

that, whereas by day, our navy could make some 14,000 signals ; at night, it had to manage its business with fifteen ; certainly a disproportionate number. The author did not know whether he was right or not in the supposition that much of our backwardness in the matter of night signalling had arisen from an idea that all improvements in it must show a continually nearer approach to the flag system, and must be founded on the same principles. At all events, this appeared to him to have been the principle followed out in the greater number of night signal systems, and to have acted as a drag upon the improvement of them ; for, as he hoped to convince the meeting, there was, in reality, no difficulty in signalling by night to a greater distance than by day ; nor in making any number of signals required in the most simple and effective manner. Perhaps, however, in saying, this, the author was somewhat anticipating his subject, and ought rather to explain the leading systems under which night signalling had been "*attempted*." He made use of this expression advisedly, for he considered that any system that could only produce fifteen effective night signals against 14,000 available in the day, could only be characterised as an attempt (and a very poor one too) at achieving the end desired. He would own that, when the subject was viewed under the fettered ideas consequent upon a desire to imitate the flag system, the difficulties to be encountered seemed very great, and it was only by acting upon an entirely different train of thought that anything like a simple and efficient system of night signalling could be arrived at ; and it required a spirit of considerable originality and boldness to strike into the new track.

Long before the date of the Christian era, two very curious systems of night signals were described by the Greek historian, Polybius, who, in the history of the "Punic Wars," makes frequent allusions to the art of signalling. These were as follows :—

The first, which has been aptly termed the "Pitcher" system, was thus arranged : "The two stations, between which signals were to be conveyed, were each supplied with a tall pitcher filled with water. A small tap was fitted to the bottom of each vessel, so that on opening it, the water might run out of both at exactly the same rate. A cork was set floating in each pitcher, and into each cork was fixed a long flat piece of wood divided into so many divisions of three fingers

breadth each as there was room for, and in each of these divisions a sentence likely to be used in time of war, was inscribed. Each station being provided in addition with a torch ready for lighting, was in a position to commence operations after dark.

"The station wishing to send one of the messages inscribed on the sticks, first showed a lighted torch, and kept it showing until answered by another. Then the first station opened the tap of its vessel and dropped the torch, which was the signal for the other station to do the same. Both corks and sticks were now descending at the same rate, so that as soon as the sentence required to be transmitted reached the level of the top of the vessel at the *first* station, the tap was stopped and the torch again shown, so that the *second* might do the same and read off the message."

The second system described by the same writer was thus carried on :

"Each station wishing to signal prepared five pieces of wood on which the letters of the alphabet were written in their proper order, five on each slip, except the last, which contained four. The person wishing to signal, first showed two torches as a 'preparative,' and then the message was *spelt* as follows : Torches from one up to five displayed on the left, signified the number of the tablet, and then so many torches on the right the number of the letter on that tablet. The letter 'delta' would thus be signified by one torch to the left and four torches to the right, and so on, throughout the course of the signal."

Considering the date at which they were produced, the systems just described were highly meritorious. They had been pronounced capable of working fully as effectively as many of far more recent date, and were believed to have been competent to convey messages to distances of from four to five miles in a clear atmosphere, and to have been distinctly visible at such distances to the naked eye. Hence it had been pertinently asked, with reference to the comparative difficulties of day and night signalling, "By what possible arrangement could signals be made visible at that distance in the daytime?"

They now came to consider what had been done in the way of night signalling in their own day, always keeping in view what the author had stated with reference to the effect of coloured glasses in diminishing range, and consequently limiting in like proportion the effec-

tiveness of any system in which colour was employed. It was unnecessary for their purpose to enter into a detailed description of all the various systems of night signals hitherto in ordinary use, as their character would be sufficiently understood from the diagrams shown. Suffice it to say that they almost all required the use of several lamps, which in some cases had to be shown in the forms of squares, triangles, &c. In others, the lamps, which were coloured, were suspended vertically over each other, the order of the several coloured and uncoloured lamps being varied to convey different meanings. Others, again, made use simply of uncoloured lanterns, which, for the reasons the author had explained, were superior, where the simplicity of the systems as regards working was equal, to those in which colour was employed. With this before them, it might probably appear to some of the hearers, while comfortably seated in a warm room, that night signalling by these means was not such a very troublesome matter after all; that lamps might be strung up, either in the form of triangles "or any other form," and changed about from one order to another with the greatest facility; but, unfortunately, the conditions under which signalling could be effected in *that room*, and those under which the operation had to be carried on *at sea*, were materially different. In "night and storm and darkness," the experience of signal officers was, that to hoist a string or frame of lanterns at all, without some of them being blown out or otherwise rendered ineffective, was no easy matter, and that to do it in such manner as to display them effectively all around, was frequently all but impossible. In the case of lights required to be seen all round in the forms of triangles or squares, it was of course necessary that the frame carrying the lights should be kept continually revolving, as, otherwise, some of the observers would see the lights in line with each other, and the character of the signal, in so far as they were concerned, would be entirely changed.

The "semaphore," which, as the hearers were aware, was formerly our principal means of inland signalling, consisted simply of a tall post, to which were jointed two arms, capable of revolving in vertical planes, and of being set to any required angle with the post, or with each other. These arms were actuated by chains, and gave 27 changes in all to the instrument. It was obvious that, by making

use of his arms to represent those of the instrument, a man might, on this principle, communicate messages to a considerable distance and they accordingly found that several systems of the kind had been used.

One or two other systems of like character to the semaphore had been invented, but did not appear to have been much employed.

They now came to another class of day signals, namely, that in which solid forms were made use of, and which, for many purposes, seemed decidedly preferable to the class in which flags were employed. A gentleman in the East India Company's service, seemed to have been the first to propose the use of solid forms for signalling, and was followed by Captain Grant, who, in 1838, patented a system comprising nearly all the forms which could be practically used. Among the solid-form systems, also, was Lieutenant Colomb's Multiform Telegraph, an apparatus which displayed much ingenuity, and of which a model was before them. The whole apparatus was extremely light and portable, and was capable of more than 12,000 distinct changes, visible from every point of view. Lieutenant Colomb said it was principally with a view to get rid of the difficulties attendant upon the display of solid shapes in the ordinary manner, that he invented this apparatus.

The next invention that had to be considered, was known as "Redl's Cone Telegraph," regarding which, the author quoted the following remarks by a thoroughly competent authority: "We now come for the first time upon a system, certainly having its own apparatus as a foundation, but being perfectly applicable besides, as far as a telegraphic system can be, to any objects under any circumstances, without requiring any additional study after the system is once learnt." This, in itself, was high praise, and it could not be disputed that the system in question was well deserving of it. The apparatus, as originally constructed, consisted of four hollow cones united in pairs at their bases. They were formed, internally, of hoops, which served to keep their outer covering expanded as necessary, but which could be drawn up or down, one within the other, when required; and the apparatus, as then constructed, required to be hoisted from a gaff or yard, as the case might be. For the adaptation of this system to military purposes, it was proposed by Lieu-

tenant Colomb to make use of cones, constructed somewhat in the manner of umbrellas, closing round a pole as in the model there exhibited. This arrangement was at once simple, portable, and effective in its character, and for movable stations, was, doubtless, preferable to any that could be devised. The system of numbering the cones was as follows: supposing them to be all open, the top represented 1; the next lower, 2; the next, 3; and the lowest, 4; 5 was then formed by the first and fourth; 6 by the second and fourth; 7 by the third and fourth; 8 by the first, third, and fourth; 9 by the second, third, and fourth; 0 was formed by the second and third cones, as there was then some resemblance to the Roman numeral X. There were then other changes, as shown in the diagram. In working short distances with this system, it had only been found necessary for the station signalled to repeat the "stops," instead of repeating the signal throughout. By adopting this plan, it appeared that the speed of transmission had reached at Aldershot, 24 figures per minute. The "alphabetical" arrangement was similarly simple in character, and was as follows: Whenever it was necessary to signal by letters, the number 5 was taken as representing *a*, and the rest of the letters were numbered onward, according to their order. The reason for the *a* being numbered 5 instead of 1, as would seem most natural, was, that if it were so, the figures 13 would equally represent *a*, *c*, and *m*, whereby confusion would arise; but by making the 5 represent *a*, the figure 1 could never represent a letter by itself, but must necessarily belong to the figure which followed it.

With regard to the universal application of this system, the author quoted the following lucid remarks from a paper recently read before the Royal United Service Institution, on the subject of signalling: "There are two states in which each cone can rest; closed and open. If, then, we say that one thing, no matter what, represents an open cone, and another thing represents a closed cone, if we run through the series of four changes, we can express the fifteen variations of which the apparatus is capable. Suppose, for example, the *right* arm represents an *open* cone, and the *left* a *closed* one; if, now, we raise the *right* arm *once*, the *left* *twice*, and, lastly, the *right* *once*, we shall have expressed—*first* cone *open*; *second*, *shut*; *third*, *shut*; *fourth*, *open*, or the figure 5. So with any other two things; as a black flag and

a white ball or flag,—a hat and a stick,—a short sound and a long one,—a single and a double sound, or a low and a high note,—any two things, in fact, no matter what or where they are.” This system had, to some extent, been adopted in the Army, but good as it undoubtedly was, would, the author thought, give place to others of still more effective and perfect character. Yet, even granting that this be the case, it was evident that at the time of its introduction, it constituted a very great step in advance, and more or less pointed the way to something still simpler, and capable of yet more extensive application.

The system to which the author had now to call their attention, was that known as the “Flashing System” of Lieutenant Colomb, R.N., which, as carried out by him, was not only applicable to, and entirely overcame the difficulties attendant upon night signalling, which by it was enabled to be carried on with even greater ease, and to a greater distance than signalling by day; but was also reduced to so simple a matter in the transmission and reading of signals, as to come within the range of the most ordinary capacity, and to be learnt by any practised signalman in the course of an hour’s, or, by others, in the course of a day’s time. According to Lieutenant Colomb’s system—which was the result of long experience in the requirements of the subject, combined with an extensive series of carefully conducted experiments, carried on under the circumstances of actual practice—one *uncoloured light* only was employed. This light was contained within a lantern, glazed in such manner, as that the light, when uncovered, might be visible from any point of view, and it was on the exposure and obscuration of it that the system was founded. Thus, *one short flash* or exposure of the light signified 1.

Two short flashes, 2.

Three short flashes, 3.

Four short flashes, 4.

Five short flashes, 5.

One long flash, 6.

One short, followed by *one long flash*, 7.

One long, followed by *one short flash*, 8.

Two short flashes, followed by *one long one*, 9; and,

One long, followed by *two short flashes*, 0.

The other necessary signals of the code were made in a similar manner, by short and long flashes variously combined, as shown in the diagram.

The mode in which the signals were produced was singularly ingenious and effective. In the interior of the lamp (of which diagram No. 6, was a magnified vertical section) was a cylindrical shade of peculiar construction, which fell by its own weight, and completely covered the light; but when raised, as completely exposed it. This shade was connected by means of a cord, with a lever in the signal-box (of which diagram 7 was a magnified plan with the cover removed, and diagram 8, a corresponding end view), which contained an apparatus closely resembling a barrel organ. The surface of the barrel (which was capable of being steadily revolved by means of a small winch-handle) was occupied by four series of pins and bars, each series representing the numeral flashes as previously given. These pins and bars were so arranged, that after the first series had passed any point, a slight interval elapsed before the next commenced, and so on. Between the end of the fourth series and commencement of the first, there was an interval amounting to one fourth the circumference of the barrel; the object of these intervals being to separate the figures, one from another, and as every signal was continually repeated till answered, the long interval was necessary to distinguish the beginning and end of the series transmitted. Parallel to the barrel, was a square iron bar, upon which were fitted five short levers or keys, capable of being moved endwise into various positions along it. Above the bar was fixed a flat brass plate, termed the "director," having engraved upon it four series of figures from 1 to 0, together with the titles of the several naval signal books. Opposite to each figure and title, and in the line of revolution of the corresponding set of projections on the barrel, was a notch into which a small catch, one of which was pointed to each of the levers or keys, could be moved, thus bringing the corresponding lever into a position to be acted upon by the projections. On now turning the handle, the revolution of the barrel caused the pins upon its surface to operate upon the short levers or keys, which transmitted their motion to the square bar, upon the end of which was fixed a lever, from which

motion was communicated, through another lever and a cord, to the lamp shade.

By what the author had said it would be understood that, with this apparatus, it was only necessary to place the catches in the notches corresponding to any required series of figures, and then to turn the handle continuously, to produce a revolving series of flashes, corresponding to the setting of the instrument, with the most unerring accuracy.

It was evident that, as every signal might thus be repeated three or four times per minute continuously, none of the accidental interruptions to signalling at sea, such as the intervention of passing vessels, ropes, smoke, or sails, could render the progress of night signals, under this system, more uncertain than flag signalling was by day, when subjected to the same interruptions. The large apparatus then before them had been for some time in use in the Channel Fleet, on board of Her Majesty's ship *Edgar*, from which it had been kindly lent to the author for the purposes of his paper. Its success in the Fleet had been most unequivocal,—a fact not to be wondered at, when the extreme simplicity of the principle, and the evident certainty of its action, were considered. When the apparatus was required to be made use of for day signalling, the cord, instead of being attached to the shade of a lamp as described, might be attached to, and made to open a collapsible cone or other opaque object, during intervals corresponding with the short and long flashes or exposures of the light in the night system. (See diagram 9.)

The author much regretted that the time at his disposal would not permit of his entering into particulars of several systems, well deserving of notice. Among these, he might mention the very ingenious lime light arrangements of Captain Bolton, already partly adopted in the Army, and several others of considerable value. But to enter fully into all the details and arrangements bearing upon the question before them, would occupy the time of many meetings, and, notwithstanding the great general importance and interest of the subject, would be apt, he feared, to become wearisome. As it was, he had endeavoured as far as possible to give them a sketch of the main features of the question; and as regards night signalling, had, he

thought, brought before them a system, and an apparatus, which fulfilled their requirements in a remarkably simple and perfect manner. That under the very imperfect arrangements in ordinary use, collisions and other disastrous accidents had not been more frequent than they confessedly had, was certainly to be wondered at; but as it was many had been acknowledged to have occurred entirely in consequence of this imperfection, and he could not doubt that, in thus producing a means whereby night signalling became so easy and certain in its character, Lieutenant Colomb would, in the end, obtain the gratitude of all naval men, and find his system adopted in all the navies of the world, whether war or mercantile.

In conclusion, the author would express his thanks to Lieutenant Colomb, Mr. Wm. Nunn, the well known signal lamp manufacturer, and several other gentlemen, for the kind assistance they had afforded him.

DISCUSSION.

Captain GILMORE HARVEY stated that it would take an hour to signal a message by the old plan, which might by the new plan be done in a few minutes. By the old form of squares, the proper form could only be accurately observed by vessels abreast of each other. By Mr. Colomb's apparatus, this could easily be obviated. This system was considered by himself and his brother officers to be a very great advantage over any form of signal previously used.

Mr. LE FEUVRE said, as the author of the paper had referred to the system of signalling adopted some time before the Christian era, he (Mr. Le Feuvre) might perhaps mention, or rather refer to, the system of signalling hitherto adopted by the Arabs in the northern parts of Africa, namely, a living semaphore. Men were employed, and by the position in which they held their arms, danger or safety was signified. It was a system that was very effectually carried out, stations being placed all over the country. Indeed, the Arabs carried out this system so effectually, that it became a source of great annoyance to the French Government, for the fact of a number of men advancing, could be signalled for a distance of fifteen miles. Since then, however, this system had been superseded by the electric telegraph, which traversed the desert. He (Mr. Le Feuvre) thought sig-

nalling might be carried out successfully in large works. For instance, in the International Exhibition, while the material was being hoisted up, the "navvies" had flags, the colours of the flags being red, green, and blue. He differed with the author of the paper as to the system he had brought before the meeting as far as regards the day signalling, for he should in all cases adhere to colour; but, as regarded night signalling, he thought it would be a great improvement upon the plan now in general use. The only difficulty was that of being able to catch the exact numbers when at a distance; unless the numbers were noted very minutely, one might be missed now and then, especially in foggy weather. The general system, he thought, was somewhat complicated, and he was of opinion that some method might be adopted by which less mechanical labour was employed; for, be it remembered, it was not a question of a large number of signs, as only ten were required. While upon this subject, he might, perhaps, refer to a subject which had received but little attention, namely, Fog Signals. He thought means might be devised to improve the present system; at any rate, he hoped the question would be touched upon during the discussion, as it was one of the greatest importance, but at the same time of difficulty.

