28. On machinery for rolling heavy rails, shafts, and bars of large sectional area, and for forging heavy masses of metal.

29. On steel, and its present position as regards production and application.

30. On the safe working strength of iron and steel, including the results of experiments on the elastic limit of long bars of iron, and on the rate of decay by rusting, &c., and under prolonged strains.

31. On machinery for washing lead ores.

32. On the present state of submarine telegraphy, and on the transmission of electrical signals through submarine cables.

The council will be glad to receive, for the purpose of forming an "Appendix" to the minutes of proceedings, the details and results of any experiments or observations, on subjects connected with engineering science or practice.

The council will not consider themselves bound to award any premium, should the communication not be of adequate merit, but they will award more than one premium, should there be several communications on the same subject deserving this mark of distinction. It is to be understood that, in awarding the premiums, no distinction will be made, whether the communication has been received from a member, or an associate of the institution, or from any other person, whether a native or a foreigner.

The communications must be forwarded on or before the 1st February, 1869, to the house of the Institution, No. 25, Great George-street, Westminster, S.W., where copies of this paper and any further information may be obtained.

CHARLES MANBY, Hon. Sec.
JAMES FORREST, Sec.

## EXTRACTS FROM THE MINUTES OF COUNCIL, FEB. 23rd, 1835.

The principal subjects for which premiums will be given are:—

"1st. Descriptions, accompanied by plans and explanatory drawings, of any work in civil engineering, as far as absolutely executed; and which shall contain authentic details of the progress of the work. (Smeaton's account of the Eddystone Lighthouse may be taken as an example).

"2ndly. Models or drawings, with descriptions of useful engines and machines; plans of harbours, bridges, roads, rivers, canals, mines, etc.; surveys and sections of districts of country.

"3rdly. Practical essays on subjects connected with civil engineering, such as geology, mineralogy, chemistry, physics, mechanic arts, statistics, agriculture, etc.; together with models, drawings, or descriptions of any new and useful apparatus, or instruments applicable to the purposes of engineering or surveying."

## ROYAL BOTANIC GARDENS.

A remarkably useful set of statistics have already been obtained by Mr. S. W. Silver, of the Royal Botanic Gardens, Regent's Park, respecting the physical geography, climate, mineral products, food products, clothing, arts and manufactures, habitations, means of transport, &c., of various countries in different parts of the world. These statistics are, of course, far from being complete, and we therefore call the especial attention to those of our readers who may in a position to contribute to Mr. Silver's efforts. We cannot, perhaps, given a better idea of the kind of information required than by quoting his circular, which is as follows:—

"Dear Sir,—It being desirable that trustworthy information should be collected relative to the present physical condition of the British Colonies, the nature of the various countries, their produce and wants, it is proposed to collect data from persons residing in the colonies, and after condensing such facts to print them for general information. You are, therefore, requested to be kind enough to supply any facts of which you are personally acquainted bearing on the several subjects mentioned in the following summary, or any other information or suggestion you may think of value either to the Colonies or to England. It is thought best that all remarks should be confined to *material* subjects, and if made by persons acquainted with England—as illustration is better than description—it will be well to compare the climate, nature of land, products, &c., with the corresponding features of the mother country. You can either return the annexed form, filled up, or quote the letter and number of the question if you write more in detail. All communications to be addressed to me, as above, and posted so as to reach London with the least delay; a copy of the report, when printed, will be forwarded to you.—I remain, dear sir, yours faithfully, S. WM. SILVER."

## THE GAS SUPPLY OF MILAN.

The following particulars relating to the gas lighting of Milan are given by *Il Gas*, a monthly journal, just published at Milan. In 1787 this city was first lighted up, 1,158 oil lamps being used for this purpose. On the 31st of July, 1845, Milan was first lighted with gas. The streets were lighted with 377 gas lamps, and 800 of the old oil lamps; in all with 1,177 lamps. The price paid for gas was 38 centimes per cubic metre for public lighting, and 66 centimes by private consumers. In 1851, the number of gas lamps was increased to 494, and the price per cubic metre reduced to 35 centimes for public lighting, and 50 to private consumers. The total quantity of gas consumed per annum by the street lamps was 210,295 cubic metres, and the annual expense for the lighting the city amounted to 211,913 francs (including the 770 oil lamps which were still used in some of the streets). The number of private burners was 2,608, which consumed 620,800 cubic metres of gas per annum. From 1851 to 1863, the number of lights, both public and private, was greatly increased; and in 1864 a fresh contract was made with the municipality at 28 centimes per cubic metre, and with private consumers at 45 centimes. The following is the number of lights both public and private, the annual consumption of gas, and expenditure for lighting Milan from 1864 to 1867:—

| | 1864. | 1866. | 1867. |
|---|---|---|---|
| PUBLIC LIGHTING:— | | | |
| No. of street lamps | 1,794 | 2,469 | 3,082 |
| Consumption of gas, cubic metres | 761,306 | 1,061,154 | 1,195,638 |
| Annual expenditure, francs | 305,394 | 295,681 | 314,227 |
| PRIVATE LIGHTING:— | | | |
| No. of burners | 20,491 | 26,127 | 30,097 |
| Consumption of gas, cubic metres | 1,874,211 | 2,412,350 | 2,721,896 |

The illuminating standard, according to contract between the gas company and the municipality is, that each lamp should consume not less than 120 litres of gas per hour to equal 42 grains of Colza oil burnt in a Carcel lamp.

## CIVIL ENGINEERING IN INDIA.

The subject of engineering in our East Indian possessions must always be of considerable interest to the profession at home as affording a sort of safety valve to the superabundance of young engineering talent in this country. At the present time when we are still suffering from the 1866 panic, this is more especially the case, and it will therefore be interesting to know that the Indian Government contemplate carrying out considerable engineering work in the next few years. At last the Government seem to be alive to the immense importance of irrigation, this subject having been most unpleasantly forced upon them both by threatened and actual famine. In Central India, which has just escaped imminent famine, 194,050 acres only, out of 123,878,215, are irrigated. In the tract of Hindostan Proper, which has been desolated by seventeen famines in three centuries, there are still a million and a half of acres which must be irrigated to guarantee thirteen millions of human beings against starvation should the rain be scanty. And this is true of most other parts of India, even after all that has been done since Lord Dalhousie's time. The Ganges Canal consists of about 653 miles of main canal, and 3,000 miles of distributing channels; it now irrigates 700,000 acres. The Eastern Jumna Canal is 130 miles long, with 600 miles of distributing channels. Besides these, there are the Baree Doab Canal in the Punjaub, 153 miles of canal in Rohilkund, and 57 miles in the Doon between the Sewaliks and Himalayas. Sir A. Cotton has made the Madras works well known.

It is not expected that there will be many new works started next year, but as soon as the great trunk system of railways is completed which is expected to be accomplished some time in 1870, there will most probably be great activity both in supplementary lines and in irrigation. A fair number of projects of irrigation are either now being surveyed, or have been already sanctioned by the Government of India. In Madras the irrigation from the Pennair River in Nellore is to be extended, at a cost of £45,000. The great Chumbrumbunkum tank near Madras is to be enlarged at a cost of £35,000, and the Kistna Works are to be extended for £40,000. These are only a very few of the plans now almost matured by the Madras engineers for extending existing works. Mysore has received an Irrigation Department to itself, and the many fine old works there will be repaired and enlarged. The projected reservoir of Mauri Conwai is the largest of the new works planned in that fertile province. In Bombay the two important works of a dam on the Kistna River, in the Deccan, and on the Gurnah, in Kandeish, have just been finished. A large reservoir, to cost £90 000 is now in progress at Ekwook, near Sholapore, in the Deccan. A project for a dam on the Taptee is now under consideration. Since Colonel Strachey's visit to Desert Sindh in 1867, it has been resolved to convert the Indus inundation canals of that province into perennially flowing canals. Colonel Fife's projected canal is to be cut; also the Bigaree Canal, in Upper Sindh. There are smaller undertakings projected in Guzerat and the Deccan. Bengal suffers from inundations in some parts and drought in others. Both embankments and canals are therefore wanted there. The rivers raise their beds from the quantity of silt which they bring down, so that it is a question whether embankments do not cause more devastation in some places than that which they prevent in others. The Secretary of State was asked to consult scientific men on this subject, and Protessor Airey has expressed an opinion as to the great danger of embanking, but he has not gone sufficiently into detail to satisfy the Government of India that no remedy can be found for these periodical floods, especially from the Damooda and Mahanuddy, which sweep over the most populous and fertile parts of Bengal.