Mr. H. P. STEPHENSON considered that the system under discussion was a great improvement upon that formerly in use, though he thought a difficulty would be experienced in distinguishing between a short and a long flash, particularly when the sea was running high.

Captain G. HARVEY said, that as every ship answered the same signals, much greater regularity could be maintained by machinery than by manual manipulation. Each signal was repeated until it was correctly returned.

Mr. H. P. STEPHENSON thought the object could be better obtained by colour.

Mr. NUNN said, that by using colour signals, the range would be shortened; for example: a bright light could be seen three miles, a red light only two miles, and a green light one mile. The chief object was to do away with colours, to secure signals being made at long distances.

Mr. ROBERTS could not see what practical difference there could be between a man pulling a string and the machine used; the levers

of the machine had to be shifted and adjusted for the required signal, and a man who learned to work the machine, could learn to regulate the flashes by pulling the string.

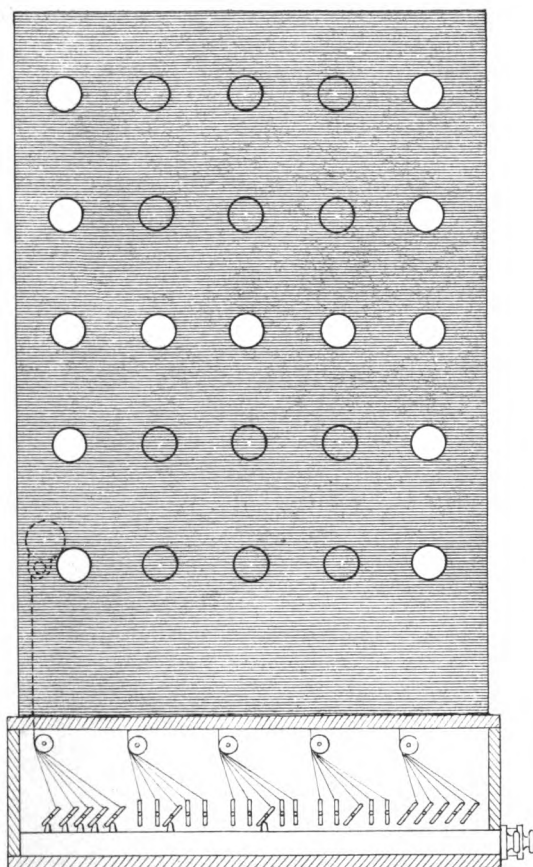
Mr. NUNN said a man would not do the work so well as the instrument, and thought it was going backwards to substitute manual for mechanical labour.

Mr. OLBICK was surprised to hear engineers advocating manual instead of mechanical arrangements. As regarded the system of signalling under discussion and those formerly in use, he considered there was no comparison, and any one who had seen the two systems in practical use at sea, would be of the same opinion. The signals under the old systems were not understood by half of the ships; he had seen several systems applied, but they were all defective, whereas the light signal of Mr. Colomb was beautifully accurate. A mistake in counting the flashes, or confusing one signal with another, could not be made, as each signal was repeated until it was answered by a corresponding signal from the ship signalled.

Mr. F. YOUNG quite agreed with the opinion expressed by Mr. Olrick, that it was not for them to advocate hand labour against machinery; and he was sure, after what they had seen that evening, they could not help feeling satisfied that the system introduced was perfect. Colour, instead of form, was every way objectionable. When crossing the Atlantic, during the laying of the electric cable, the colour of the signal flags of the ships speaking could not be detected. Of course, if there were a plane surface shown, it could be made out, but seeing it on edge, as it were, it could not be distinguished. The mistaking one signal for another was obviated by repeating it until acknowledged. Some short time since, when travelling along a straight piece of railway, he particularly noticed the fact adverted to by Mr. Nunn, namely, that coloured lights were distinguishable at different ranges, for while the white light could be seen for a mile, the green and red were closely approached before they were seen. All he could say relative to the system of signalling introduced to the meeting was, that while he thought some improvement could be effected in the manipulation, the principle deserved every commendation.

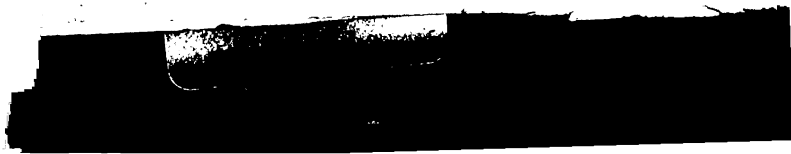
Mr. A. F. WILSON thought the light from the oil lamp was too

BOAZ'S NIGHT SIGNALS.
A.D. 1801.



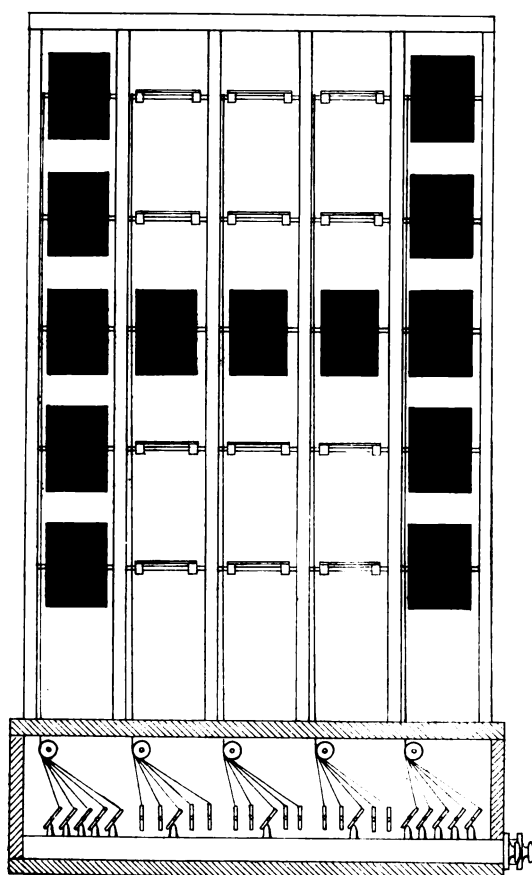
F. AND F. N. SPON, BUCKLESBURY, LONDON

Litho. G. & C.



BOAZ'S DAY SIGNALS.

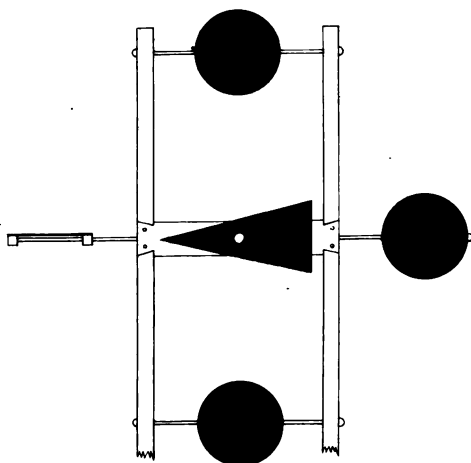
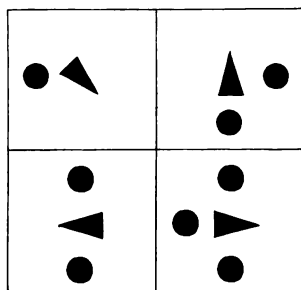
A.D. 1801.





LINDSAY'S DAY SIGNALS.

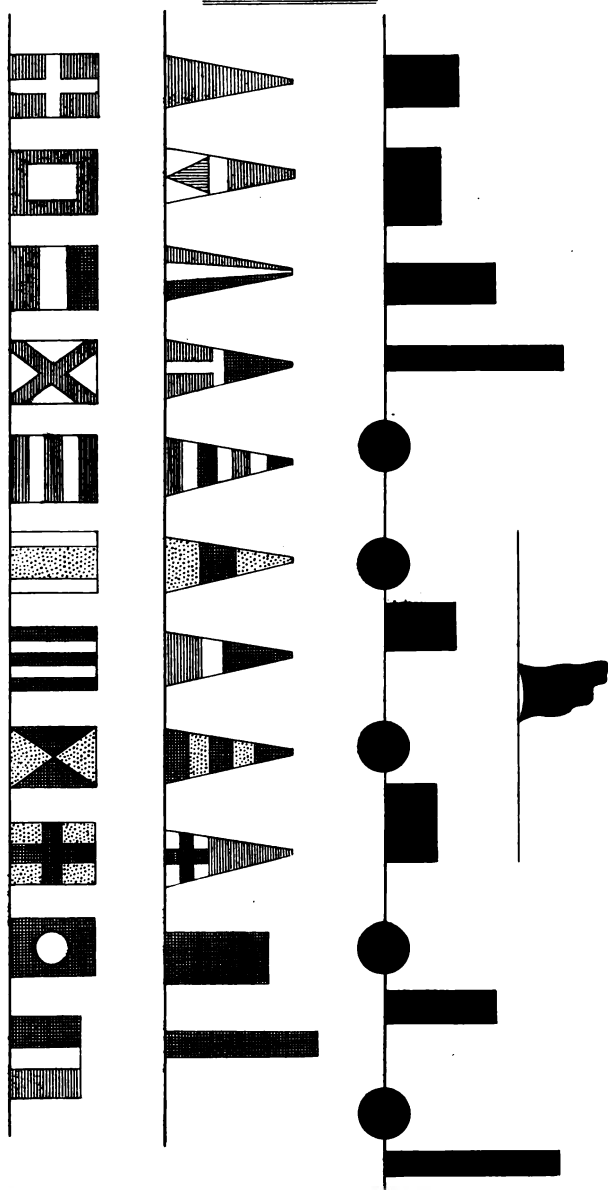
A.D. 1809.



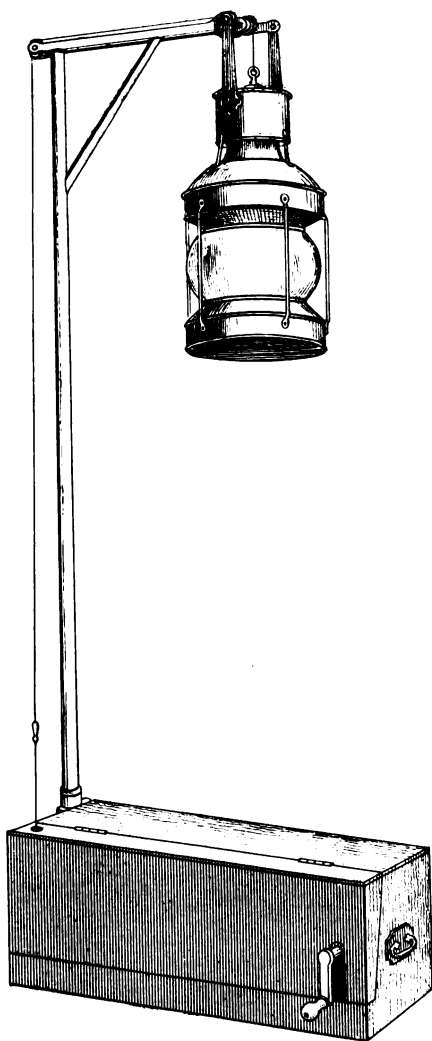


RAPER'S SIGNALS.

Diagram 4.





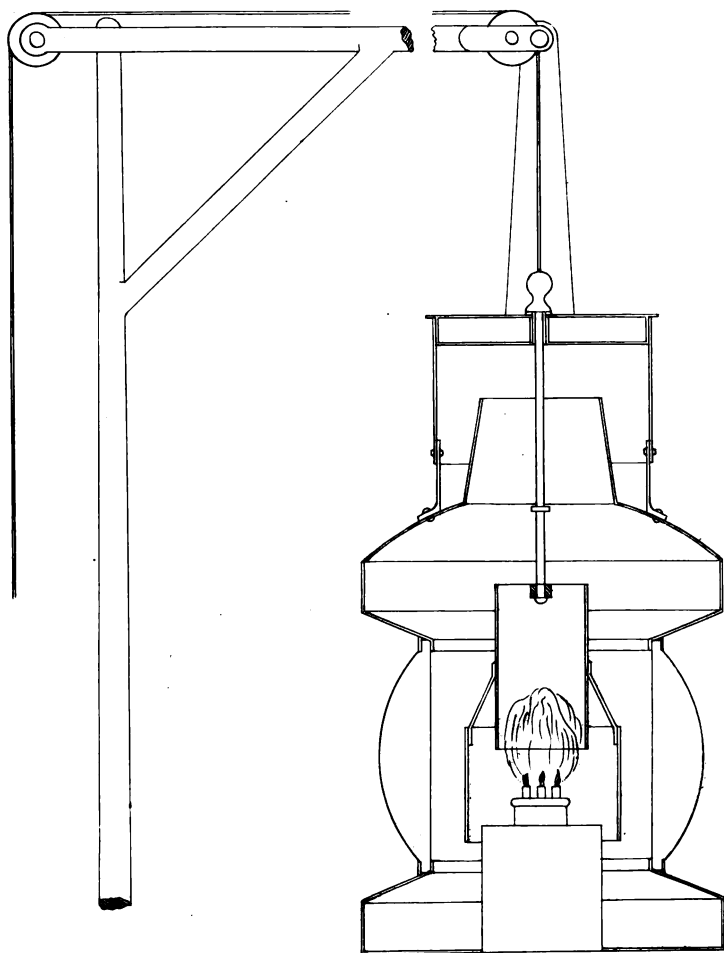
COLOMB'S FLASHING SIGNALS.**APPARATUS COMPLETE.**

E. AND F. N. SPON, BUCKLERSBURY, LONDON.

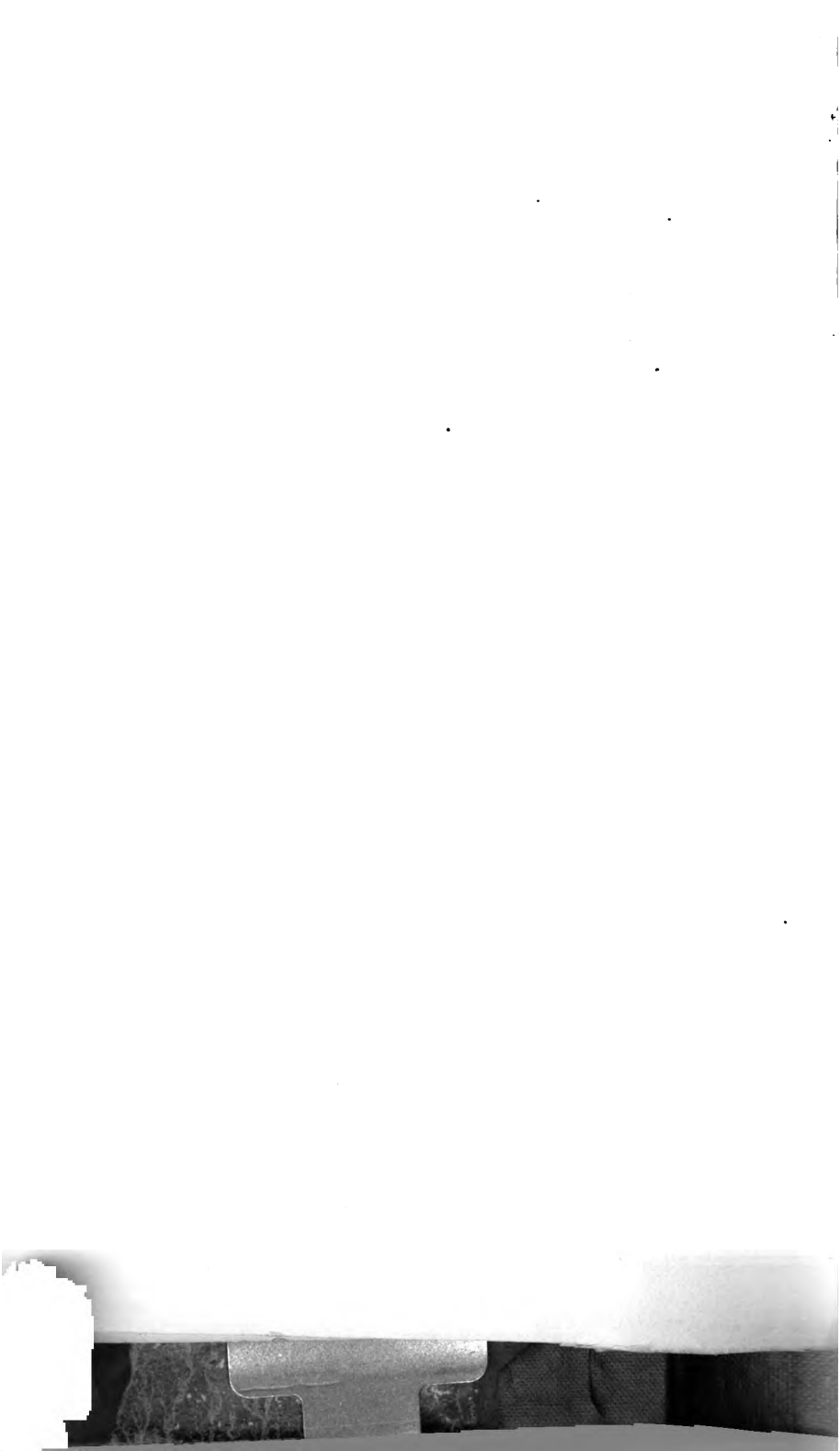
Upfield Green, Ltd.



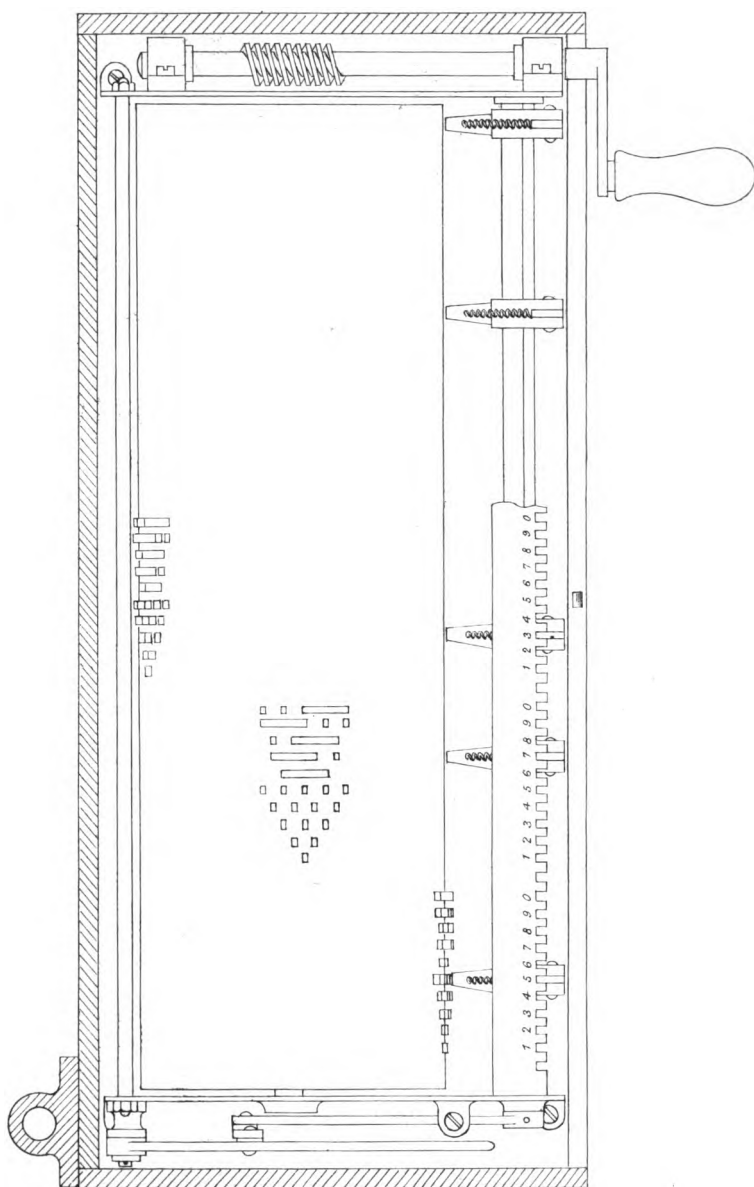
COLOMB'S FLASHING SIGNALS.



VERTICAL SECTION OF LAMP.



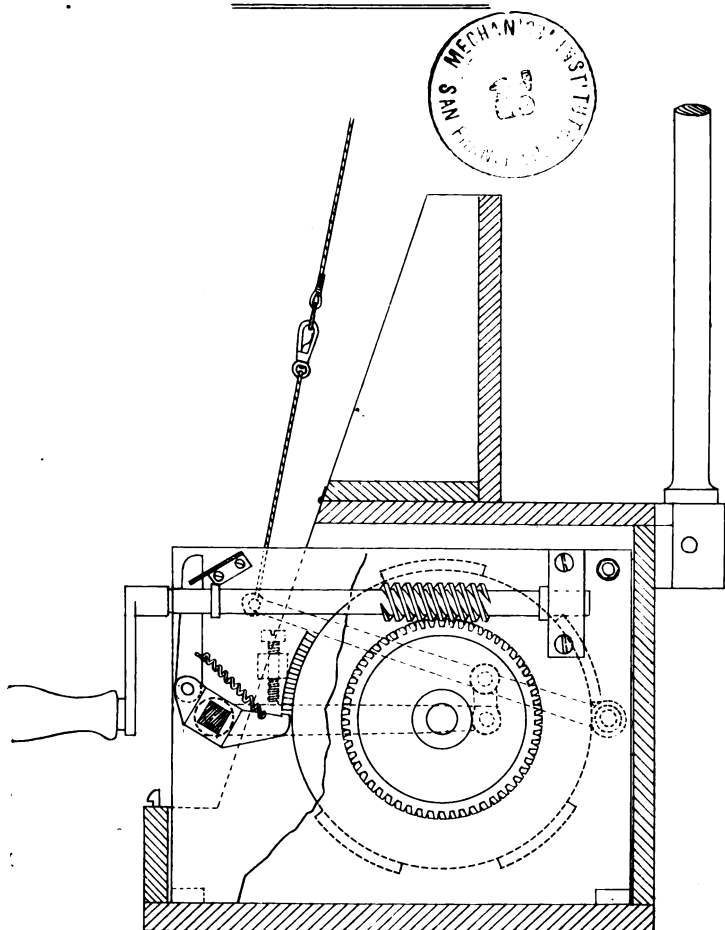
COLOMB'S FLASHING SIGNALS.



PLAN OF SIGNAL BOX WITH COVER REMOVED.



COLOMB'S FLASHING SIGNALS.



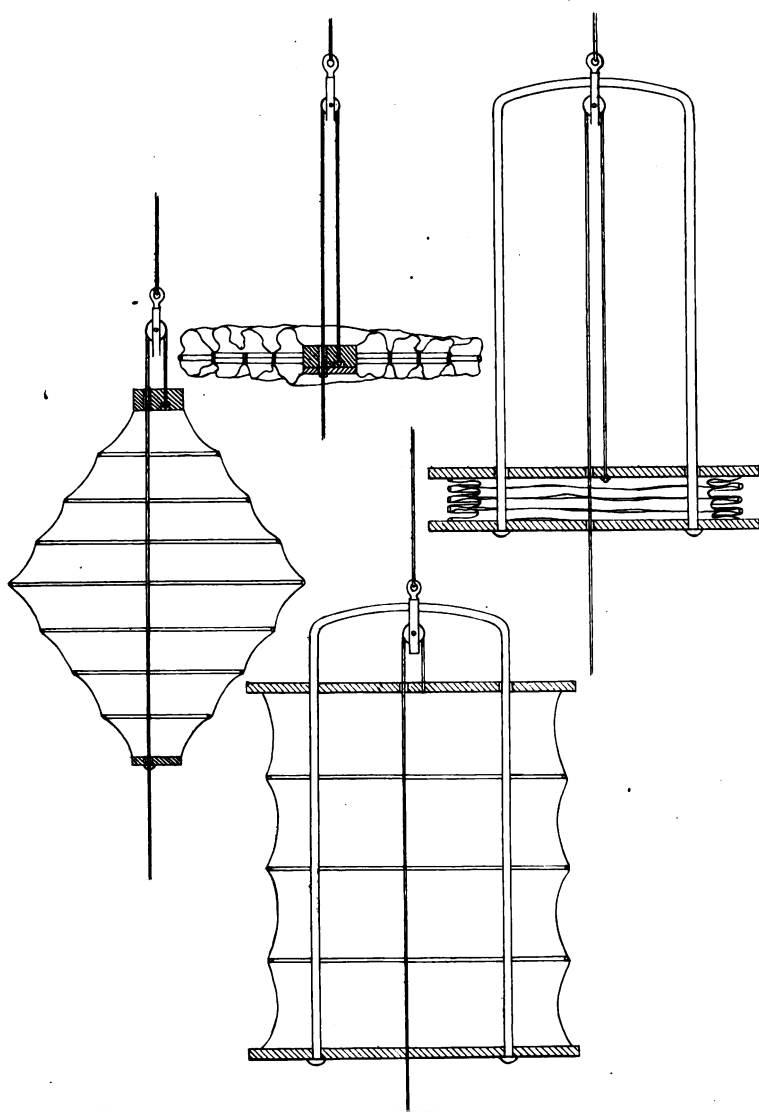
SECTION OF SIGNAL BOX.

E. AND F. N. SPON, BUCKLERSBURY, LONDON

Uplfield Green, L.



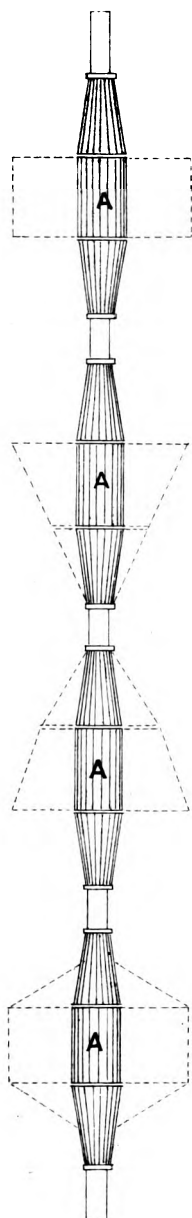
COLOMB'S DAY SIGNALS.



E. AND F. N. SPON, BUCKLESBURY, LONDON

Uptield & Co.

COLOMB'S MULTIFORM TELEGRAPH.



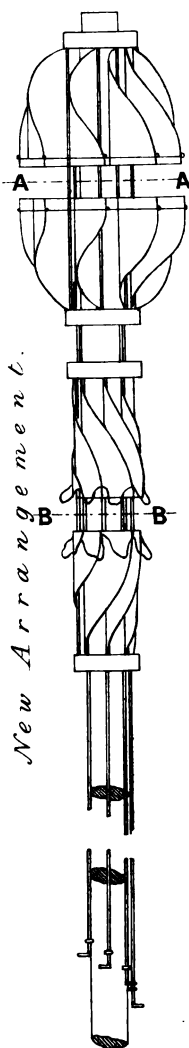
Forms capable of being assumed by each of the parts A.

E AND F. N. SPON, BUCKLERSBURY, LONDON

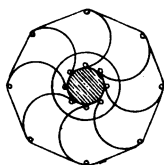
Upfield Green, Lit.



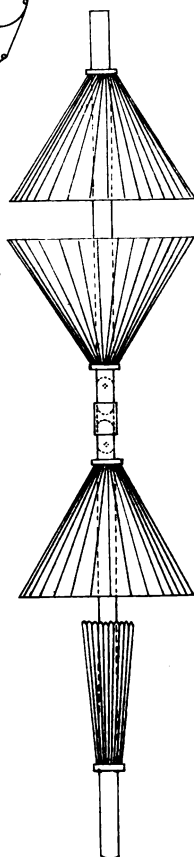
RED'S CONE TELEGRAPH.



SECTION AT A.A.



SECTION AT B.B.



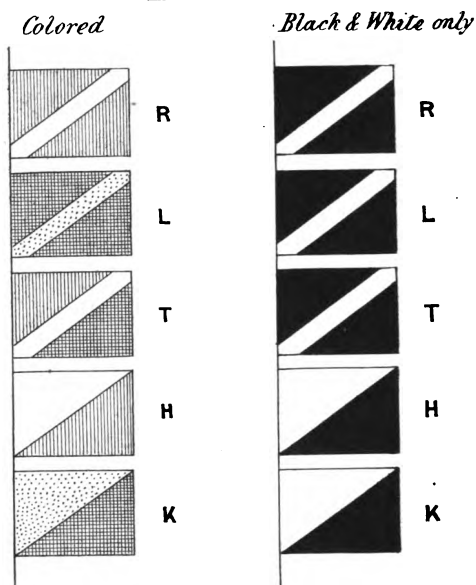
E AND F. N. SPON, BUCKLERSBURY, LONDON

Upheld Green.

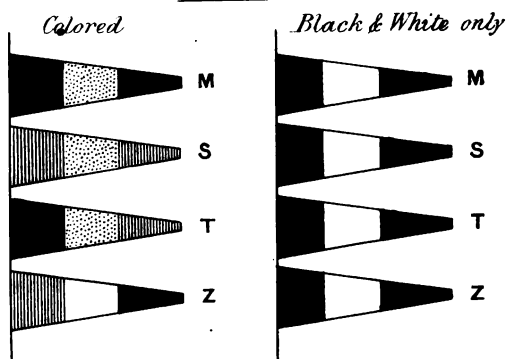
3



ROGERS' FLAGS.



WARD'S FLAGS



Colors are shewn thus.

<i>Red</i>	
<i>Blue</i>	
<i>Yellow</i>	
<i>Black</i>	
<i>White</i>	

dim, and suggested that the same system should be carried out with an electric light.

Mr. NUNN did not approve of the electric light, which had hitherto proved a failure, especially on the night of the late illuminations in honour of the Prince of Wales's wedding. The light exhibited could be seen at sea at a distance of $6\frac{1}{2}$ miles.

The CHAIRMAN said that he had had no practical experience of the working of these lights. The only objection to the system of signaling proposed, but which was obviated by repeating the signals, was the liability of missing the short flashes, or as they came rather rapidly, to mistake the end of one figure for the beginning of another. As regarded the use of a lime light, he thought it was difficult to use it at sea. A mast-head lantern might be suspended, as that gave a very powerful light which could be seen at a considerable distance, and as no reflectors were used the light could be seen in every direction. The umbrella signals appeared to be useful, but he did not know that they were better than signalling by arms, and, moreover, he thought there would be considerable difficulty in using them in a high wind.

December 7th, 1863.

R. M. CHRISTIE IN THE CHAIR.

STEAM NAVIGATION ON THE INDUS.

By ALFRED WARREN, Assoc. I.N.A. (late Marine Engineer to the Indus Steam Flotilla).

THE subject of this paper is one that can hardly fail to be of interest to engineers. The Indus is at present the only artery of commerce between the North West of India and the Western coast, and it must continue to be so until the completion of a railway up the valley of the Indus—an event which can hardly take place for ten or twelve years at least. It is, therefore, of great importance that an efficient steam communication should be established on the river. The attempts hitherto made to accomplish this have, however, met with so little success, that it becomes interesting to inquire into the

cause of the failures, and to ascertain, if possible, the best way of remedying them in future.

DESCRIPTION OF THE INDUS—ITS COURSE.

The Indus rises in Thibet, but little is known of it until it issues from the Himalayas, at Attok, where it is joined by the river of Cabul. Small steamers have ascended the river as far as Attok, where there are rapids which it is not possible to ascend. At Mit-tenkote, at the south-western extremity of the Punjaub, the Indus is joined by the Chenaub or united rivers of the Punjaub, all of which flow from the Himalayas, and are for the most part navigable by small steamers. After this the Indus receives no farther affluents during the whole of its course of about 500 miles to the sea. The portion of the river on which regular steam communication is now established is between Kotree, opposite Hyderabad, in Scinde, the upper terminus of the Scinde Railway, and Moulton on the Chenaub, the lower terminus of the Punjaub Railway. The distance, measured along the banks, is 570 miles, but the navigable channel is much longer than this. The Delta lies below Kotree, and is seldom now navigated by steamers.

RISE AND FALL OF WATER.

The water of the river is subject to a rise and fall of 17 ft. to 19 ft. every year. During the winter months, or from the end of November to the middle or end of March, the water is at the lowest—in some places not exceeding 2 ft. or 3 ft. in depth. It then rises gradually till the end of August, remains a few days at the highest, and then falls gradually till the end of November. The rise of the water is due almost entirely to the melting of the snows in the Himalayas, and is hardly affected at all by the rainfall, which is very small in that part of India, and generally occurs only on a few days in July and August.