To regulate the Damooda river and drain the country a canal has been projected from the river at the coal mines of Raneegunge direct to Calcutta—a work which will arrest the sickness and promote the trade of some five millions of people. The surveys are now being made. On the other side of the Hooghly the Government is about to cut a canal, first recommended by Sir A. Cotton, from the Ganges at Rajmahal to Calcutta—a much vaster work than the other. Tirhoot and Northern Bengal, which are now threatened with famine, are to be provided for by canals from the Gunduck. Connected with these canals will be found the works in Goruckpore and Oude. The surveys for the great Sardab Canal are nearly complete. They have proved that there are two sites for the head of the canal at the *débouchure* of the stream from the Himalayas, and that it contains water enough to irrigate the country as far as Fyzabad, whence it may be extended to Azimghur, Jounpoor, and Benares. The East India Irrigation Company's works in Orissa have been admirably constructed, and now that the water-rate has been reduced one-half, the people are taking the water.

In Hindustan proper and the Punjab, the Ganges Canal is susceptible of improvement and extension. There are the Cawnpore, Futtehghur, and Etawah branches, canals of themselves. A new canal from the Jumna, below Delhi, is to irrigate the Muttra and Agra districts, and supply a line of navigation from Delhi to both of these cities, at a cost of more than half a million sterling. There is the draining of the Serai, in Rohilcund. Bundlecund is to be irrigated by canals from the Betwa. The Baree Doab Canal in the Punjab has never been completed, owing to the insufficient supply of water in the Baree, but the Beas river will be indented on so as to irrigate the country as far as Moultan. The Western Jumna Canal is to be greatly improved and extended, at a considerable cost. The Sutlej Canal project, broached in 1861, has been revived, and will be begun this cold season. One third of the water has been assigned to the Puttceala and other States adjoining the supply, and they will be left freedom of action in the management of the portions within their territory, subject to one general control. This canal will take up the good work of irrigation at the point to which the influence of the Jumna extends, and hand it over on the other side to the Baree Doab Canal, with which it will effect a junction. The cost will be more than two millions sterling. Attention has been directed to irrigation in the Peshawur Valley. In the Central Provinces two designs have been sketched—one from the Penub river, north of Nagpore, the other from Wurdah, to the south-west. In Burmah embankments are to be made at a cost of £100,000, and an officer having experience in deltaic rivers is about to be sent to examine the Irrawaddy.

It will thus be seen that there is a large field for engineering talent already sketched out in this country, and the question now remains whether the Government will afford sufficient remuneration to induce competent engineers to encounter the discomforts and risks of an Indian climate.

## DISASTROUS COLLIERY EXPLOSION.

In The Artizan of last month an account of the life cost of coal getting for the year 1867 was given in which the causes for some of the accidents were pointed out; but perhaps as no particularly disastrous explosion had happened during that year one fertile source of danger was not mentioned. It was observed a few years ago that it almost invariably happened that at the time, or shortly before the occurrence of an explosion the barometer had varied very considerably, and thereupon very little reasoning was required to connect the one with the other. It was immediately perceived that a high barometer, or in other words, an excessive pressure of the atmosphere acted upon the pent up gases of a coal mine in a similar manner to an extra weight on the safety valve of a steam boiler, and prevented them from escaping; while on the other hand a low barometer afforded proportionately increased facility for their escape. Thus an unusually high barometer, followed by an excessive fall, is a period when special care should be exercised in the inspection and ventilation of mines. This fact was pointed out by a scientific writer, and published in several of the daily papers only a few weeks ago; yet as soon as such a peculiarity as above described occurs in the state of the air a terrible explosion has occurred at the Arley Mine, Hindley-green, near Wigan, resulting in the loss of fifty-seven lives.

The workings extended due east and west. Upon the east side there were about a hundred and fifty men and boys employed; while upon the west there were sixty or seventy.

At six o'clock in the morning, before the day shift men descended the mine, an examination of the workings on both sides was made in the usual way by two firemen. They reported the mine free from danger, and the miners descended. Nothing remarkable was noticed—at least no danger was reported—and the men continued at work until half-past eight, when the explosion happened. This took place on the west side, where sixty or seventy were at work, nearly all of whom perished. The men on the east side suffered somewhat from the after-damp, and several had very narrow escapes with their lives.

One remarkable feature in this explosion was the rapidity with which the mine became cleared of the poisonous vapour. Within six hours of the accident every portion of the mine had been thoroughly explored.

## REVIEWS AND NOTICES OF NEW BOOKS.

*An Elementary Treatise on Electrical Measurement*, for the use of Telegraph Inspectors and Operators. By Latimer Clark. London: E. & F. N. Spon, 48, Charing-cross.

Many people who are constantly working the electric telegraph know little or nothing of the theory of electricity, and, consequently, should a hitch of any kind occur and communication be interrupted, they are entirely at sea respecting the cause, or, even if that is successfully guessed at, they have no notion how to proceed in such a case. The work now before us is designed to raise telegraph inspectors and operators to something above mere machines, and to explain as simply as possible, firstly, so much of the theory as is necessary, and then to reduce that theory into practice. After thoroughly describing the meaning of the various terms—*electro-motive force*, *resistance*, *tension*, &c.—he proceeds to describe the use of various instruments, and the *modus operandi* of some of the more delicate tests required for determining the position of faults. We need scarcely add that, as no name stands so high for practical and theoretical electricity combined as Mr. Latimer Clark, so no work of the same dimensions treats so thoroughly and practically upon those subjects coming peculiarly under the notice of telegraph operators.

*A Rudimentary Treatise on the Manufacture of Bricks and Tiles.* By Edward Dobson, A.I.C.E., M.I., B.A., &c.; revised and corrected by Charles Tomlinson, F.R.S. Fourth edition, with additions by Robert Mallet, A.M., F.R.S., M.I.C.E., &c., with Illustrations. London: Virtue & Co.

This excellent treatise, which deserves a better title than "rudimentary," being, in our estimation, the best and most complete work upon the subject ever published, has just arrived at its fourth edition. As the work has already been favourably noticed upon the issue of former editions, it will be sufficient to say that that portion of the work which treats of machinery for brickmaking has been vastly improved by being brought down to the present date. The description of the different machines which have of late years been invented for making bricks, both with wet clay and dry clay, as also the machines for preparing the raw material, are given with Mr. Mallet's usual clearness; whilst the accompanying illustrations leave nothing to be desired.

*A Handy Book for the Calculation of Strains in Girders, &c.* Calculated by formulæ and diagrams. By William Humber, Assoc. Inst. C.E. London: Lockwood & Co.