CURRENT.

During the low season the current in the Indus is three to four miles per hour, and in the Chenaub two or three miles. When the water is high the current in the Indus varies in different parts from four to six miles an hour, and is, occasionally, even more than this; and in the Chenaub it is three to four miles.

CHANNEL.

The width of the river between the permanent banks varies very much. In some places it is not more than half a mile wide; while, in others, it spreads out to a width of some miles. In the wider places islands are formed, which become covered with low brush-wood, but are liable, from year to year, to be washed away and formed again in other places. The water of the river contains so much sand in suspension, the current is so strong, and the eddies so numerous, that the formation and washing away of sand-banks is a process continually going on, and the navigable channel is, in consequence, continually shifting. At the height of the inundation the permanent banks are always a good deal washed away. Villages may then be seen undermined by the water, and falling into the river. During the inundation of last year (1862) the flourishing town of Mittenkote, the largest and most important place between Sukkur and Moulton, was entirely washed away.

It has happened that a steamer has made fast at night under the shelter of a projecting portion of the bank, and in a few hours the bank has been washed away, and the steamer cast adrift. A steamer was nearly lost in this manner in August, 1861. The banks are generally low, flat, and uninteresting except at Sukkur and Sehwan.

SUKKUR PASS.

At Sukkur there is a narrow pass between high rocks about half a mile in length. There is a bend in the river just above the pass, and two islands in the pass. The current has been gauged as high as 9·9 knots, or more than 11½ miles an hour. The eddies are very violent, and at such times there is much difficulty and danger in getting up the pass. This prodigious current, however, will only last for a few days at a time during the rise of the waters. During the low season the current is not stronger there than elsewhere.

NAVIGABLE CHANNEL DURING THE LOW SEASON.

The navigable channel during the low season is narrow and shallow. It winds about from side to side of the bed of the river, and not only changes its position after every inundation, but is continually chang-

ing it, so that a channel which is navigable one week will often not be so the next, another channel having been formed. The bottom, in many places, rises as the water rises. In 1861, when the water was high, there was a place below Kotree where there was said not to be more than five feet depth of water all across the river. Many of the bends of the river are exceedingly sharp, and in such places the current is almost always very strong. The most difficult period of the year for the navigation is during the fall of the river. The channel that has been formed during the low season is generally silted up or absorbed into a wider channel as the water rises. When the water falls again, another channel has to be formed, and during this process it is sometimes difficult to find the channel at all, and the changes in it are very rapid.

NATIVE PILOTS.

With such varying channels it would hardly be possible to navigate the river at all were it not for the skill of the native pilots in what they call "reading" the water, *i.e.*, telling by the appearance of the surface what the depth is. They are very rarely mistaken, but they sometimes take a channel which has become stopped up, and then they have to turn back and seek another channel. Englishmen who have commanded steamers on the river for years say that they could never learn to read the waters as the native pilots do.

WOODING STATIONS.

In such channels it is impossible for steamers to proceed in the dark, and they are obliged to make fast to the bank. Wooding stations occur at every twenty or thirty miles, and steamers always endeavour to reach a station before nightfall, so as not to lose time by wooding during the day, wood being hitherto the only fuel used.

GOVERNMENT STEAMERS.

The first steamers were placed on the Indus during the conquest of Scinde, and were of material assistance to Sir C. Napier in his military operations. After the conquest other steamers were built, with an especial view to the peculiarities of the navigation. They were principally employed in the conveyance of troops and stores,

which were carried in an accommodation flat towed alongside. Passengers were conveyed by them, but general merchandise was not sought for.

DIMENSIONS.

The four largest of these steamers, built by Messrs. Laird, of Birkenhead, are in—

	ft.	in.
Length on water-line	168	0
Length on deck	175	0
Beam	28	0
Draught when quite light	3	3

Steeple engines by Messrs. Maudslay and Field, 110-horse power :—

	ft.	in.
Diameter of cylinder	0	43
Length of stroke	4	0
Diameter of paddle-wheels	17	6
Width of do.	8	6
Length of engine-room	35	0

SPEED.

Their ordinary working speed, without a barge in tow, is twelve to thirteen miles an hour.

FORM.

They are spoon-shaped stem and stern, but they have a movable dead wood, which can be raised up and down, and is generally left down as the rudder is then found to act more efficiently. The spoon form of these vessels has been strongly advocated for two reasons. First, on account of the supposed facility for getting them off sand-banks; and secondly, because they are thought to be less affected by the eddies of the river. The author was of opinion however, that these supposed advantages were to a great extent fallacious. A spoon bow will take the ground nearer amidships than an ordinary bow, or, if the vessel is going with any speed at the time of striking, it will be liable to lift itself on the sand-bank, and then it would be more difficult to get it off than if the bow had been wedged in. With

respect to the effect of eddies on the bow, there may, perhaps, be some advantage, but he could not observe any superiority in their steering qualities when in troubled water.

CONSTRUCTION.

These steamers are very strongly constructed. There are five transverse water-tight bulkheads and two longitudinal bulkheads which rise about 2 ft. above deck at the engine-room, and give great longitudinal stiffness to the vessel.

DRAUGHT AND CAPACITY.

The draught, with all stores and fuel on board, is 3 ft. 9 in. or more. They are therefore incapable, when the water is low, of carrying cargo on board, but they can then tow a barge carrying 100 or 120 tons, or two barges with the same quantity, but it has been customary to put the cargo into one barge only. When the water is high and the current strong they may carry 80 to 100 tons on board, but are not then capable of towing a barge.

DEFECTS AND MERITS.

The chief defects of these steamers are their small carrying and towing power, and their great draught. On the other hand, their speed is good, and the experience of several years shows that they are capable of withstanding the wear and tear of the river service better, probably, than any other steamer on the river.

ORIENTAL INLAND STEAM NAVIGATION COMPANY.

The first company started for placing steamers on the river was the Oriental Inland Steam Navigation Company. Their plan was to carry out Mr. Bourne's patent train of barges. The steamer was 200 ft. long, 20 ft. beam, and 5 ft. deep. It had a spoon bow and convex stern. The first or connecting barge was 40 ft. long, and 18 ft. beam, with concave bow and stern. There were to be four other barges 100 ft. long, 18 ft. beam, and 5 ft. deep, with convex bows and concave sterns, so as to fit close into one another. The hindermost barge had a spoon-shaped stern. It was supposed that by this plan a number of barges could be towed with the bow resistance of only the one steamer. The result of a trial in the harbour

of Kurrachee in 1859 is singular.* The speed of the steamer alone was 9·37 statute miles, with 273 indicated horse power, a very small speed if the steamer was in good working condition. With the 40 ft. barge, and one 100 ft. barge, loaded to 2 ft. 10 in., in tow, the speed was reduced to 7·19 miles with 303 indicated horse-power. With a second 100 ft. barge, the speed was reduced to 5·75 miles with 332 indicated horse-power; and with a third barge to 4·33 miles, showing a diminution of speed for the first barge of 2·18 miles, for the second of 1·44 miles, and for the third of 1·42 miles. With such a speed it was of course hopeless to effect anything on the Indus, but an attempt was made to ascend the river with one barge only in tow beside the connecting barge; it proved, however, an utter failure. The train was found to be quite unmanageable in the sharp bends and cross currents of the river, and after some further trials the train system was abandoned. The steamer and barges were altered so as to act in the ordinary way, two barges being towed, one on each side of the steamer; her speed has always been slow, but she has run pretty regularly with her two barges until the spring of this year, when she unfortunately grounded amidships and broke her back.

STEAMERS FROM THE CLYDE.

The company, finding that the trains were a failure, determined to purchase some of the Clyde steamers, and send them out to India. One, the *Windsor Castle*, was taken to pieces in the Clyde. The hull was shipped in a vessel which went to the bottom before it had got to sea. It was therefore determined to build a new hull for the engines. This hull was made 30 ft. longer than the old one, but the same in other respects, and an additional boiler was provided for the engine. This steamer was launched at Kurrachee in the autumn of 1861, and called the *Indus*. Her length over all is 218 ft. 7 in.; beam, 19 ft. 6 in.; depth, 7 ft. 5 in.; draught with all stores and fuel on board, full 4 ft.; engines, 120 nominal horse-power. She has a very fine entrance and run, and her speed at the trial in the harbour was said to be above 21 miles an hour. She has towed up the river three barges carrying 1500 hogsheads of ale, or about 430 tons. This,

* From Mr. Leys' paper on "Indian River Steamers," read to the Scottish Shipbuilders' Association.

however, was under favourable circumstances of the river, and she could not do that on an average. Probably two barges with 150 tons in each would be a fair average load for her. Owing to her great draught she is incapable of carrying any car go on board.

MERITS AND DEFECTS.

The great merit of this steamer is its large towing power, but it may be doubted whether the same power might not be obtained in a steamer better suited to the navigation of the river. A steamer built for a speed of twenty miles an hour is surely not the best adapted, and, therefore, not the most economical for towing barges at the rate of twelve miles. If a vessel is not intended to go faster than twelve miles an hour, there can be no advantage in giving her a form suited to twenty miles. It was, he believed, an acknowledged principle, that if a vessel were fine enough to pass through the water at a given speed without raising a wave, there would be no diminution of resistance at that speed by giving her a finer form, but, on the contrary, by increasing the length, the surface is increased, and thereby the frictional resistance. He was of opinion, therefore, that a steamer of shorter length, but greater beam and less draught, and the same engine power, would have quite as much towing capacity and be more manageable and useful in the river; for it is certain that the shorter the length and the less the draught, the more suitable is the steamer to the navigation of the river. The chief defect of this steamer is its excessive draught.

HARBOUR TUG.

This company have also a harbour tug steamer at Kurrachee. Others of the Clyde steamers purchased by them were lost in their passage out to India. Another of the train steamers altered is now in course of erection.

INDUS STEAM FLOTILLA COMPANY.

The next attempt to establish steamers on the river was made by the Scinde Railway Company. Their object was to have steamers running in connexion with the Scinde and Punjaub Railways, so as to have a continuous steam communication from Kurrachee to Lahore.

A company was, therefore, formed in 1858, called the Indus Steam Flotilla Company, in order to carry out this object. Designs and tenders for steamers were obtained from various shipbuilders. The principal conditions laid down were, that the length was not to exceed 200 ft., nor the draught of water 2 ft., and the power to be sufficient to tow a barge with troops or cargo. The tender selected was by Mr. J. Scott Russell, and as there were some peculiarities in the design and method of construction, it was determined to have one steamer erected and tried on the Thames before ordering more. The dimensions of this steamer, the *Stanley*, are as follows :

DIMENSIONS.

Length, 200 ft. ; beam, 38 ft. ; depth on side, 6 ft., with houses on deck ; engines, 120 nominal horse-power ; diameter of cylinder (three in number) 34 in., oscillating, working on same crank pin ; stroke 4 ft. ; ordinary marine boilers, 25 lb. pressure ; paddle-wheels, 14 ft. 6 in. diameter. In form she was flat-bottomed, with long straight sides. The bow is 60 ft. long, the stern 40 ft., and the centre or straight part 100 ft., or half the whole length. She has hollow water-lines in the bow, and the bottom rising at the stern to the height of 2 ft., with convex water-lines. In the steamers subsequently built the bottom rose to a height of 3 ft. 6 in. She was tried in the Thames in February, 1859, and was said to have a speed of thirteen miles an hour. The draught was under 2 ft., and the indicated horse-power was 663. This was considered such a favourable result that it was at once determined to have six other similar steamers built. The contract, however, was not given to Mr. Russell, but tenders were again invited. The specification was for hulls similar to that of the *Stanley*, with a few alterations, intended to give greater stiffness and strength, but the design of the engines was left to the contractor, the horse-power only being specified—120-horse power nominal. The contract was given to Messrs. Richardson and Duck, of Stockton, the engines being made by Messrs. Kitson and Hewitson, of Leeds.

LONGITUDINAL SYSTEM.

The method of construction of these vessels is somewhat peculiar. They are not constructed in the ordinary way, with transverse ribs 2 ft. to 3 ft. apart, but are on what Mr. Scott Russell calls the longi-

tudinal system. He considers that in the ordinary method the large quantity of iron put into the ribs of a ship does not impart strength where it is required, and is, therefore, to a great extent wasted. He says, to quote his own words, "In the longitudinal system I take all that excessive, and, as I think, comparatively useless quantity of iron, which is usually formed into ribs, and placed across the ship, loading it with a weight which contributes far less than its due proportion to the general strength, and I place it lengthways along the skin so as to contribute materially to the strength and efficiency of the skin, where it is much wanted, and to give strength to the structure as a whole, where it is at present weakest. To give the best idea of the difference between the new system and the old system, I give the following example of ships of 600-700 tons scale, built on both systems.

WEIGHTS OF IRON USED IN THE GENERAL STRUCTURE.

	Old System.	New System.
	Tons.	Tons.
In the skin	110	110
In transverse internal strengthening	130	40
In longitudinal „	40	130

It thus appears that the iron expended in strengthening the ship longitudinally in the new system is to that in the old in the proportion of 130 to 40.* It would certainly appear that this system has great advantages for light flat-bottomed vessels, of shallow draught and liable to ground, where longitudinal stiffness is the great desideratum, and comparatively little is obtained from the skin of the vessel. The author then explained the construction of the steamers built by Messrs. Richardson and Duck.

DETAILS OF CONSTRUCTION.

There are two longitudinal bulkheads 22 ft. apart, running the whole length of the ship. For 142 ft. amidships, *i.e.*, to the end of the deck houses, of which they form the sides, they have a height of 14 ft. 6 in. Beyond this they are carried below deck tapering at the ends to about 3 ft. 6 in. There are seven keelsons on the bottom,

* Transactions of the Inst. of Nav. Arch., vol. iii. p. 164.

and two on the sides, three of them 18 in. deep, and the rest 9 in. In the engine-room they are all 15 in. deep. There are five transverse water-tight bulkheads. Those at the ends of the engine-room are 14 ft. 6 in. in height between the longitudinal bulkheads. Fore and aft the engine-room there are ten of what Mr. Russell calls partial bulkheads, or bulkheads with the centre part cut out, forming a continuous girder round the vessel, 18 in. deep at the bottom and 15 in. at the sides, the deck beam being 5 in. deep. These are 11 ft. to 12 ft. apart, and there are no ribs between them. In the engine-room they are about 6 ft. apart, and 15 in. deep. Stringer plates, 18 in. wide, run round the gunwale and along the top of the longitudinal bulkheads. The plates of the skin are $\frac{3}{8}$ in. thick under the engine-room, and 8 wire gauge elsewhere. The plates of the bulkhead are 8 and 9 wire gauge. The iron is charcoal iron, manufactured at the Pontypool Ironworks, and is of excellent quality. The decks and wood fittings generally are of teak. No other wood is capable of standing the heat of the climate. The engines extend over the whole length of the engine-room, which is 52 ft. long, and rest on box girders, 2 ft. deep, 8 in. wide, and $\frac{1}{8}$ in. thick. They are direct-acting, working at an inclination on opposite sides of the shaft, the cranks being connected by a drag link. The diameter of the cylinder is 34 in.; stroke, 7 ft.; diameter of wheels, 23 ft. There are four boilers, of locomotive shape, capable of working to 40 lb. pressure.

OBJECTIONS TO LONGITUDINAL SYSTEM.

It will be seen by the above description, and a reference to the drawing, that between the keelsons and bulkheads there are large spaces where the plate has no support. Some of these spaces are as much as 11 ft. 6 in. by 4 ft. 6 in. In a sea-going ship with thick plates, there is no objection to this; but when the vessel is constantly grounding, and the plates are very thin, the effect of the grounding is to bulge the plates inwards between the frames. This effect was just apparent in the *Stanley* after one voyage up the river; and it is to be feared that, in a year or two, it will become serious. It may be doubted whether this defect will not more than counterbalance the advantages of the longitudinal system.

PERFORMANCE OF THE "STANLEY" IN INDIA.