This capital little work is intended to supply a want, often found by engineers, viz., of having the requisite formulæ for calculating strains in a complete form, and yet sufficiently portable to be carried in the pocket. In this case, however, almost every formula that could possibly be required, together with diagrams of strains, is put concisely, yet clearly, in a work of considerably less size than an engineering pocket-book, whilst Mr. Humber's well-known works upon kindred subjects is a sufficient guarantee of the completeness and accuracy of the contents.

## NOTES AND NOVELTIES.

### MISCELLANEOUS.

Sheep Washing by Machinery.—The Australian sheep farmers are washing sheep by the aid of machinery. Both to the north-west and south-west men of enterprise have not stuck at £1,000, or £2,000, for steam engine and washing gear. Washing sheep in hot water is becoming pretty general on large stations. The sheep are first passed through hot water with soap; they take what is called the soap-suds swim, the temperature of the water being about 110° Fahr. When thoroughly soaked they are floated to a tank of cold water, and are brought by hand beneath spouts properly adjusted to play a film of water upon and into their fleeces. Centrifugal pumps are used to throw up the water to a height of 12ft., and one spout will polish off about 500 sheep a day. The machinery has been constructed by Messrs. Gwynne and Co., of the Essex-street Works. Very spirited exertions are being made, likewise, to fence the runs. Wire fencing is also used to a very large extent. For instance, on the Lacblan, in one year, £8,000, has been spent for one station in the purchase of wire. The storage of water is likewise engaging attention, and hundreds of thousands of pounds, it is stated, are being spent in the damming of water-courses and the creation of reservoirs.

The Shawmut Oil Company, at East Boston, runs fifteen stills, having an aggregate capacity of five hundred barrels of oil per week.

An English company have, after overcoming almost insurmountable difficulties, established extensive iron works at Zimspan, in Mexico.

A new artillery locomotive has been invented, armed with two pieces of artillery, and intended to perform scouting duty on the banks of the Rhine.

The *Industrial American* says that buckwheat has been made use of in dyeing wool. An infusion made from the succulent stems and blossoms, with the addition of a preparation of bismuth or tin, produces a beautiful brown color. From the dried flowers are obtained different shades of green. The Siberian buckwheat yields a fine yellow which, when the wool is still further boiled in the dye, changes into a golden tint and at length becomes a beautiful yellow.

The new Smithfield meat and poultry market was opened on the 24th ult. In the unavoidable absence of the Prince of Wales the ceremony was performed by the Lord Mayor.

The Smithfield Club Cattle Show is to commence at the Agricultural Hall, Islington, on Monday, December 7th, and will continue open during the four following days. The Earl of Hardwicke is the president for the year, and amongst the prominent members of the club are the Dukes of Marlborough and Richmond, Earls Leicester, Powis, and Spencer, Viscount Bridport, and Lords Berners, Tredegar, and Walsingham. The aggregate amount of the prizes is £2,300

Trade and Navigation.—A blue book has just been issued, containing statistics of the trade and navigation of the United Kingdom for the year 1867. The total value of the imports was £275,183,137. The value of the exports was £225,135,088. By the side of these figures are given the value of the imports and exports of the preceding four years, showing a considerable increase since 1863, when the imports were £248,919,020, and the value of the exports £196,902,406; but a decrease upon 1866, when the value of the imports amounted to £295,290,274, and the exports to £233,905,682. The total number of British and Foreign vessels entered and cleared at the ports of the United Kingdom, with cargoes and in ballast, is given at 117,287, with a tonnage of 32,756,112. The trade and navigation accounts for September show a total value of £16,927,240, for the exports of the month, and of £116,777,023 for the preceding eight months. The imports for the eight months, ending August 31st, amounted to £152,561,886.

Encroachment of the Sea.—An American paper notices the wearing away of the coast of New Jersey by the action of the sea. It appears that the dimensions of many farms have been seriously affected, and men are living who used to plough lands which now cannot be found. It is stated that the Seven Mile Beach, opposite, Seavile, has worn away a hundred yards in the last twenty years. Dennis Creek is said to have lost more than a mile of its length by the wearing away of the marsh at its mouth in the last seventy years. The tide is found to be rising to higher points upon the land than formerly, and the salt grass is killing out the fresh grass and timber. Numbers of farmers along the sea shore of Cape May can point to pieces of land which were covered with timber when they came into possession of the land, but are now covered with marsh, and the timber has been killed out. Where the marsh abuts upon the upland, fallen timber is often found buried, and the stumps of trees are seen standing with their roots in the ground where they originally grew. Large numbers of stumps of pine, cedar, and other durable woods are seen standing in the waters. In digging a ditch through a tide pond, magnolia and huckleberry roots were found under the mud. Then, after four feet more of mud large pine stumps were found while cedar snags were found four and five feet under the pine. They were standing with four and five feet of water above them at low water. Other facts and cases are cited showing the sinking of the coast of this State below the ocean. The whole amount of this subsistance is supposed to be seventeen feet or more, and it is calculated that it proceeds at the rate of two feet in a century, or about a quarter of an inch a year. This may seem slow, but when it is recollected that the major portion of the Southern part of the State has but little elevation above the level of the ocean, it will be perceived that great changes may occur as the subsidence proceeds.

A Huge Mud Digger.— The largest mud excavator in the United States has just been completed in Portland for a Boston party to be used in excavating the South Boston flats. The digger is eighty feet long and forty feet wide, It has a double dredger. with twenty-nine large iron buckets on each elevator. The elevators are placed on the sides of the scow and can be worked singly or together. Its operation is as follows:—Two large scows are anchored ahead and astern of the digger, about 200ft. apart. These scows are secured by timbers that are driven into the mud, and raised, when necessary. by machinery. Two chains run through the digger and are attached to the anchored scows. When the engines are in operation they move a shovel, which is held is position under the dredger by an arm, one of these shovels being attached to the lower end of elevator. As the dredger moves along between the two anchored scows the shovels stir up the mud, and the buckets on the elevator scoop it up and deposit it in a scow secured to the forward part of the dredge.

### LAUNCHES.

Messrs. A. and J. Inglis have launched from their building-yard at Pointhouse, Partick, a splendid screw steamer, of about 3,000 tons, for Messrs. James and Alex. Allan, of the Montreal Ocean Steamship Company. Her dimensions are: Length, 340ft.; breadth, 40ft.; and depth, 36ft. She is of unusual strength of build, and her passenger departments are elegantly and commodiously fitted up. As she left the ways she was named the *Prussian*. She is to be fitted by her builders with a pair of surface-condensing direct-acting engines of 300-horse power nominal, embracing all the recent improvements.

From the shipbuilding-yard of the London and Glasgow Engineering and Iron shipbuilding Company (Limited), a screw steamship of the following dimensions:—Length, 265ft.; breadth, 33ft.; depth of hold, 25½ft.; and gross tonnage, 1,900 tons. The ship while leaving the ways was named the *Tagus*. This vessel is sister ship to the *Ganges*, recently built by the above company for the same owners. Her engines, which are 160 nominal horse-power, are built and fitted by the same company.

Messrs. Thomson launched on the 29th Oct, from their building yard at Govan, the screw steamship *Raven* another addition to the fleet of Messrs. Burne. The *Raven* is of 900 tons and 170 horse-power, built for the trade between Glasgow and Liverpool.

Mr. J. G. Lawrie launched recently, at Whiteinch, a large screw-steamer, measuring 272ft. in length, 31ft. 6in. breadth of beam, and 20ft. in depth, named *Toscoff*, for Michael Spartali, Esq., London.

Messrs. Scott and Co. have launched from their shipbuilding-yard at Greenock a screw-steamer of about 800 tons register, which was named the *Shuera*. The vessel, which has been built for a Marseilles company, will be supplied with engines of about 128-horse power.

Launch of the "Spartan".—Her Majesty's steam screw ship *Spartan* was launched at Deptford Dockyard on the 14th ult. in the presence of about 2,500 visitors, including Mr. E. J. Reed, C.B., Chief Constructor of the Royal Navy, from whose design the *Spartan* was built. The vessel was christened by Mrs. A. P. Eardley-Wilmot, wife of the Captain Superintendent of the yard, and the launch was in every way successful. The *Spartan* will receive an armament of six guns, the vessel being built so as to fire in a line with her keel. The principal dimensions of the *Spartan* are as follows:—Length between perpendiculars, 212ft.; length of keel for tonnage, 185ft. 10½in.; extreme breadth 36ft.; breadth for tonnage, 35ft. 10in.; moulded breadth, 35ft. 2in.; depth in hold, 19ft. 4in.; tons burden, 1,268 66-94ths; horse-power, 350. The vessel has been commenced and completed during the year in No. 1 slip. There is only one vessel remaining in the, yard—viz., the *Druid*, which is being completed in No. 4 slip, and will be launched early in the year, after which the Deptford Dockyard will be closed.

Launch.—There was lately launched by Messrs Dobie & Co., of Govan, an iron sailing barque of 500 tons, for a Liverpool firm. She was christened *Penung*, by Mrs. Stobo, of Glasgow. The *Penang* will be immediately put in a loading berth for San Francisco.

The frigate *Inconstant* has been successfully launched at Pembroke dock, Lady Muriel Campbell, daughter of Lord Cawdor, performing the ceremony of christening. She is built wholly of iron, sheathed with wood, and was designed by Mr. E. J. Reed Chief Constructor of the Admiralty. Her principal dimensions are as follow:—Length, 337ft. 4in.; breadth, 50½ft.; depth in hold, 17ft, 6in.; burden in tons, 4,066. Her armament will be 16 heavy guns, and her engines will be very powerful.

### RAILWAYS.

Ten cars of the Atlantic and Great Western Railway were destroyed by fire recently. The fire was caused by an explosion in the forward car which is supposed to have contained nitro-glycerine. The engine was completely demolished, and the engineer seriously wounded, and the fireman slightly hurt. The cars were loaded with flour and pork. A house, a quarter of a mile from the wreck, was demolished by the concussion.

A Convention of railroad conductors is being held at Cincinnati, for the purpose of inaugurating a mutual insurance scheme. It is proposed that, in the case of the death of a conductor belonging to the organisation, every other member shall contribute one dollar to his family. The organisation is not yet perfected.

The report of the Sutherland Company states that the line from Bonar Bridge to Golspie was opened for public traffic on the 13th of April last. The traffic from that date to the 31st of August averaged £99 per mile, and up to the 24th of October, £152 per mile. The working charges paid to the Highland Railway Company, under the agreement, amounted to 64 per cent. of the receipts. By an agreement with the Postmaster-General the mails were transferred to the line when it was opened for traffic.

At a special meeting of the Hartlepool Port and Harbour Trust it was decided, after a conference with the directorate of the North-Eastern Railway, to lose no time in applying to Parliament for powers to construct the necessary outworks for a new and complete harbour for both Hartlepools. A chairman and committee were appointed to carry the recommendations into effect.

The contractors of the Honduras Inter-oceanic Railway, Messrs. Waring Brothers, have made arrangements for the shipment of all the plant required for the first section of the railway from the harbour of Puerto Caballos, on the Atlantic coast, to the town of Santiago.

It is understood that the new company for the International Simplon line to Italy is about to issue a new loan for £1.200,000, through the medium of 134,166 obligations, at the price of 249f. The interest payable will be equal to about 6 per cent., and there are advantages connected with the drawings which will place the holders in a favourable position. An agent is now in London empowered to carry out the operation.

The Italian papers state that the great tunnel through Mont Cenis is making very satisfactory progresss. From the 16th to the 31st October the distance excavated at the southern end was 28 metres, and at the northern 34 metres, making together 62 metres. The average of the previous fortnights for some time has not exceeded 50 metres. The total length of the tunnel is to be 12,220 metres, and the length already completed is 1,958 metres, so that there now remain 3,261 metres to excavate. Under any circumstances, it is thought that the entire undertaking will be finished by the commencement of 1871.

### STEAM SHIPPING.

The Imperial schooner *Levrette* has just left Toulon for the Red Sea. She is to pass through the Suez Canal, and her trip is to be considered in some sort as the official opening of that route. She is to head a procession of yachts and pleasure boats to the number, it is said, of a thousand.

On the 5th ult. the *Bismarck*, an iron screw steamer of 500 tons register, built by Messrs. Henderson, Coulborn and Co., and fitted with their compound surface condensing engines, of 90-horse power nominal, went on her trial trip on the Clyde, and attained most satisfactory results. With full power she ran a mean speed of 11 1-5th knots, burning eight cwt. coal per hour. The speed guaranteed was 8½ knots on a consumption of six cwt., and to test this the engines were put on a lower grade of expansion, and the measured knot was run several times. Her speed was found to be over nine knots, and the report of consumption of coal, accurately weighed by the owner's engineer, was given by him as 4 cwt 15lbs per hour during her trial on this grade. The *Bismarck* has been built on Hamburg account by Mr. Constant Staeven, and she proceeds shortly from Glasgow to the Cape with passengers and emigrants.

The *Main* screw steamer, just completed by Messrs Caird and Co., proceeded down the Clyde on the 7th ult. on her official trial trip. The *Main* steamed the distance between the Cloch and Cumbrae at a rate of 14 knots per hour, and in all other respects gave the greatest satisfaction. She is upwards of 3,000 tons, and is the twelfth vessel of nearly the same dimensions built by Caird and Co. for the North German Lloyd's. Her dimensions are—332ft. keel, 40ft. beam, and 33½ft. deep. Captain Von Oterudorp will command the steamer, which will trade between Bremen, Southampton, and New York, carrying the German, British, and American mails.

The *Ringdove*, 3, double screw gun vessel, 666 tons, 160-horse power, Commander Percival, has made her final trial of speed over the measured mile in Stokes Bay, near Portsmouth, previous to her departure on foreign service. On her trial the *Ringdove*, being in commission, had her crew, armament, and all her weight on board to her sea trim, and under full boiler power she attained a mean rate of speed of 10·721 knots per hour; under half-boiler power she attained a mean rate of 9·583 knots per hour.

## DOCKS, HARBOURS, BRIDGES.

At a meeting of the Mersey Docks and Harbour Board, last week, a letter was read from Messrs. Hall, Stone, and Fletcher, solicitors, of Liverpool, informing the board that they had been empowered to draw up a bill for presentation in the next session of Parliment to empower a company, now in course of formation, to construct a tunnel from the western end of Birkenhead Docks to the north end of Liverpool, and converging with the line of railway at that point. It was agreed that the Board of Works should meet a deputation from the company.

The iron bridge over the Housatonic river at Great Barrington, Massachusetts, is completed. It is an elegant and expensive structure.

The Suez Canal.—The directors of the Maritime Canal of Suez have published a table showing the general situation of the works on the 30th September. In the narrow channel and basin of Port Said, and along the canal to Suez, the total to be extracted was 74,112,130 metres cube; between the 15th August and 15th September, 2,081,367 were taken out; the total up to the present time being 49,309,522. There remain to be removed 24,802,608. Fifty-eight dredging machines are at work, and two more are in preparation; the number of labourers is 14,853.