The *Stanley* was sent out to India and re-erected there, but she never had the speed said to be attained in the Thames. Her engines were raised 18 in., and the wheels increased 3 ft. in diameter. This alteration improved the working of the engines, but the speed hardly exceeded eleven miles. She made a trial trip up the river to Moultan in December, 1860. The water was unusually low at the time, and her light draught enabled her to pass over shallows where Government vessels were aground; but her great size made it very difficult to steer her in narrow channels and shallow water. All steamers steer more or less badly in shallow water, and the greater the extent of flat bottom the worse they steer. This effect is particularly seen in passing from deep water into shallow water. Steamers on approaching shallow water will often fly off against their helm, while there is still several feet of water below the bottom. This defect was very manifest in the *Stanley*, and he believed it was impossible to remedy it. In deep water she steered with great ease. The paddle-wheels caused great commotion in the water, raising large waves at the stern. This was no doubt due to the great length of straight sides, the extent of flat bottom and want of a fine run, which prevented the water escaping freely from the wheels. The *Stanley* is now running regularly on the river.

PERFORMANCE OF THE OTHER STEAMERS IN INDIA.

The first steamer built by Messrs. Richardson and Duck was tried in Kurrachee harbour in April, 1861. The engines were found defective in two particulars. The condensers could not maintain a vacuum, and the boilers primed so much that it was found impossible to prevent the water from passing over into the cylinders. These defects were remedied after a delay of some months, after which further delays took place, and it was not till the spring of this year that the steamer was sent up the river. None of the other steamers have been tried. This result is very much to be regretted, for he was persuaded, though these steamers were not all that might be desired, yet that they are capable of doing good service in the river, and that there is no sufficient reason why they should not all have been at work on the river by this time.

GREAT CAPACITY.

These steamers have one great merit which has not yet been tested. They have great capacity for carrying cargo at a light draught. They are capable of carrying 250 tons, including fuel, or, say, 220 tons, exclusive of fuel, at a draught of 3 ft. 6 in. ; he believed it would be far preferable to put all this cargo on board than to tow it, or a portion of it, in a barge alongside, as has hitherto been done.

DECK-HOUSE.

The house on deck is certainly a mistake. The object was to provide a cool cabin for passengers, but in the extreme heat of Upper Scinde this result is not obtained ; on the contrary, the heat in the cabin of the *Stanley* was once at 112 deg., with an awning over it. In cabins below deck the temperature would never rise much above 90 deg., and with a punkah this heat is quite bearable, and indeed feels cool on passing into it out of a temperature of above 100, which the air generally has during the day in summer. The deck-house greatly increases the difficulty of managing the vessel, and opposes considerable resistance to the wind.

CORROSION.

The author here mentioned a singular circumstance which had occurred to one of these steamers. She was launched at Kurrachee in the beginning of 1861, and remained at anchor in the harbour. She was perfectly tight till this year, when she was suddenly found to be leaking in several places through the centre of the plates of the bottom. She was put on shore at once, and then it was found that her bottom was full of holes, having the appearance of being eaten by worms. He never before heard of an instance of worms eating through iron. This company have lately purchased six of the best of the Government steamers with the dockyard and machinery, and the Government establishment is broken up. They have also some tugs and a number of barges of galvanised corrugated iron, but they have been found too small, and altogether unsuited to the service of the river.

NEW GOVERNMENT STEAMER.

A steamer and barge for transporting troops, of very large dimensions, have lately been built by the Government, according to the recommendations of a commission appointed by them in 1857, to report on the navigation of the shallow rivers of Europe. The steamer is 350 ft. long, 45 ft. beam, and 2 ft. draught, spoon-shaped fore and aft, 120 horse-power. (He believed these were the correct dimensions.) She is strengthened longitudinally by two arched girders. The barge is 220 ft. long. The speed of the steamer at the trial trip at Kurrachee is said to have been 8 miles an hour. She has got up to Kotree, and the Government has placed her in the hands of the Indus Steam Flotilla Company, in the hopes that they may be able to work her, but there is little hope of her being of any use in the river. She is much too large to get up the river when the water is low, and she has not nearly power and speed enough to stem the current when the water is high.

Drawing No. 6, shows plans of all the different steamers on one sheet. The differences between them may be seen at a glance.

Having thus described the peculiar characteristics of the river, and pointed out the merits and defects of the various steamers at work upon it, we have sufficient data to lay down the principles which should guide us in designing steamers for the river.

LENGTH.

Steamers should not exceed 200 ft. in length. This may appear an unnecessarily small limitation of length, as the most powerful steamer on the river is 210 ft., but he had pointed out that this steamer would probably do her duty better if she were somewhat shorter. It is certain that small steamers, 150 ft. long, have always made their journeys more regularly than the larger ones in the low seasons, and it must be remembered that this season extends over four months, and is the busiest season of the year. The *Stanley*, which is 200 ft. long, has been aground fore and aft across the main channel of the river in by no means the narrowest place. If she had been much longer than she is, there would have been great difficulty in getting her up the river at all at her trial trip, when she was

without a cargo. The universal opinion of commanders of steamers on the river is, that 200 ft. is the extreme length that a steamer should have, and that it is preferable to keep within it.

DRAUGHT.

The extreme load draught should not exceed 3 ft. 6 in., and it would be better to keep it to 3 ft. Steamers drawing 4 ft. are sometimes delayed for weeks in the passage up and down the river when the water is low, while those drawing under 3 ft. are seldom delayed seriously.

CARRYING AND TOWING.

They should be easily manageable in the shallow, narrow channels, sharp bends, and strong currents of the river. This opens the question whether towing or carrying steamers are preferable. Hitherto towing has been the universal practice, but he thought there was some ground to question its correctness. It is certain that, in such a river as the Indus, a steamer by itself is more manageable and less liable to accidents, and will make her journeys with much greater regularity, than one having barges in tow. On the other hand, she could hardly carry as much cargo. The example of the steamer *Indus* shows that we may rely on a tug steamer to tow two barges, with 300 tons, up the river. A steamer of suitable size for the river could hardly carry more than 200 tons at 3 ft. 6 in. draught, but this is more than any of the steamers formerly belonging to the Government are able to convey. This question can only be determined by practical experience, but the author is strongly of opinion that proper carrying steamers will be found the most efficient.

FORM.

The form should be suited to a speed of twelve or thirteen miles an hour. The spoon bow is not a necessity. The hollow bow of the *Stanley* answers perfectly well. At the same time the performance of the spoon bows in shallow and in troubled water is good if it is not rough. A spoon stern is objectionable, as it affects injuriously the passage of water to the rudder. Straight sides should be avoided, and it would be better to give the bottom a rise of an inch or two, rather than keep it perfectly flat.

CONSTRUCTION.

The construction of the steamers should be such as to enable them to withstand constant grounding without injury by straining or in other ways, and should be as light as possible.

ENGINES.

With respect to the engines nothing has hitherto been said, but there is no great difficulty about them. Oscillating engines have the advantage of having no exposed rubbing surfaces, which is desirable in the case of sand storms, which frequently occur, at times lasting for hours, and doing much injury to exposed surfaces. The steeple engines of Messrs. Maudslay and Field have, however, worked well on the river for years. The direct acting engines of Messrs. Kitson and Hewitson have the advantage of spreading the weight and pressure over a great length of the vessel, but they are not compact, and the arrangement of the boilers is open to objection. Surface condensers should certainly be provided in consequence of the intense muddiness of the water. The starting gear should be on deck. The paddle-wheels are very liable to injury. It has been found best to provide against this, not by making them very strong, but by making them very slight, so as to be easily repaired. If a wheel is seriously injured by striking a bank, as often happens, the steamer is made fast, the injured part is taken out and replaced by spare material, which is always kept on board, and in half an hour or so the wheel is entirely repaired, and the vessel proceeds on her way. Boilers must be provided with large furnaces for burning wood. They should have large water and steam room, so as not to be liable to sudden fluctuations of water level and pressure. As all the stokers are natives, this is a desirable precaution. The square marine boiler, with return-tubes, seems to have an advantage over the locomotive form of boiler.

PROPOSED CARGO STEAMER.

The author then proceeded to give a rough outline of two designs for steamers, in which he endeavoured to embody the above principles, and which he ventured to think would be found efficient steamers for

the river. One is intended for carrying, and the other for towing. He first described the cargo steamer. Its dimensions being:

	ft.	in.
Length on 3 ft. water-line	190	0
Ditto, over all	200	0
Beam	38	0
Depth from underside of deck to skin . . .	9	6
Draught, with all stores, but no fuel, under .	2	0

1000 maunds, or 36·5 tons of wood fuel, equivalent to about twenty hours' consumption; 3 in. draught; 200 tons of cargo, 17 in.; extreme load draught, without fuel, 3 ft. 5 in.; ditto, with fuel, 3 ft. 8 in.

FORM.

There is a slight rise of 3 in. in the floor, so as to avoid a perfectly flat bottom. The sides begin to taper almost at once from the mid-ship section, so that there is no length of flat side. The water-lines are slightly hollowed, so as to give as fine an entrance and run as possible. There is a slight rise forward. The stern projects aft over the rudder. There is an advantage in this, as it protects the rudder, and enables the anchor-boat to be towed astern without fear of damage from the rudder, and it renders it possible to steer from the fly, which was found a great advantage in the *Stanley*. (The *Stanley* had a projecting stern added after she was built.)

CONSTRUCTION.

The method of construction is substantially the same as that of the Government steamers. The skin is supported by transverse ribs 2 ft. apart at the engine-room, and 2 ft. 6 in. elsewhere. The floors are 6 in. deep, and $1\frac{3}{8}$ in. thick. Reverse angle irons are carried along the top of the floors, and up the frames at the sides. There are five transverse water-tight bulkheads. The longitudinal strength is obtained by two longitudinal bulkheads, fastened to the top of the floors and the deck beams, 22 ft. apart, and by four keelsons 15 in. deep at the engine-room, and 12 in. fore and aft. There will be deck beams 5 in. $\times$ 3 in. on each alternate frame, and a gunwale stringer 15 in. wide running all round the vessel. The engine bearers and

beams would of course have to be adapted to the engines. They should be made as stiff as possible, so as to avoid any straining of the engines when the vessel grounds. The plates should be of the best quality of iron; they would be $\frac{1}{2}$ in. thick in the bottom, and $\frac{3}{8}$ in. in the sides, and 9 wire gauge in the bulkheads. The angle iron generally would be $2\frac{1}{2}$ in. $\times$ $2\frac{1}{2}$ in. $\times$ $\frac{1}{4}$ in.

ENGINES.

The engines would be 110 horse power nominal; oscillating cylinders 43 in. diameter, 4 ft. stroke; diameter of paddle-wheels 18 ft., length 9 ft. To have surface condensers. Boilers to be of the form of ordinary marine boilers, to work to 25 lb. per inch, with large furnaces for burning wood. They should be supplied with superheating apparatus, and any other improvement which would tend to economise fuel, the great item of expense.

PASSENGER ACCOMMODATION

Could be provided in the after hold similar to that provided in the Government steamers; but it would, of course, materially diminish the space for cargo, and there is, in the steamers now at work on the river, quite sufficient present accommodation for passengers. Cabins would, of course, be provided for officers and crew.

PROPOSED TUG STEAMER.

The dimensions of the tug steamer would be—

	ft.	in.
Length on 3 ft. water-line	190	0
„ over all	198	0
Beam	28	0
Depth from underside of deck to skin	9	6
Draught with stores, but no fuel	2	8

1000 maunds of wood fuel, equivalent to 4 in. draught. The form of this steamer is similar to that of the cargo steamer. The principal difference is a diminution of 10 ft. in the beam. The method of construction is precisely similar, with such adaptation as the diminished beam requires. The engines to be of 120-horse power nominal. They have more work to do, and should, therefore, have more power than

those of the cargo boat. As the hold is not wanted for cargo, the engines and boilers may be spread over a greater length of the vessel, by placing the boilers fore and aft of the engines. There is, however, an advantage in having the boilers altogether abaft the engines, as it keeps the engine-room and stoke-hole so much cooler. The barges for this steamer should be capable of carrying 150 tons at 3 ft. draught.

	ft.	in.
Length	150	0
Beam	22	0
Depth from underside of deck to skin	7	0

The author thought it unnecessary to enter further into the details of construction of these steamers and engines, being anxious only to point out the kind of steamers which he considered most suitable for the navigation of the river, and the principles which should guide us in their construction; and he was confident that steamers of this description would prove altogether efficient on the Indus, and accomplish all that could be required of them. He then made a few observations with respect to the commercial view of the case. It has been stated lately, by the chairman of the Indus Steam Flotilla Company, that there is a much greater demand for freight than they are able to provide for, and that more steamers are urgently required. They have, indeed, obtained tenders for two tug steamers 275 ft. long to tow each two barges 200 ft. long. If this design is carried out, there can be little doubt that it will add another to the failures already made in navigating the Indus, as steamers of such a length will be useless for several months of the year, as has been pointed out. He hoped wiser counsels would prevail with respect to them. It is difficult to estimate, with anything like accuracy, the cost of such steamers as those described. The cargo steamer, when completed with all her equipment, would hardly cost less than 20,000*l*. The tug steamer would cost somewhat less, but the two barges would probably come to 4000*l*. apiece. No estimate that the author could make of the probable earnings would be of any value, but the steamer *Indus* earned on one occasion more than 2000*l*. on the freight of the down journey alone, and other steamers have earned as much for the double journey, and as the cost of a double journey

would not be more than 500% exclusive of wear and tear, there is surely sufficient margin for profits.

It is owing to the misfortunes that have befallen both companies having steamers on the Indus, and the great consequent expenditure of unprofitable capital, that they have been unable, as yet, to pay any dividends. If suitable steamers could be placed on the river at a reasonable cost, and judiciously worked, there can be little doubt that they would earn very good profits. It must be conceded, however, that steam communication on the Indus can never be rapid. The up journey will always take on an average a fortnight or more, and the down journey about a week. When a railway is completed from Kotree to Moulton, the journey may be accomplished in a day. The actual cost of freight per mile is more by the steamers than by the Scinde Railway. There is, therefore, no chance of steamers competing with a railway for through traffic; but there will always be a considerable amount of local traffic on the river, which a railway could not accommodate, and for which steamers will still be required.

Drawing No. 7, shows the lines of a native Indian coasting trader. All the native-built vessels, whether coasters or small fishing-boats, are very fast sailers. The diagram at the top of the drawing may explain why they should be so. The lower line is the 3 ft. water line, supposing the vessel to be trimmed 6 in. by the stern. The upper line is one of Mr. Scott Russell's true wave lines. The coincidence between the two is remarkable, and if the wave theory is true, these vessels ought to be fast, as in fact they are. The rig is one large lateen sail with the mast raking forwards. The largest size vessels only have two masts. With this rig they cannot tack, but are obliged to wear when they change their course. This makes them unhandy for beating up against the wind, but when running before the wind very few vessels can beat them.

In conclusion, he expressed a hope that steam navigation on the Indus would be more successful in the future than it has been in the past. There are certainly great difficulties in the way; but difficulties are not impossibilities, and should only stimulate us to greater exertions, and encourage us to look forward to more gratifying successes.

DISCUSSION.

Mr. BARTHOLOMEW could not understand the object of putting the barge by the side of the steamer. If the channels were devious and narrow, it would appear that the steamer should cut the way for the barge to follow. By placing the barge at the side of the steamer, a wider channel of a certain depth was required. He did not exactly remember the draught of the barge, but he supposed it would be about the same as the steamer. As regards the holes which were found in the iron, that was a very important point, and one which required further investigation. He would ask Mr. Warren, if the question had been gone into, to see if there were any cause to account for it in the iron itself. He (Mr. Bartholomew) inquired if the same thing were observed in any of the other steamers, because, if not, it might arise from some peculiarity in the iron.

Mr. OLRICK inquired whether any leakage occurred in consequence of the plates being damaged, and also whether the twin screw propellers had ever been tried upon the Indus.