## MINES, METALLURGY, &c.

Statistics of the Manufacture of Iron During the Past Year.—The mineral statistics of the United Kingdom record some interesting particulars relating to the production and manufacture of iron during the past year. Of the 10,021,058, tons of ore produced in that year, of the value of £3,210,098, the North Riding of York contributed 2,739,039 tons; Cumberland, 890,566 tons; Staffordshire, 1,319,509 tons; Lancashire 667,356 tons; West Riding of York, 579,000 tons; Northamptonshire, 416,765 tons; Monmouthshire, 341,057 tons; Derbyshire, 350,000 tons; Shropshire, 250,000 tons; Gloucestershire, 156,169 tons; Lincolnshire, 192,213 tons; Durham and Northumberland, 115,700 tons; South Wales, 501,186 tons; Scotland, 1,264,800 tons; and Ireland, 42,061 tons. The quantity of iron ore imported in 1867 was 86,569 tons; of this 49,327 tons were received at Cardiff, 13,781 tons at Swansea, and 12,258 tons at Newport. The returns relating to iron manufacture show that 10,167,626 tons of ore were converted into pig iron in 1867; the number of furnaces in blast was 551½, and the pig iron produced in Great Britain 4,761,023 tons—namely, in England, 2,810,946½ tons; Wales, 919,077 tons; Scotland, 1,031,000 tons. This quantity, estimated at the mean average cost at the place of production, would have a value of £11,902,557. The mean market price per ton was £4 3s 9d for Welsh pig, and £2 19s 3d for Scotch pig. The number of puddling furnaces at work last year in Great Britain was 6,009 belonging to 254 works; 115 of these works, having 1801 puddling furnaces, were situated in South Staffordshire; next in order of number is Durham, with 18 works and 719 furnaces. The number of rolling mills returned in Great Britain is 831, of which 283 are in South Staffordshire, 83 in Glamorganshire, 71 in the Sheffield and Rotherham district of Yorkshire. Taking Yorkshire as a whole, it has 34 works, and 1,037 puddling furnaces.

A Quarry of stone, said to be equal to the best French burr for millstones has been discovered near South Pass in Southern Illinois.

Great excitement is reported in the western portion of Idaho concerning the discovery of gold in the Cœur d'Alene Mountains. The road is crowded with miners from Beartown to the new diggings. The precise location of the mines has not been announced.

## SHIPBUILDING.

Messrs Napier, of Glasgow, have received orders to construct the *Hotspur*, a vessel which bears no resemblance to anything in our navy at present. She is neither a broadside ship nor a monitor, and in fact the best idea we can give of her is to term her a vastly improved *Belier*. She is officially known as an armour-plated steam ram. Her length is 235ft., breadth 50ft., burthen in tons 2637 B.M., with a draught of water of 22ft. aft and 20ft. forward. Like the *Belier*, this vessel is intended to fight end-on, which the twin-screws with which she is to be fitted will give her great facilities for doing. The armour belt at the water-line consists of two strakes of plating, the upper one being eleven inches thick, and the lower one eight inches. The arrangement of the fore part is peculiar to this ship. In order to strengthen and support the ram when in use, the lower edge of the armour is suddenly inclined downwards at about 30ft. from the stem, so that the ram is protected with armour for a considerable distance aft. On the main deck is an armour-plated breastwork extending about one-third the length of the ship, similar to that which has been adopted in the new monitors. From the bow aft to the breastwork the main deck is plated with 3in. armour; and at the forepart of this breastwork a pear-shaped battery, covered with 8in. armour, is brought above the upper deck. This battery is pierced with several ports, and contains a turn-table carrying an 18-ton gun, the whole being trained, &c., by suitable machinery situated on the main deck. The only other gun to be carried by the *Hotspur* is a 400 pounder Armstrong; this will be placed aft. It is intended to give her two masts (of iron), and she will be barque-rigged.

## MILITARY ENGINEERING.

A new needle gun, invented by Herr Werder, of Nuremberg, has just been tried at Pesth. The weight is but 8¼lbs., the weapon was fired 20 times in a minute, and that number, it is said, can be increased.

The Whitworth nine-inch gun, by which the unprecedented range of 10,300 yards was obtained at Shoeburyness on the 20th ult. was fired again the following day, when it beat even its previous performance, and with 33 degrees 5 minutes elevation, and a 50lb charge, threw a 310lb. shell to 11,127 yards, first graze, being about 1,000 yards farther than ever iron mass was hurled by any other gun.

## APPLIED CHEMISTRY.

M. Delamier, in a communication to the Academy of Sciences, states that the following mixture forms an exciting liquid for galvanic batteries of energy and economy, disengaging no deleterious fumes or gas:—Dissolve twenty parts by weight of protosulphate of iron in thirty-six parts of water. Then stir in seven parts of diluted sulphuric acid (equal parts); then in the same manner add one part of diluted nitric acid (equal parts).

Gilding Glass.—W. Wernicke. The following are the ingredients required:—1st. Solution of gold: pure gold (free from silver) is dissolved in aqua regia, the solution evaporated, and the residue taken up with water, so that 120 c.c. contain 1 gramme of gold. 2nd. Solution of sodic hydrate (which need not be absolutely pure) of 1·08 sp. gr. 3rd. Reducing liquid: 50 grammes sulphuric acid (monohydrate), 40 grammes alcohol, 35 grammes water, and 50 grammes powdered manganic peroxide, are distilled into 50 grammes water until the bulk of the latter is doubled—10 grammes cane sugar, inverted by dissolving in 70 c.c. water and boiling with 0·5 grammes nitric acid of sp. gr. 1·34. The distilled liquid, the inverted sugar, and 100 c.c. alcohol are mixed together, and the mixture diluted to 500 c.c. In using these solutions 1 volume of the sodic hydrate solution is mixed with 4 volumes of the gold solution, and to this mixture is added from 1-35th to 1-30th volume of the reducing liquid. The object to be gilded is placed on the top of the solution, having the surface intended to be coated turned downwards. The temperature of the bath should be below 60° C. Glass surfaces must be cleaned with a solution of sodic hydrate and alcohol; cleaning with acids would prevent the film of old from adhering firmly.—(*Pogg. Ann.*, cxxxiii., 183).

## LATEST PRICES IN THE LONDON METAL MARKET.

| | From | | | To | | |
|---|---|---|---|---|---|---|
| COPPER. | £ | s. | d. | £ | s. | d. |
| Best selected, per ton | 76 | 0 | 0 | 77 | 0 | 0 |
| Tough cake and tile do. | 74 | 0 | 0 | 75 | 0 | 0 |
| Sheathing and sheets do. | 78 | 0 | 0 | 79 | 0 | 0 |
| Bolts do. | 78 | 0 | 0 | ,, | ,, | ,, |
| Bottoms do. | 81 | 0 | 0 | ,, | ,, | ,, |
| Old (exchange) do. | 64 | 0 | 0 | 65 | 0 | 0 |
| Burra Burra do. | 80 | 0 | 0 | ,, | ,, | ,, |
| Wire, per lb. | 0 | 0 | 10½ | ,, | ,, | ,, |
| Tubes do. | 0 | 0 | 11½ | ,, | ,, | ,, |
| BRASS. | | | | | | |
| Sheets, per lb. | 0 | 0 | 8½ | 0 | 0 | 9 |
| Wire do. | 0 | 0 | 8 | ,, | ,, | ,, |
| Tubes do. | 0 | 0 | 10¼ | ,, | ,, | ,, |
| Yellow metal sheath do. | 0 | 0 | 6¾ | 0 | 0 | 7 |
| Sheets do. | 0 | 0 | 6¾ | ,, | ,, | ,, |
| SPELTER. | | | | | | |
| Foreign on the spot, per ton | 20 | 12 | 6 | ,, | ,, | ,, |
| Do. to arrive | 20 | 12 | 6 | 20 | 15 | 0 |
| ZINC. | | | | | | |
| In sheets, per ton | 24 | 10 | 0 | 25 | 0 | 0 |
| TIN. | | | | | | |
| English blocks, per ton | 103 | 0 | 0 | ,, | ,, | ,, |
| Do. bars (in barrels) do. | 104 | 0 | 0 | ,, | ,, | ,, |
| Do. refined do. | 106 | 0 | 0 | ,, | ,, | ,, |
| Banca do. | 102 | 0 | 0 | ,, | ,, | ,, |
| Straits do. | 100 | 10 | 0 | 101 | 0 | 0 |
| TIN PLATES.* | | | | | | |
| IC. charcoal, 1st quality, per box | 1 | 6 | 0 | 1 | 8 | 0 |
| IX. do. 1st quality do. | 1 | 12 | 0 | 1 | 14 | 0 |
| IC. do. 2nd quality do. | 1 | 5 | 0 | 1 | 6 | 0 |
| IX. do. 2nd quality do. | 1 | 11 | 0 | 1 | 12 | 0 |
| IC. Coke do. | 1 | 1 | 6 | 1 | 2 | 6 |
| IX. do. do | 1 | 7 | 6 | 1 | 8 | 6 |
| Canada plates, per ton | 13 | 10 | 0 | ,, | ,, | ,, |
| Do. at works do. | 12 | 10 | 0 | ,, | ,, | ,, |
| IRON. | | | | | | |
| Bars, Welsh, in London, per ton | 6 | 10 | 0 | 6 | 15 | 0 |
| Do. to arrive do. | 6 | 10 | 0 | 6 | 12 | 6 |
| Nail rods do. | 7 | 0 | 0 | 7 | 2 | 6 |
| Stafford in London do. | 7 | 12 | 6 | 8 | 10 | 0 |
| Bars do. do | 7 | 10 | 0 | 9 | 10 | 0 |
| Hoops do. do. | 8 | 2 | 6 | 9 | 15 | 0 |
| Sheets, single, do. | 9 | 0 | 0 | 11 | 0 | 0 |
| Pig No. 1 in Wales do. | 3 | 15 | 0 | 4 | 5 | 0 |
| Refined metal do. | 4 | 0 | 0 | 5 | 0 | 0 |
| Bars, common, do. | 6 | 0 | 0 | ,, | ,, | ,, |
| Do. mrch. Tyne or Tees do. | 6 | 10 | 0 | ,, | ,, | ,, |
| Do. railway, in Wales, do. | 6 | 0 | 0 | ,, | ,, | ,, |
| Do. Swedish in London do. | 10 | 0 | 0 | 10 | 5 | 0 |
| To arrive do. | 10 | 5 | 0 | ,, | ,, | ,, |
| Pig No. 1 in Clyde do. | 2 | 14 | 0 | 2 | 19 | 0 |
| Do. f.o.b. Tyne or Tees do. | 2 | 9 | 6 | ,, | ,, | ,, |
| Do. No. 3 and 4 f.o.b. do. | 2 | 6 | 6 | 2 | 7 | 0 |
| Railway chairs do. | 5 | 10 | 0 | 5 | 15 | 0 |
| Do. spikes do. | 11 | 0 | 0 | 12 | 0 | |
| Indian charcoal pig in London do. | 7 | 0 | 0 | 7 | 10 | |
| STEEL. | | | | | | |
| Swedish in kegs (rolled), per ton | ,, | ,, | ,, | ,, | ,, | ,, |
| Do. (hammered) do. | 15 | 0 | 0 | 15 | 10 | 0 |
| Do. in faggots do. | 16 | 0 | 0 | ,, | ,, | ,, |
| English spring do. | 17 | 0 | 0 | 23 | 0 | 0 |
| Quicksilver, per bottle | 6 | 17 | 0 | ,, | ,, | ,, |
| LEAD. | | | | | | |
| English pig, common, per ton | 19 | 0 | 0 | ,, | ,, | ,, |
| Ditto. L.B. do. | 19 | 5 | 0 | 19 | 7 | 6 |
| Do. W.B. do. | 21 | 10 | 0 | ,, | ,, | ,, |
| Do. sheet, do. | 20 | 0 | 0 | ,, | ,, | ,, |
| Do. red lead do. | 21 | 0 | 0 | ,, | ,, | ,, |
| Do. white do. | 27 | 0 | 0 | 30 | 0 | 0 |
| Do. patent shot do. | 22 | 0 | 0 | 22 | 10 | 6 |
| Spanish do. | 18 | 5 | 0 | 18 | 7 | 0 |

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* At the works 1s. to 1s. 6d. per box less.

## 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 October 17th, 1868.

3177 E. T. Hughes—Adhesive substance
3178 C. Mayer—Tourists' bottles
3179 D. Wilson—Drag or brake for the wheels of vehicles
3180 A. Deshonnet—Lighting apparatus
3181 W. T. Rickard and W. C. Paul—Washing ores
3182 E. Ludlow—Cartridges
3188 H. Bunning, jun.—Burning combustible liquids
3184 F. P. Warren—Ranges
3185 R. A. Green—Treatment of the folded paper sheets used for printed works

### Dated October 19th 1868.

3186 T. Wrigley and W. E. Yates—Improvements in beaming warps
3187 T. Wrigley and J. Richardson—Looms for weaving
3188 J. Cockshoot and H. Weatherill—Carriage axles, &c.
3189 B. Hunt—Scissors
3190 A. Clark—Submarine telescopic lantern
3191 C. Whitehouse—Manufacture of augers, boring bits, &c.
3192 W. E. Newton—Gun barrels, &c.
3193 W. H Howes—Movements for swing frame looking glasses
3194 W. R. Lake—Preserving, &c., fish
3195 J. Rae—Carts for removing refuse matter from roads
3196 W. Fitch—Carriages for ordnance

### Dated October 20th, 1868.

3197 W. Dore and J. Thornhill—Motive power engines
3198 H. A. Bonneville—Safety lamps
3199 J. Elce—Mules for spinning
3200 J. A. Farrar and B. R. Huntley—Hatches of ships, &c.
3201 G. Voight—Railway brakes
3202 C. Lauenstein—Purifying paraffine
3203 G. Chapman—Treating sewage
3204 E. T. Hughes—Tea and coffee pots
3205 E. Harrison—Mills for grinding and flouring grain
3206 J. Sykes and G. Malin—Composition to be used for filling up the bodies of carriages, &c.
3207 J. Lorkin—Improvements in pipes for smoking tobacco
3208 E. T. Hughes—Machines for polishing and finishing needles
3209 D. Poseuer, A. Posener, and M. Uuger—Holders for glass, &c.
3210 J. F. Brinjes—Centrifugal machinery
3211 J. H. Johnson—Boots and shoes
3212 J. M. Brierley and E. C. Vine—Fastenings for stays
3213 W. Maudslay and W. C. Rawlins—Improvements applicable to furnaces
3214 J. Westwood, jun.—Socket joints for metal piles
3215 T. Forster and J. Heartfield—Sponge or bath gloves

### Dated October 21st, 1868.

3216 J. Stafford—Chimney terminals
3217 J. J. Parkes—Stoves for cooking and heating purposes
3218 C. Shaw—Propelling vessels
3219 I. Holden—Combing wool
3220 H. Clifton—Butter churns
3221 J. H. Johnson—Reels or bobbins
3222 T. Richards and C. H. Carter—Extractors for breech loading firearms
3223 H. C. E. Malet—Projectiles
3224 E. O. W. Whitehouse—Protecting telegraph wires
3225 H. Warner—Mowing machines, &c.
3226 C. Macmillan—Protecting iron ships from corrosion
3227 W. K. Foster—Carriage wheels