Mr. LIDBETTER (of Kurrachee) replied, that, with respect to the holes in the iron plates of the bottom of the *Sir Bartle Frere* steamer, the vessel was lying close to the beach at Keamaree Island in Kurrachee harbour. The water of Kurrachee harbour is supersalt, it receives no fresh-water streams into it except at rare intervals, perhaps once a year, when the Lyaree for a few hours rolls down a little water into the head of the harbour. The vessel was lying a few feet from the shore, just in sufficient depth of water to keep her from grounding at low water. Barnacles and seaweed accumulated very fast on iron vessels' bottoms in Kurrachee harbour, occasionally to the extent of 3 or 4 inches in thickness, and this was the case with the steamer in question. Suddenly this vessel sprang a leak, and on examination on the inside of the ship a number of minute holes were visible. On laying the steamer aground and scraping off the barnacles, it was evident that these holes were made by the Pholas, a seaworm very abundant in the harbour; the holes were clear of the rivets, some right in the centre of the plates. If he could obtain a piece of a plate with holes in, he would have pleasure in forwarding the same to the society. It seemed to him not to be the result of an

acid applied by the Pholas, but had every appearance of being done by mechanical action, and in his opinion was a case of real boring. The holes were $\frac{1}{4}$ to $\frac{3}{8}$ of an inch in diameter outside, but when discovered were only the size of a pin's point on the inside. The plates on these steamers are under $\frac{1}{4}$ in. in thickness, and the holes had the exact and regular appearance of auger holes in wood.

Mr. E. RILEY said there were many insects—some of the Mollusca, for instance—which possessed the power of attaching themselves to the bottoms of ships, &c., and of giving out an acid matter which corroded the iron. The results produced in the plates referred to could not arise from a mechanical action, it must have been caused by an acid.

Mr. H. P. STEPHENSON understood that one of the navigation companies of India had constructed vessels which drew only 2 ft. of water. He should be glad if Mr. Warren could state the performance of these boats. He thought the non-success, commercially, of some of these companies arose from the unfortunate way in which they had been managed. He had heard that one of them had made profits to the extent of 60 per cent.

Mr. LIDBETTER said the profits of 60 per cent. mentioned by the last speaker were realised entirely upon the Ganges, and not on the Indus. In his opinion, the train system of Mr. Bourne—of a steamer, a connecting barge, and cargo, and passenger barges, to the length in all of about 600 ft.—was a total failure on the Indus. The steamer had a convex stern, and the connecting barge a concave and almost hemispherical bow, which held water and would always impede progression, and was fatal to good steering, and to the possibility of making such a connexion as to ensure safety with facility of working. The stern of the connecting barge was also concave, and the other barges had all convex bows and concave sterns, the bow of one being fitted in and jointed, in a manner, to the preceding vessel. Eventually the *Sutledge* steamer was altered, and adapted to tow the ordinary shaped barges alongside. This steamer was the only one belonging to the Oriental Inland Steam Company on the Indus for many months. There was no want of cargo to carry up and down the river; what was required to ensure success and make the company a paying one, was a sufficiency of vessels of the right

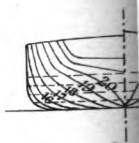
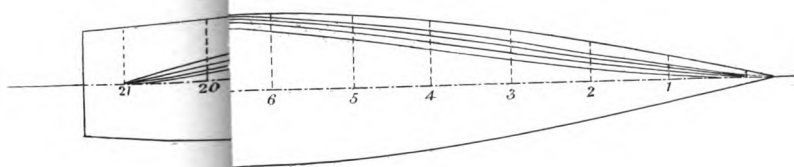
kind. The *Indus*, the second vessel of that name belonging to the same Company, had been very successful, she had towed down the river from Moulton to Kotree four barges, two on each side, laden with cotton, and other produce, and on some of these trips she must have grossed nearly 30000 sterling, freight on the downward trip. Vessels of the class of the *Indus*, answer well on the river, as a whole, but they might be improved with respect to draught of water. Three feet should be an outside draught for vessels and barges on the Indus during the low season, but during the inundation, there was no limit to draught speaking comparatively. As even if the railway from Kotree to Moulton were sanctioned, it would take several years to complete, there was in Mr. Lidbetter's opinion, a great and open field for mercantile enterprise on the river Indus. Successful as the steamer *Indus*, before mentioned, had been, it was quite possible for any company with sufficient capital and well conducted, to build, and maintain on the river, a still more suitable and consequently successful class of steamers, which in his opinion would realise large profits to the company, in carrying merchandise, railway, commissariat and Government stores up the Indus to the Punjab, and bringing down produce. In the present juncture especially, of warlike operations on our trans-Indus frontiers, steam tonnage would be largely in demand; and lamentable to say, from one cause or another, there is not now, and has never been since the trade was opened, a sufficient amount of available steam tonnage on the river, such as to give shippers of goods upwards or downwards the facilities of speedy and punctual delivery, much more to respond to any such emergency as the present. Mr. Lidbetter said that he had lately been on the Mississippi, and he observed that in all the steamers there the engines were unconnected, one engine to each wheel, and he thought this plan would be a great advantage on the Indus.

Mr. WARREN said the reason the barges were attached to the side of the steamer was that in the sudden bends of the river with the current rushing round them, if the barge were astern it would be driven against the bank and it could not be steered. If the steamer ran aground the barge would immediately run into the steamer. Of course wider channels were required than if the barge were astern, and occasionally the channels were so narrow that the barges had to be dropped

astern in order to get them up. The twin screws had been tried on the river in three gun-boats. They went up the river and came down again, but he believed they had done nothing farther. Screws were not applicable to vessels of such shallow draught. As regards the holes in the plates, they were perfectly round. It seemed impossible that any simple corrosion could have caused them. Any description of jointed vessel would have the same difficulty as Bourne's; because when going round sharp bends, the vessel would go right into the bank. He did not believe any jointed system of barges could ever succeed upon the Indus, on account of the sharp bends, and the strong currents running round them. The barges were certainly a protection to the wheels of the steamer. As no one had said anything about his (Mr. Warren's) cargo steamer, he supposed there was no objection to it. With respect to disconnecting engines he certainly thought it would be desirable to try them on the Indus, for there might be circumstances under which it would be desirable, and an advantage to work the engines separately, but they must also be able to work them together. The *Stanley* was made with a full stern in order to get as light a draught as possible. It was a misfortune when the company had more steamers to make, that they persisted in making them of 2 ft. draught, because it was really less than necessary. There was no doubt that this style of stern was objectionable, because it caused a great commotion in the water. He thought there was a very fair chance for steamers making good profits upon the Indus. As regards the temperature of the water, it was in summer about 90 deg. in the middle of the day, and in the winter about 50 deg. Having explained the manner in which the barges were fastened to the steamer, he resumed his seat amid some applause.

The CHAIRMAN said, Mr. Warren had communicated a very practical paper upon a very important and interesting subject. It showed what had been done, and what had not been done, and he (the chairman) merely wished to say that Mr. Warren must not go away supposing his system was perfect for the navigation of the Indus, because no particular objection had been raised to it, he was afraid *that* arose more particularly from the want of information of the members on this subject. There must be one great drawback to the

get them up. The twin screws had been tried on gun-boats. They went up the river and came down. They had done nothing farther. Screws were vessels of such shallow draught. As regards the

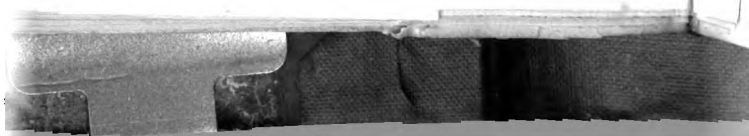


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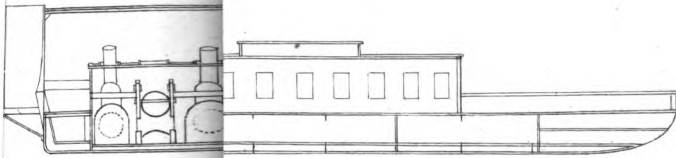
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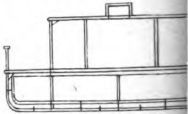


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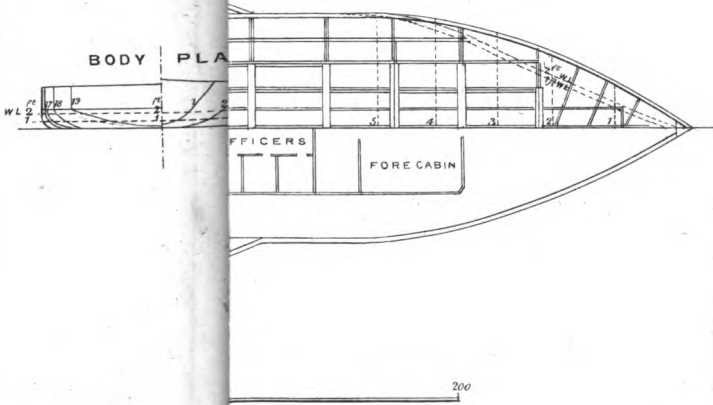
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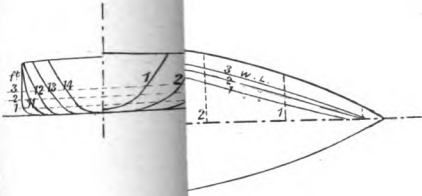
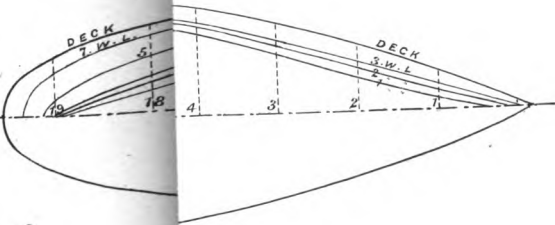
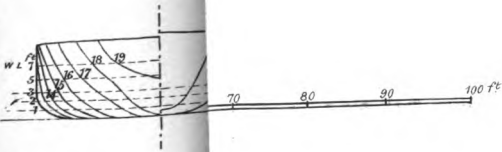
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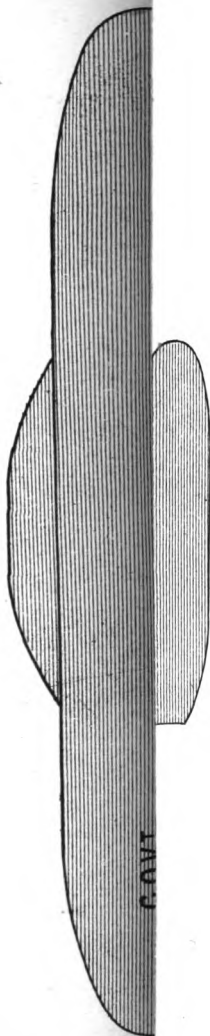
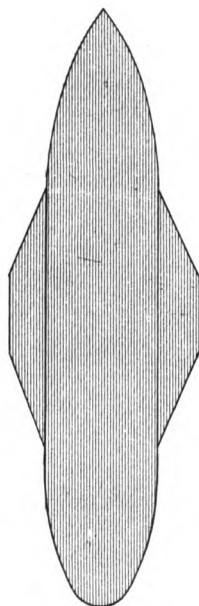
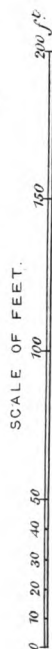
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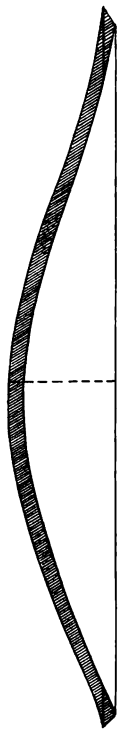




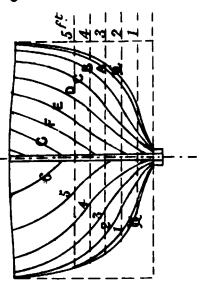
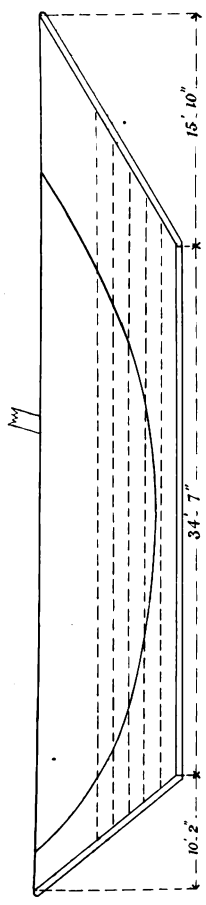
E. AND F. N. SPON, BUCKLESBURY, LONDON.

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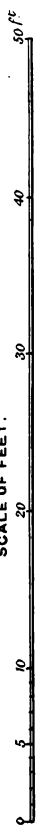




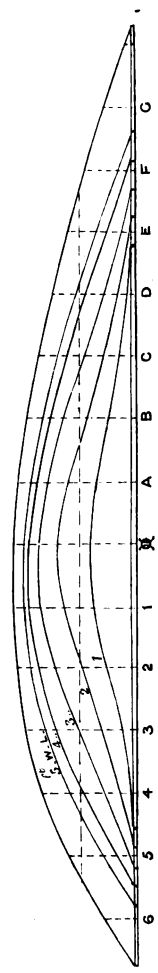
AFT BODY. FORE BODY.



SCALE OF FEET.



Length of Deck — 60' 7"
 — d. — 34' 7"
 Beam — 15' 0"
 Depth — 8' 2"



E. AND F. N. SHON BUCKLEBURY, LONDON

United States Navy

navigation of the Indian rivers, that was the want of commercial success; without this being overcome the navigation of the Indian rivers would remain an unaccomplished fact. He only hoped Mr. Warren would soon be placed in a position to enable him to carry out his views with regard to the best system of ship construction for the navigation of the Indus, and trusted, if so, he would meet with the success he anticipated.

October 5th, 1863.

R. M. CHRISTIE IN THE CHAIR.

STEAM FIRE ENGINES, AND THE LATE TRIALS AT
THE CRYSTAL PALACE.

BY W. ROBERTS.

IN bringing the subject of steam fire engines before the Society of Engineers, it is unnecessary to enlarge upon the saving that must accrue from the use of steam, as compared with hand worked, or, as they are usually denominated, manual engines. It will suffice briefly to state that from carefully conducted experiments with two engines having pumps identical in every respect, one being fitted to a manual and the other to a steam engine, the work done by the steamer, with a consumption of $2\frac{1}{4}$ cwts. of coal, or say 2s. 6d., was from six to seven times as much as done for 30s. by the manual.

From the best information, it appears that the honour of constructing the first steam fire engine is due to Mr. John Braithwaite, who constructed one of about 10 horse power in 1829. Full particulars of it are not obtainable, but from the account of it in the *Mechanics' Magazine* of February 13th, 1830, it appears to have been capable of throwing 90 tons of water per hour, through one large or four small jets. Shortly after this Messrs. Braithwaite constructed another but smaller steam fire engine. The

account of it as given in the same number of the magazine says : "Shortly after the conflagration broke out, to which the Argyle Rooms fell a prey on Friday last, a new fire engine worked by steam, on the same principle as the 'Novelty' steam carriage, and manufactured by the same ingenious and enterprising engineer, made its appearance on the scene, under the direction of Mr. Alfred Braithwaite, and earned for itself universal admiration, by the powerful services which it rendered on the occasion."

It was worked incessantly for nearly five hours ; discharged upon the burning pile and adjacent buildings from thirty to forty tons of water per hour, and sent its jet of water completely over the dome of the building, a height of at least eighty feet.

Several gentlemen who were present at the fire have stated that they distinctly saw the water ejected from Mr. Braithwaite's engine quite over the dome, and one of the same individuals previously witnessed a private trial of the engine when it threw the water over a pole 90 ft. high, erected for the purpose of the experiment. The expenditure of fuel to produce these wonderful effects was only about three bushels, during the whole five hours, two men being sufficient to keep the steam up and superintend the working of the engine.

(Plate No. 1.)—The following is the description of the engine : In all that regards the generation and application of steam, the same contrivances are adopted in this engine as in "The Novelty;" but there is a difference in the form of some of the parts and in the general arrangement.

The furnace and boiler K, are exactly the same as those of "The Novelty," but of less power. The hot air pipe, instead of being vertical, has received a serpentine form, B, which adds much to the appearance of the engine in point of elegance and compactness. This pipe has also been made to turn on a swivel, so that the engineer or driver of the carriage can turn the mouth of it in any direction which he finds most convenient. The blowing apparatus is here placed in front under the driving box, and is worked by the tappet lever C. The cylinders M, are placed horizontally, and the steam piston is connected with the water pump (E) plunger by one rod working through the two stuffing-boxes, so as to form its own parallel motion. A

crosshead attached to the piston rod, sliding on the frame which supports the two cylinders, works the tappet lever C, connecting with the slide D, the feed pump F, and the blowing apparatus. The feed pump and blowing apparatus have also separate appendages for working them by hand occasionally, and provision has been further made for regulating the stroke of the former, according to the work of the engine. P is the mercurial gauge, R the safety valve, S the feed box to the furnace, and T the eduction or waste steam pipe. A box O, serves to hold the coke or other fuel, and as a platform for the assistant engineer.

The steam cylinder is 7 in. in diameter; the length of the stroke of the piston 16 in.; the number of strokes per minute from 35 to 45; the power barely 6-horse.

The parts of this apparatus peculiar to it as a fire engine are as follows: The globe or sphere A, is the air vessel; the water pump E, is $6\frac{1}{2}$ in. in diameter; the oblique pipe, G, G, is one of the suction pipes. The action of the water pump, being double these suction pipes, either connect with the tank H, or in the common way at J. The object of having the tank H, is to enable other engines to supply this one with water in situations—such as narrow streets and alleys—where a supply of water close at hand cannot be obtained. But it must not be supposed from this that there is any necessity for placing this engine in a particular situation, in order to connect it directly with the water main. On the end of its suction pipe is a common perforated rose, and it may lie in any part of the water way, with the suctions of other fire engines, and take in supply from the same source. It worked with one jet only at the late fire, but is constructed to operate with one or two jets, as occasion may require. The total weight of the machine, with its complement of fuel and water, is incredibly small, not more than 45 cwt.

In 1832 Mr. Braithwaite constructed a third steam fire engine, called the "Comet," for the Prussian Government. The boiler was constructed on the same plan as the "Novelty's," except that combustion was promoted by an exhauster instead of a blower. The steam cylinders, two in number, were 12 in. diameter with a 14 in. stroke, and two water cylinders, $10\frac{1}{2}$ in. diameter, also 14 in. stroke.

The steam from the eduction pipe passed through two coils of

tubing laid in the feed water tank, thereby raising the temperature of the feed water.

The steam was got up to 70 lb. per inch in twenty minutes; and, with $1\frac{1}{4}$ in. jet, the water was ejected to a height of from 115 ft. to 120 ft., the engine making eighteen double strokes per minute.

The weight of this engine was about four tons, and the consumption of coke about three bushels per hour: a few months back, a gentleman who had recently returned from Berlin stated that it was still in existence, although it was now employed to pump the water from a mine.

Although Messrs. Braithwaite built two more engines they did not succeed in getting them generally introduced; and it does not appear that any more steam fire engines were made in England for upwards of twenty years.

In the meantime a Captain Ericsson, a Swede by birth, and who had been for some time with Messrs. Braithwaite, went to America, and evidently remembered what he had seen in this country; for upon the Mechanics' Institute of New York, in 1840, offering a gold medal for the best plan of a steam fire engine, he obtained the prize.

The boiler of this engine was of the ordinary locomotive type, and contained twenty-seven tubes $1\frac{1}{4}$ in. diameter, and a blowing apparatus was used to fan the fire, very similar to Braithwaite's first engines. The arrangement of the steam and water cylinders was also very similar to Braithwaite's.

About the same time Mr. Paul R. Hodge built an engine for an association in New York, in which the steam power was used as an auxiliary to propel it.

About 1850 Mr. A. B. Latta, of Cincinnati, constructed an engine similar to the above, but weighing from ten to twelve tons. The principal peculiarity of Latta's engines are the boilers; these consist of a rectangular fire-box, open at bottom, and having a light iron top. In this fire-box, immediately over the fire, are sections of tubes, all connected to a pipe at the bottom, and coming into the top of the fire-box. This pipe is connected to a circulating pump, which pump is also connected to the bottom of the fire-box. Upon lighting the fire with but a small quantity of water in the fire-box the tubes quickly become hot. The circulating pump is then started by hand. The

water being drawn from the lower part of the fire-box, is forced into the hot tubes, and steam is thereby quickly formed. Indeed it is stated that sufficient steam is got to start the engine in from three to six minutes, but from the experience the author has had with one, he concludes the donkey engine that works the circulating pump must be meant; for he never yet had steam to work the main engine under fifteen or twenty minutes.

From this time the steam fire engine made very rapid progress in America; fire companies were formed, and these, being taken under the protection of the state, having certain privileges granted them, a spirit of emulation soon sprang up amongst them; each became anxious to have the best engine at any cost, and, as a natural consequence, some of the most eminent engineers found it worth their while to take the matter in hand, and the result was that our cousins across the water had some very excellent steam engines whose puff puff, could be heard at their fires, whilst we, with our old-fashioned notions, could only hear the old bump, bump, relieved now and again with the cry of "beer, oh!"

Up to 1852 the most powerful engines in London were two float-engines, each having two 9 in. water cylinders (single-acting) on each side the boat; but in that year the authorities appear to have discovered that it was rather expensive to work these machines by hand; one of the floats was, therefore, placed in the hands of Messrs. Shand and Mason; the hand levers were removed, boilers were put in, and a steam cylinder erected over each water cylinder, the connecting rods having slotted cross-heads; in these cross-heads crank shafts were placed, the cranks being opposite each other. On one end was a fly-wheel, having a ratchet on one side to get a lever to work to pinch it over the centre occasionally. The steam cylinders were double-acting, and as the pumps were single-acting, the one cylinder upon its up-stroke assisted the other through the crank shaft.

At the same time arrangements were made to carry the water aft to propel the boat upon the reaction principle, but this was a miserable failure, as it scarcely gave the boat steerage way.

The saving effected in working this float was, however, so satisfactory that, two years later, the committee decided to have a boat built and fitted expressly as a steam fire engine.

Many disparaging accounts of the first floating steam fire engine had been given, but the author had seen it at work several times, and it did very good work indeed, and considering that it was only converting a hand into a steam-worked engine, it was as successful as could be expected, always excepting the propelling.

The second—or, as it is styled, the upper float—was built by Mare and Co., of Blackwall, the length being 130 ft.

The engines, pumps, &c., were made by Shand and Mason, the steam cylinder being 14 in. diameter, with an 18 in. stroke, the pumps (double-acting) being 10 in. diameter.

The engines were placed horizontally one on each side the vessel, and a large Appold pump was placed in midships to propel the boat upon the reaction principal. The engines were arranged so that they could be readily thrown off the pumps when wanted for propulsion, but, by what seems to have been an oversight, only one could be thrown out of gear at the same time with the propelling pump; thus a considerable amount of power was lost, but even in this state it was capable of working four $1\frac{1}{2}$ in. jets at one and the same time. At the great fire in Tooley-street it worked nearly 400 hours.

The engines are nominally of 80 horse power, but are frequently worked up to double that power.

During the present year some alterations have been made in the mode of propelling the boat, the outlets have been brought above the water's edge, and arranged something upon the Ruthven plan, and although a decided improvement, the boat is still very very slow for the amount of power consumed.

About this time the East and West India Dock Company had their steam tug *Dragon* fitted with a large Downton pump, to be worked by the boat's engines. This is a very effective engine, delivering a $1\frac{1}{2}$ jet to a distance of 160 ft. to 180 ft.

In 1860 Messrs. Merryweather and Sons constructed from the designs of Mr. Edward Field, a member of this Society, an engine for the Tyne docks. The performance of this engine was very satisfactory.

About the same time the author fitted for the East and West India Dock Company, on board their tug *Lucy*, a pair of his patent double action twin pumps (of the same construction as those he has the

honour of supplying for the use of Her Majesty's Navy) each pump had two cylinders of $11\frac{1}{2}$ in. diameter $\times$ 12 in. stroke; the collective discharge being equal to a column of water $11\frac{1}{2}$ in. diameter $\times$ 8 ft. high, or thirty gallons at each stroke; these were the largest fire engine pumps he knew of, they had once been used at a fire, and then they worked so satisfactorily that he was informed by the chairman of the company that they had paid for themselves.

In May, 1856, the late Superintendent of the London Fire Brigade read a paper at the Society of Arts, and during the discussion that followed, Mr. Braithwaite, smarting no doubt from the treatment he had experienced, roundly charged the Fire Insurance Offices with not being anxious that fires should be extinguished.

The answer of Mr. Braidwood, goes far to show the reason why steam fire engines were not brought into public use earlier. He said "he could also state, that the subject of steam fire engines had been seriously considered, but if the fire offices were disposed to incur the expense or cost which six or eight of these engines would involve, there was not at the present time an adequate supply of water from the mains to work any number of them at a fire. There was scarcely a sufficient supply for ten or twelve of the ordinary engines now in use; therefore steam fire engines, admitting their great efficiency, were out of the question until a larger supply of water could be obtained. If he might compare large matters with small he would compare the steam engine to a battering train, most efficient when well placed and served, but slow of movement, and requiring large supplies."

"The common fire engine, well constructed, and not too heavy, might be likened to field artillery, which, from its power, but especially from the rapidity of its movements, was invaluable.

"To carry out the simile, hand pumps might be supposed to take the place of musketry, which might be used when and where it was desired; from a washhand basin, if necessary.

"With regard to the water supply his impression was that, when they came to have an adequate supply for steam fire engines, a higher pressure would be given, so that they could work from the main without requiring the steam fire engine." (See *Journal of the Society of Arts*, May 23, 1856, p. 459.)

Shortly after this, in a conversation the author had with Mr. Braidwood, he offered to construct a steam fire engine, to be drawn by two horses; and subsequently discussed with him the details of boiler and engine; but he would not hear of it. In fact, when he constructed his engine "True Blue," and offered it to him for twelve months, he told him a large engine like that was worse than useless, as, if they wanted to deliver 180 gallons from one jet, they had only to marry two ordinary engines to one branch pipe. He lived long enough to acknowledge that it was not worse than useless, and to see it do good work repeatedly; also to pen the following sentence: "That at large fires beyond the reach of the steam floating engine, the land steam fire engine has been of great service. It is not only the large quantity of water it throws, but the height and distance to which it is thrown, that makes it so valuable; at the same time it can be worked as gently as an ordinary engine."

(Plate No. 2.)—In 1858 Mr. James Shand obtained letters patent for a steam fire engine, and one was constructed in that year, and publicly tried at the Grand Surrey Canal, Camberwell, on the 14th October of the same year.

In 1860 Messrs. Shand and Mason constructed an engine which was used by the London Fire Brigade for some months, and is the one referred to by Mr. Braidwood in his report previously referred to. This engine worked for something under twelve months, and was then withdrawn, its last public performance being at the great fire in Tooley-street. The specification describing it, says, "According to this invention the steam cylinder which actuates the pump is inverted, and situate over the air-vessel of the pump, which is made double-acting, one barrel being placed above the other, and a double or two-throw crank is placed between them. One or both of the pistons or plungers of the pump is fitted with a valve, and the piston-rod of the steam cylinder is connected directly with the piston of the upper pump-barrel, which latter serves as a guide to the piston-rod of the steam cylinder. A connecting-rod from the upper pump piston connects it with the crank, while a second connecting-rod connects the piston of the lower pump barrel with its throw of the crank. The slide valve of the steam cylinder is worked from eccentrics on the crank-shaft outside the pumps, and the lower

pump barrel is enclosed in a suction air vessel, fitted with a separate valve, if necessary. A fly-wheel on the crank shaft and a feed pump are placed near the boiler. The whole is supported on a carriage, consisting of a suitable framing running on travelling wheels, and furnished with springs and locking carriage. In the centre of the hind axle is placed an upright boiler, the steam pump being situated vertically between the the front and hind axles, and behind the driver's seat. Beneath the seat is placed the hose-reel or a box for containing the hose and implements."

The next steam fire engine supplied by Messrs. Shand and Mason for the use of the London Fire Brigade is now stationed at Tooley-street, and was supplied in April, 1861. This is very similar in its general arrangement to Braithwaite's, except that it has a slotted crosshead and fly-wheel, with an eccentric to work the slide instead of the tappet; the following description of this engine is taken from the report of Mr. Lewis M. Becker to F. Hodges, Esq., at whose place this engine was tried, the dimensions, &c., of several other engines have also been obtained from this source.

"STEAM FIRE ENGINES constructed for, and now in use by the London Fire Engine Establishments, Shand and Mason, inventors and manufacturers, 75, Upper Ground-street, Blackfriars (late of 245, Blackfriars-road), London.

"The engine 'No. 5' (Tooley-street Station, London Fire Engine Establishment) and the Engine 'No. 10' (Wellclose-square Station, London Fire Engine Establishment) are similar in construction though varied in outward form. They are fitted with high wheels and boxes to contain hose and implements, upon which the firemen ride; on the rods at the sides the suction hoses are suspended. The following description will serve for both engines:

"The extreme outside dimensions are: Length, 13 ft.; width, 6 ft. 5 in.; height, 9 ft. without chimney. The total weight, as made up for running, including coke in bunkers, is 2 tons 14 cwt. 51 lb.; the weight of water in boiler is 3 cwt. 64 lb. extra. These engines, similar to the manual manufactured by this firm, can draw water from the cistern which forms a part of the engine.

"The single steam cylinder is $8\frac{1}{4}$ in. in diameter, the piston-rod of

which is fixed to the piston of a double-acting pump 7 in. in diameter—both pistons necessarily having the same stroke, which is 9 in. The pump is composed of gun-metal and copper, the valves being India-rubber, as used in the steam floating fire engines of the London Fire Engine Establishment. The whole of the machinery is of a very simple construction, and is not liable to be affected by rapid transit over rough roads.

"The boiler is of the upright tubular construction, affording means for superheating the steam; it contains 199 brass tubes, each of $1\frac{1}{2}$ in. outside diameter and 15 in. in length. The fire-box is composed of copper, and is 3 ft. 4 in. in diameter. This boiler is, in fact, the one used in the engine last described.

"*No. 5 Engine.*—Steam was raised from cold water to a pressure of 30 lb. in $12\frac{1}{4}$ minutes; 40 lb. in 13 minutes; 50 lb. in 14 minutes; 60 lb. in $14\frac{1}{2}$ minutes, and 70 lb. in 15 minutes. The engine was then set to work through 210 ft. of hose, a jet of $1\frac{1}{2}$ in. diameter being used, and a vertical height of 160 ft. was reached. A considerable breeze was blowing. With the same jet pipe and length of hose a horizontal distance of 202 ft. was reached. The engine was continuously worked with the greatest smoothness and regularity for two hours, drawing and delivering 440 gallons of water per minute.

"*No. 10 Engine.*—At the trial of April 16th the following results were obtained: Steam was raised from cold water to a pressure of 60 lb. in $14\frac{1}{2}$ minutes. The steam gauge moved in 6 minutes from lighting the fire, and 10 lb. of steam was raised in $10\frac{1}{2}$ minutes. A jet of $1\frac{1}{2}$ in. diameter was thrown a height of 174 ft. (34 ft. over chimney), working under steam pressure of 120 lb., and of water pressure 140 lb. A $\frac{3}{4}$ in. jet was thrown horizontally a distance of 187 ft.; with an inch jet, 196 ft.; and with a $1\frac{1}{2}$ in. jet, 190 ft. A tank, capable of containing 448 gallons, was filled with two deliveries, each of 1 in. in diameter, in 1 minute 15 seconds; on this trial being repeated the same results were obtained. The average pressure of steam was 120 lb., and the water pressure 140 lb. A strong wind was blowing the whole of the time.

"In 1861 Messrs. Merryweather constructed a steam fire engine, which they called the 'Deluge,' of which the following description is their own.

"THE 'DELUGE,' Merryweather and Son, and E. Field, C.E., inventors and manufacturers, 63, Long Acre, London.

"This engine, mounted on a strong wrought iron frame, is, with hose, coals, water, &c., $3\frac{1}{4}$ tons weight. The boiler is made of steel plate; a large heating surface is obtained by a quantity of vertical tubes, and the upper part of the boiler or steam chest is fitted with strong wrought-iron tubes for carrying off the smoke and creating a draught, which act as strong stays; the outer water-jacket is also well and frequently stayed, so that altogether it is very secure for high pressures. The internal arrangement of the boiler is such that a perfect circulation of water is carried on, and no deposit remains in the tubes, as the rapid circulation throws any foreign matter over into the outer jacket. As the copper tubes are not fixed at their lower ends, and the upper tubes are of iron, no unequal expansion or contraction of metals take place, and leakages are avoided. The boiler is fitted with every requisite for its safe working, viz., two safety valves, gauge-cock, gauge-glass, pressure-gauge, blow-off cocks, &c. It is fed by a Giffard's Injector, which feeds itself from a tank that is self-supplied from the pump; the boiler can also be fed from the main pump if required. It is felted (to prevent loss of heat by radiation), and covered with sheet iron and brass bands. Steam is taken from four points, and supplied direct through the valve-chest into the cylinder, passing in its way under the cylinder. This class of boiler does not prime.