### Dated October 22nd, 1868.

3258 F. Bennett and R. Ward—Facilitating the capture of whales, &c.
3229 K. J. Winslow—Conveying rotary motion to axles
3230 M. A. F. Mennons—Engine for raising or forcing water
3231 J. Ryder—Kilns for burning bricks
3232 C. Acrill—Burning creosote, &c.
3233 G. T. Bousfield—Propelling water craft
3234 C. D. Abel—Improved system of railways, &c.
3235 T. Carr—Disintegrating minerals

### Dated October 23rd, 1868.

3236 W. T. Carrington, H. Gielgud, and Z. L. Wessely—Breech loading firearms
3237 A. B. Berard—Apparatus for converting cast iron into steel
3238 H. Dowling—Bottles intended for containing poisons, &c.
3239 T. Walker—Lever buckle
3240 J. Birch—Casting Bessemer steel ingots
3241 W. W. Tonkin—Valves of engines, &c.
3242 J. De Redon and T. Faucheux—Cigars and cigarettes
3243 J. Gregson and W. Monk—Looms
3244 M. Sautter—Preparing wool
3245 M. Sautter—Preparing fibre, &c.
3246 C. B. James—Needle cases
3247 J. Bernard—Preparing ores, &c.

### Dated October 24th, 1868.

3248 I. Baggs—Smelting iron
3249 J. Anderson—Manufacture of felts
3250 J. Spratt—Food for horses
3251 B. Hunt—Power capstans
3252 R. S. Burn and E. S. Eyland—Conservatories, glasshouses, &c.
3253 C. W. Davies—Paper collars
3254 G. Nurse—Coating of metals
3255 E. Wimbridge—Preparing blocks for surface printing
2356 A. Giraud—Separating silver from argentiferous lead, &c.
3257 W. Reid—Trucks, &c.
3258 W. G. James—Improvements in propelling
3259 S. Clark—Cleaning cotton
3260 H. E. Newton—Steam pumps
3261 H Mayhew—Button fastening
3262 W. E Gedge—Glove fastening
3263 J. L. Kieffer—Sewing machines
3264 E. A. Rippingille—Means employed when obtaining motive power, &c.
3265 J. Silvester—Pressure gauges
3266 W. Dawes—Pulley block

### Dated October 26th 1868.

3267 P. M. Crane—Sizing cotton yarns
3268 W. Heasler—Coating wire with india rubber
3269 B. Nicoll—Plastic composition
3270 C Horrison and R. Wilson—Indicating a rise or fall of temperature for fire, alarm, &c.
3271 J. Loader and W. H. Child—Rotary engines
3272 W. A. Lyttle—Electro telegraph instruments
3273 W. E. Gedge—Gas burner
3274 W. Boulton—Articles of pottery
3275 J. Jones and S. P. Bidder—Breaking down coal, &c.
3276 T. Speight and W. H. France—Wool combing machines
3277 T. Priestley and W. Deighton—Looms
3278 W. Mort—Obtaining reduction of temperature, &c.
3279 F. Ransome—Preserving stone
3280 A. M. Clark—Scouring wool

### Dated October 27th, 1868.

3281 W. E. Gedge—Salt stones
3282 A. H. Smith—Gas heating apparatus
3283 G. Zanni—Electro magnetic telegraph printing instruments
3284 W. E. Hickling—Washing casks
3285 J. Little—Glass furnaces
3286 J. B. O'Hea and W. Bullen—Breech loading firearms
3287 G. Fajen—Ventilators, &c.
3288 W. D. Young—Tiles of iron, &c.
3289 J Wallace—Dentistry
3290 E. T. Van Hecke—Locomotive engines
3291 J Johnson—Apparatus applicable to window frames

### Dated October 28th, 1868

3292 T. Mordue—Steam boilers
3293 R. Hamilton—Railway chairs
3294 H. J. Sanders—Regulating the discharge of liquids, &c.
3295 J. Moran—Boots and shoes
3296 M. A. Soul—Permanent way of railways
3297 C. E. Brooman—Condensers of steam engines
3298 A. Wilson—Metallic moulds
3299 W. Dawes—Pianofortes
3300 G. E. Donisthorpe—Packing the pistons of steam engines
3301 P. B. Cow and J. Hill—Tooth brushes
3302 C. Kelson—Horse collars
3303 W. Prowett—Knitting machines
3304 J. G. Tongue—Warning signals

### Dated October 29th, 1868.

3305 M. Benson—Shaft couplings
3306 B. Dobson and J. Clough—Machinery for preparing cotton
3307 R. Meldrum—Utilisation of waste steam
3308 F. A. Blanchon—Tops
3309 W. H Liddell—Treating pig skins
3310 Q. Whyie and J. Whyte—Looms
3311 W. Scott—Drying and cleansing wool
3312 J Adams and W. Adams—Manufacture of bricks and tiles
3313 J. Heaton—Production of iron and steel
3314 H. Wallwork—Taps or valves
3315 R. Oxland—Treatment of ores, &c.

### Dated October 30th, 1868.

3316 W. Brown—Rolling metals
3317 A. S. Paterson—Heels for boots
3318 W. Collins, jun.—Separating paper
3319 J. Wright—Printing presses
3320 G. Allix—Improvements in raising and lowering ships' boats
3321 S. Sharrock—Lamp posts
3322 W. E. Dando—Mourning hats
3323 R. Irvine—Alcoholic liquors

### Dated October 31st, 1868.

3324 J. Brouner—Shades to gaslights
3325 W. E. Bates and T. Dodd—Machinery for cracking nuts
3326 A. M. Clark—Sewing machines
3327 J. Langford—Non conductors of heat for the handles of teapots
3328 B. Dickinson—Propelling ships
3329 S. A. Varley—Generating static electricity
3330 A. Munro and W. B. Adamson—Manufacture of tools, &c.

### Dated November 2nd, 1868.

3331 S. Ault—Plastering trowels
3332 J. Lodge—Looms for weaving
3333 F. T. Labitte—Advertising
3334 J. Dannatt and T. S. Turnbull—Garments for saving life
3335 J. Vavaseur—Discharging ordnance
3336 J. H. Bertie—Lace machines

### Dated November 3rd, 1868.

3337 J. Moore—Woven fabrics
3338 L. Berenger—Ironing cloth
3339 J. A. R. Main—Iron sheds
3340 E. Barton—Scarves
3341 S. Schumann—Treating fecal matters
3342 B. Johnson—Torsion springs
3343 G. F. Morant—Cases for packing game

### Dated November 4th, 1868.

3344 W. R. Lake—Low water alarm apparatus for steam boilers
3345 R. W. Beckley—Pen rest
3346 M. Samuelson—Corrugated plates to be used as envelopes, for pressing oil, &c.
3347 E. Holden—Preparing wool
3348 A. V. Newton—Water elevating engines
3349 E. T. Hughes—Manufacture of furred threads and fabrics
3350 I. Holt, W. Holt, J. Holt, and J. Maude—Spinning fibrous materials
3351 J. B. Houghton—Holders for umbrellas
3352 M. Sautter—Preserving vegetable and animal substances

### Dated November 5th, 1868.

3353 S. Ward, W. Hurst, and J. Tuer—Looms for weaving
3354 T. Burt—Floating dredgers
3355 H. Jewitt—Slabs or blocks for erecting toy houses
3356 T. Robinson—Manufacture of iron and steel
3357 R. Cook—Bobbin spools
3358 R. Needham—Scrapers of fuel economisers
3359 B. Hunt—Electro physiological battery, &c.
3360 J. Clark—Apparatus for turning, boring, and shaping wood, &c.
3361 A. Reid—Rolling tobacco
3362 J Corbett—Railway carriages
3363 A. L. Bricknell—Rotary engine pump and water meter
3364 J. Edwards—Harness
3365 W. R. Lake—Machinery for nailing soles to boots

### Dated November 6th, 1868.

3366 A. H. Robinson—Cocks or taps
3367 C. Archer—Improvements in the manufacture of cigars
3368 J. H. Johnson—Improvements in the treatment of carbonate of lime
3369 T. Lucas and T. P. Lucas—Locks for railway doors
3370 J. Samuel—Locomotive steam carriages to be used on railways
3371 J. Taylor—Steam boilers
3372 J. Parrott—Machinery for beetling woven fabrics
3273 F. C. Phillippson—Improvements in pumps and fire engines
3374 F. E. Martineau—Hasps for fastening doors and gates
3375 T. Harrison—Pianofortes
3376 W. Baker—Certain improvements in furnaces and firebars
3377 M. A. F. Mennons—Forming screw threads on wrought iron bolts
3378 W. Irmer—Corn flour jelly
3379 W. Broughton—Kitchen ranges
3380 A. M. Clark—Manufacture of ropes, cordage lines, &c.

### Dated November 7th, 1868.

3381 J. C. Haddan—Cannon wads, &c.
3382 S. Arnott—Braces
3383 J. Lewthwaite—Apparatus for boring in rock, stone, &c.
3384 M. Brown-Westhead and C. B. James—Packing needles
3385 H. Steffanson—Buffers and draw rod fittings to be used on railways
3386 Sir J. Macneill—Cases for containing postage stamps
3387 J. H. Johnson—Cutting screw threads
3388 J. Sturrock—Metallic caps
3389 A. M. Clark—Machinery for planing wood, &c.
3390 A. M. Clark—Separation of solid matters contained in liquids
3391 W. J. Criddle—Washing linen
3392 W. Corden—Lamp glasses
3393 G. T. Bousfield—Improvements in cooling and barring soap

### Dated November 9th, 1868.

3394 N. Wilson—Sewing machines
3395 H. Davis and J. Parsons—Tobacco dish and cigar rack
3396 W. Manwaring—Improvements in reaping machines
3397 R. McHardy—Improved implement for hoeing land
3399 W. M. Brown—Man engines for raising water, &c.
3400 P. E. De Wissocq—Improvements in treating lead ores
2401 W. R. Lake—Securing a door knob upon a spindle
3402 J. L. L. Sweatnam—Kilns for burning bricks, tiles, &c.

### Dated November 10th, 1868.

3403 H. L. Bennison—Improved rotary engine and pump
3404 L. A. Israel—Simplifying the manufacture of sulphuric acid
3405 T. Rose and R. E. Gibson—Utilising a certain waste material
3406 P. B. Tyler—Splices for connecting the ends of rails
3407 J. H. Johnson—Utilising the waste heat of furnaces
3408 G. Clark—Treatment, manufacture, and use of explosive compounds
3409 J Hine—Apparatus for cutting or dressing millstones
3410 C. E Winby and F. C. Winby—Preventing collisions on railways
3411 J. H. Wilson—Improvements applicable to waterclosets in ships
3412 J. Gregory—Charring bones to produce animal charcoal
3413 W. H. Hall and J. Cooke—Improvements in safety lamps
3414 T. Cain—Treating potatos
3415 J. Hickisson—Pencils for writing or marking on linen
3416 O. G. Abbott—Distribution of sewage water and other fluids
3417 W. Riddle—Hooping bales
3418 T. R. Crampton—Furnaces for burning combustible fluids
3419 H Bessemer—Cast steel and homogeneous malleable iron

### Dated November 11th, 1868.

3420 T. Vaughan and E. Watteeu—Improvements in screw bolts
3421 E. Dixon and F. Dixon—Packing bottles
3422 R. Halliday—Oiling the axles of waggons used in collieries
3323 E. Mudge—Manufacturing tin
3424 W. S. Thomson—Manufacture of corsets, jackets, &c.
3425 M. H. Davies—Construction of fences where strained wire is employed
3426 G. Wilson, sen., & J. Wilson, jun.—Kilns for burning bricks, cement, &c.
3427 F. Holmes—Smoking pipes
3428 G. Piercy—New safety stay for the shafts of carriages
3429 J. Lewthwaite—Machinery for wood shaping and similar purposes
3430 A. M. Clark—Printing machines

### Dated November 19th, 1868.

3431 C. J. Chaplin—Improved composition for cattle food
3432 S. Holt and G. Holt—Pickers
3433 H. Henkel—Breech loading firearms and cartridges
3434 A. A. Hely—Umbrellas, &c.
3435 T B. Collingwood and W. Hardman—Spindles and flyers, &c.
3436 P. J. Livsey—Sewing machines
3437 D. Griffiths—Timber bearers
3438 W. R. Griffiths—Boilers
3439 L Wray—Crushing quartz, &c.
3440 E. Haas—Sewing machines
3441 W Donisthorpe—Machinery for getting coal and minerals
3442 G. P. White—Screw piles
3443 J. Kellow—Cutting rock, &c.

### Dated November 13th, 1868.

3444 E. Owen—Cases for night lights
3445 W. Thomas—Boots and shoes
3446 B. P. Walker—Improvements in forging or shaping metals
3447 J. Denby and J. H. W. Biggs—Arrangements of warps
3448 R. A. Dalton and G. S. Barton—Upholstery trimmings
3449 C. E. Brooman—Manufacture of coverings for walls, &c
3050 J. Stephens—Apparatus applicable to carriages
3451 C. Markham and W. Knighton—Moulding pipes, &c
3452 T. Lawson and A. T. Lawson—Improvements in carding engines
3453 C. Markham and W. Knighton—Moulding and drying moulds, &c.
3454 R. A Gold—Two wheeled carriages
3455 W. Burgess—Signal apparatus
3456 A. J. Deblon—Expansive condensing and rotary steam engine
3457 C. Jones—Treatment of sewage

### Dated November 14th, 1868.

3458 W. N Nicholson—Hay making machines
3459 J. B. Green—Preparing yarn
3460 T. Mills—Steam generators
3461 W. Harrison—Kilns for drying bricks
3462 P. Hill—Preparing strips of paper, &c.
3463 G. J. Worssam—Obtaining motive power
3464 R. Beckley and J. J. Hicks—Measuring flowing liquids, &c.
3465 H. E. Newton—Propelling vessels
3466 A. Turner—Elastic fabrics
3467 W. Richardson—Carding engines
3468 J. Howard and E. T. Bousfield—Tubular steam boilers
3469 C K. Bradford—A new velocipede
3470 J. C. Macdonald and J. Calverley—Stereotype printing surfaces
3471 H. Aitken—Treating iron ores
3472 J. H. Johnson—Railway wheels

### Dated November 16th, 1868.

3473 T. Berney—Mounting ordnance, &c.
3474 J. C Bowler—Construction of castors
3475 H. A. Bonneville—Shape and casting of missiles, &c.
3476 J. Smith—Stretching, &c., woven fabrics
3477 H. Carter—Gas burners
3478 T. Martin—Supplying ammunition, &c.
3479 P. J. Ravel—Steam generator
3480 J. Matheson, jun.—Dyeing yarns
3481 E. Priest and A. Priest—Carding engines
3482 E. Hogg—Straightening and planishing rolled iron
3483 J. Hare—Expanding tables
3484 A. McNiel and W. Wheaton—Salts of ammonia, &c.
3485 R. M. Boniwell—River boats
3486 W. Low and G. Thomas—Bridges
3487 S. W. Campain—Tilling land by steam power

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