"The steam cylinder is 9 in. in diameter, with 15 in. stroke of piston; no fly-wheel is used, and, by the valve arrangement, a uniform speed of piston throughout its stroke is produced, which has great effect in working the pump, as an unusually steady column of water is obtained, and the engine can be started at any point by opening the steam-valve; and by this arrangement the engine can be made to run at any required speed, from 1 or 2 up to 150 or 160 double strokes per minute. The piston-rod is coupled direct to that of the pump, and two stout guide-rods connect the pump with steam cylinder, the rods taking the whole of the strain.

"The pump is horizontal, double-acting, and $6\frac{1}{4}$ in. in diameter; the piston makes the same length of stroke as the piston of the steam cylinder. The whole of the valves, both suction and delivery, are placed beneath the cylinder. The advantages of this arrangement are

300 ft. of hose was led over the distillery buildings up the fire observatory (a perpendicular height of 140 ft.) and with a $1\frac{1}{2}$ in. nozzle, the engine threw from 75 ft. to 100 ft. horizontally, working under 140 lb. steam pressure, and 160 lb. on the pump, running at a rate of 120 strokes to the minute. Wind very fresh, E.N.E.

About the same time he (Mr. Roberts) constructed the first self-propelling steam fire engine in this country, if not in the world, for the American self-propelling engines, in all cases that he had heard of, had to be assisted by horses or men, particularly in steering. The author's engine was also arranged for driving machinery, or for a hoist. (Plate No. 3.)

The extreme length of the engine is 12 ft. 6 in., and the extreme breadth is 6 ft. 4 in. Its gross weight, with 5 cwt. of coals, 40 gallons of water in the tank, suction hose, delivery hose, ladders and tools complete, is $7\frac{1}{4}$ tons. The engine has Benson's forced circulation boiler, in which the water is contained within several series of parallel tubes, laid horizontally, and connected with a large steam-proof vessel called the receiver. Originally a constant circulation of water was maintained through the tubes, and between the tubes and "receiver," by means of a small donkey-pump called the circulating-pump, which is independent of, and additional to, the force pump. The author has since found it advantageous to alter this arrangement materially. The steam is worked through a pair of vertical steam cylinders, 6 in. diameter, each of which has a stroke of 12 in. The diameter of each water cylinder is $9\frac{1}{4}$ in., with a stroke of 8 in. Power may be applied at pleasure to either or both of the driving wheels, which are 5 ft. in diameter, pitch chains being employed to get up the speed. The engine was propelled along the public road at a rate of 18 miles per hour. By working only one of the driving wheels, which are hung on springs, and with the aid of a single steering wheel in front, of 3 ft. diameter, the engine was turned within a circle of 12 ft. in diameter. On the engine shaft is a pulley or rigger, and a windlass, the former being used for driving machinery of almost any kind, and the latter as a hoist. The fire engine pumps are a pair of the author's patent double-acting pumps, $9\frac{1}{4}$ in. in diameter each, and fill for 8 in. of the length of the barrel at each double stroke of the steam pistons.

At the trial on September 12th the following results were shown : With a $1\frac{1}{2}$ in. jet a column of water was thrown over the chimney shaft, which is 140 ft. in height, and, with the same jet, a horizontal distance of 182 ft., exclusive of broken water and spray, was reached. By forming a connexion, whenever required, between the suction chamber and delivery chambers of the pumps, a $\frac{3}{4}$ in. and a $\frac{1}{2}$ in. jet can be used. With a jet $\frac{1}{4}$ th of an inch a quart measure was filled, which occupied 12 minutes 30 seconds, the engine working under a steam pressure of 120 lb., and 100 strokes per minute ; average pressure of steam at the trial, 50 lb. to 160 lb.

The boiler at the date of the trial was very defective, but several improvements have been made in it, and the last trial shows 150 lb. steam pressure was obtained in 19 minutes 45 seconds after lighting the fire (all coal). The fire was then let down, and the steam pressure reduced to 70 lb. The engine was at this time working at 40 to 45 strokes per minute, and, in ten minutes from lowering the pressure, the steam had risen to a pressure of 170 lb., and the strokes to 112 per minute, when it had to be checked in consequence of a deficiency of water to supply the pumps, which were delivering at this time at the rate of 450 gallons per minute.

Since this time the boiler had been very much improved, so much so that there was none of that fluctuation so much complained of in fire engine boilers in general, and the American in particular.

This engine was taken one morning to Her Majesty's Dockyard, Woolwich, over the road that had just been opened for the main drainage, and which was so soft that it repeatedly sunk to the foot-plate, and after working all day returned at night.

Upon one occasion the machinery of the factory of Messrs. Brown and Lennox, of Millwall, was driven with this boiler ; the bottom of the boiler gave out, and stopped the engine. He had the propeller taken up alongside, and made a connection from the boiler to the engine, and started the next morning first thing. The cylinders were two $11\frac{1}{2}$ in. diameter, with 23 in. stroke, and the usual pressure with the proper boiler was 30 lb., but the steam fire engine had to work with 80 lb. in the boiler.

We have now arrived at the time when the first American steam fire engine made its appearance among us. This was a small engine,

made by Messrs. Lee and Larned, of New York. These gentlemen were among the foremost of steam fire engine builders in America, and came over with their little engine for the International Exhibition, and which was first tried at the Lambeth Distillery, the following account is taken from the report before referred to :

STEAM FIRE ENGINE TRIALS, Lee and Larned, Inventors and Manufacturers, Novelty Ironworks, Brooklyn, New York.

This engine, of a light, elegant, and strong construction, is with the exception of the boiler tubes (which are of wrought iron), composed of steel of the best brand. The engine itself, which has neither water tank nor coal bunkers, weighs 1 ton 12 cwt. The cylinders, which are 7 in. in diameter, with an $8\frac{1}{2}$ in. stroke, have a pair of light balance wheels, to carry it over the centres ; the piston-rod is $1\frac{1}{4}$ in. in diameter, the crank shaft $1\frac{1}{2}$ in. in bearing, the boiler 4 ft. high by 26 in. outside diameter at steam chest. The engine, which is single reciprocating, works very smoothly indeed : and, though running at the rate of 400 revolutions per minute (full power), scarcely any vibration is visible. The pump, which is fastened to the bottom of the cylinder, is Cary's patent rotatory, very highly finished ; the valve movement is obtained by means of a rock-shaft, actuated by an eccentric rod from the main shaft. The boiler (Lee and Larned's patent annular) has 125 ft. of heating surface, and is supplied by a Giffard's feed-water injector ; it has also a connexion with the main pump. The upper steam chest (double-riveted $\frac{1}{4}$ in. sheet plates) has a flat top and bottom, resting on tubes fastened to the bottom of the same ; these tubes encircle the whole of the interior of the boiler. The arrangement of the carriage springs (invented by J. K. Fisher, of New York) is very beautiful ; the centre of the load is directly over the hind axle, and the engine will stand any amount of jolting over rough roads, without any strain of the engine proper. A tender, at will, is attached behind, to carry the hose, coals, &c. At the trials of February 4th and March 24th the following results were obtained :

Feb. 4th, 1862.	h.	m.	lb.
Fire lighted at	3	58	0
Steam gauge moved	4	3	0
Steam pressure at	4	5	5

N

Feb. 4th, 1862.				h.	m.	lb.
Steam pressure at	.	.	.	4	8	12
Started pump at	.	.	.	4	9	15
Steam pressure at	.	.	.	4	9 $\frac{1}{2}$	20
Ditto ditto	.	.	.	4	10	30
Ditto ditto	.	.	.	4	10 $\frac{1}{2}$	40
Ditto ditto	.	.	.	4	11	65
Ditto ditto	.	.	.	4	11 $\frac{1}{2}$	90
Ditto ditto	.	.	.	4	12	120
Ditto ditto	.	.	.	4	13	135
Ditto ditto	.	.	.	4	15	140

At this time it threw, through an inch nozzle, a stream of water to a vertical height of 135 ft.; 4.30 P.M., working with a pressure of 145 lb. to 150 lb. of steam to the square inch, it threw, through an inch nozzle, a stream 197 ft. horizontally, and with 160 lb. to 170 lb. of steam, it threw a 1 $\frac{1}{4}$ in. jet horizontally 194 ft. Wind rather fresh. S.S.W.

March 24th. Steam was raised from cold water 48 deg. Fah. 3 $\frac{1}{2}$ minutes after lighting the fire. In 7 $\frac{1}{2}$ minutes from the time of lighting, the engine was started slowly, with 5 lb. pressure. In 15 $\frac{1}{2}$ minutes it was working with a pressure of 145 lb. to 150 lb., throwing a 1 $\frac{1}{2}$ in. jet 150 ft. high (10 ft. over the chimney shaft), and afterwards two 1 in. jets 120 ft. high. It threw an inch jet horizontally 200 ft. Its best single stream for distance is an inch jet, for quantity a 1 $\frac{1}{2}$ in. jet; but for ordinary fire duty it will throw, with good effect, two 1 in. streams, with an average number of 300 revolutions per minute.

In April, 1862, Messrs. Shand and Mason supplied the Engine "No. 10," formerly described, to the London Fire Brigade, and this brings us up to the first competitive exhibition. Hitherto, Messrs. Shand and Mason had the whole run; but, by some means, Messrs. Merryweather had got permission to put their engine, the "Deluge," into the Exhibition, and the author thought the behaviour of the authorities of the Exhibition was not satisfactory. Messrs. Shand and Mason, and Messrs. Merryweather and Co.'s exhibitions commenced at the main entrance, and were continued all over the build-

ing, and the engines of all other makers were stowed away in a sort of lumber room at one corner of the building, under one of the towers. Even after the awards were made the author repeatedly had letters to know where the engines were placed, as they could not be found.

After the trials of hand engines, and when the "Deluge" was ready, the sub-committee decided to have the steamers tried; but for reasons best known to themselves, Messrs. Lee and Larned declined to have their engine tested or tried. The author was in difficulties with the Benson boiler in his engine, and had not the London Fire Engine Establishment lent the Engine No. 10, and the one made by Shand and Mason, under their patent dated April 11th, 1861, and supplied to the London Fire Engine Establishment in June, 1862, Messrs. Merryweather and Sons would have walked over the course. As it was, a field day was got up: Messrs. Merryweather's was first to get steam, but, unfortunately, the nut of their piston-rod worked loose, and, for a time, disabled their engine; and, later in the day, they burst a pipe, which compelled them to withdraw from further trial. There can be no doubt that Messrs. Shand and Mason's engine No. 10 worked the most comfortably, upon this trial. They were a considerable time longer getting steam; but, when it did start, it went off smoothly. Upon the other hand, Messrs. Merryweather's engine bumped in a very unpleasant manner, sometimes banging back and forward with sufficient force to break it up, and this was the cause of its failure, and would always be a source of weakness in this style of engine; for if, from any cause whatever, the main slide valve did not act, then there was very little to prevent the piston from flying to the end of its stroke with sufficient force to knock the end or cover off the cylinder.

Shand's small engine worked very well; the most noticeable thing being the priming of the boiler, and sometimes, for fifteen or twenty minutes at a time, it was impossible to tell where the water was. It is a double-cone, the water space being between the two and the fire inside; the steam cylinders are single-acting, and placed over the pumps precisely as in the first float; the crank shaft is between them, but, instead of working in a slot, is connected to the pump piston, in the same manner as in the pump of 1858; the pumps are also single-action, exactly as the first float; and, like the hand engines, the

engine had worked at 32 fires in six months, the average time at each being two to three hours.

This engine, however, gave considerable trouble from breakages; but this might be expected, the cylinders being single acting, each piston has upon its down stroke to raise the piston plunger-rods E, C, of the other set, the result being a rapid succession of cross strains upon the crank; however, from its lightness it was found so handy that another upon the same general plan was ordered, and was supplied in February of the present year, and there had not been any serious complaint of its working.

As all the steam fire engines since made in London were tried at the Crystal Palace in July, we will now proceed to review those trials.

The jury, or perhaps, more properly, the sub-committee of Class 8 in the late Exhibition, feeling that the three engines exhibited, or rather tried in Hyde Park, did not fairly represent the skill of this country, a movement was set on foot to get a fund, and offer such prizes as would induce other makers to come forward with engines.

A committee was formed, consisting of the following noblemen and gentlemen:

Chairman, his Grace the Duke of Sutherland; Members, the Right Hon. the Earl of Caithness, Lord Richard Grosvenor, J. G. Appold, Esq., J. T. Bateman, Esq., W. M. Brown, Esq., T. R. Crampton, Esq., W. M. Crossland, Esq., W. Fairbairn, Esq., T. Hawksley, Esq., J. E. McConnell, Esq., H. Maudslay, Esq., J. Mathews, Esq., J. Penn, Esq., J. Nasmyth, Esq., W. Smith, Esq., and Captain E. M. Shaw, Hon. Sec.

A sum of money was obtained, and the following prizes offered, viz., £250 for the best, and £100 for the second best engine in each class, the classes being two, those between 30 and 60 cwt., and those under 30 cwt.

The chief points to which the committee directed, or rather were to direct, their attention, in addition to the consideration of cost and weight, were those relating to the general efficiency of the machines as fire engines; combining among other points of excellence, rapidity of raising and generating steam; facility of drawing water; volume thrown; distance to which it could be projected with the

least amount of loss; simplicity, accessibility and durability of parts.

Upon the faith of this, seven makers entered their names for ten engines as follow :

Merryweather and Sons, two; Shand, Mason, and Co., two; Butt and Co. (American), two; Easton and Amos, one (American design); Nicols (American), one, "Manhattan;" Gray and Son, one, and W. Roberts, one.

As two of these engines were old acquaintances, they would be taken in the order of seniority. First :

THE TORRENT.—Merryweather, Sons, and E. Field, inventors and manufacturers, 63, Long-acre, London. (Plates No. 4, 5, 6.)

Fig. 1 is an elevation of a single cylinder steam fire engine for land service, constructed according to this invention; and Fig. 2 is a vertical longitudinal section of the steam cylinder and valves appertaining thereto. The framing of the machine *a, a*, is formed principally of angle iron supported on springs, and carried by the travelling wheels *b*. The boiler *c* is attached to and carried by the framing at a level below the steam and water spaces, so that the bolts employed for fixing do not pass into either of them, thus avoiding liability to leakage. It communicates by the steam pipe *d* with the valve chest *e*, as also by a small pipe *d*¹ with the valve chest *e*¹, made use of for regulating the motion of the piston valve, whereby the ingress and egress of steam to and from the main cylinder are regulated. The construction of the cylinder and valves is clearly shown at Fig. 2, in which the same letters are employed to indicate the same parts as in the other figures. The two pistons *f, f*¹, of a piston valve work in a suitable cylindrical valve chamber or chest *e*, into which steam is led from the steam pipe *d*. The rod *f*² of the piston valve is continued forward, and fitted with a small piston *i* working in a cylinder, to which steam is admitted alternately on each side of the piston as required by means of a small slide valve *i*² of ordinary construction. The valve chamber *e* communicates with the main cylinder *j* by means of four passages *k, k*¹, and *l, l*¹, which open into thoroughfares *m, m*¹, communicating respectively with the forward and backward ends of the cylinder. Small passages *n, n*¹, lead into the main thoroughfares *m, m*¹, and are formed with cocks for the

purpose of regulating the escape of steam after cushioning. The action of the valve piston is regulated by means of levers o, o^1 , connected by links p, p^1 , with the piston rod, common to both the steam cylinder j and pump q . The levers o, o^1 , communicate motion to a rocking shaft r , upon which is keyed a disc, s , fitted with adjustable stops, which act alternately upon each side of a tongue lever, t , taking into the rod of the slide l^2 . In the position of the parts as shown, the piston j^1 propelled by steam (admitted through the opening k to its forward side), has just completed its backward stroke, and by closing the backward main port has caused the steam behind the piston to form a cushion, whereby the momentum of the piston has been checked sufficiently to avoid injury to the end or cover of the cylinder; while the steam forming the cushion has, at the same time, been gradually escaping through the opening n into the exhaust passage l^1 . The piston-rod during its backward action has given motion in that direction to the levers o, o^1 , the shaft r , and disc s ; the latter moving through a great portion of its arc without moving the tongue lever t . When, however, the corresponding adjustable stop has come into contact with the forward side of the tongue lever, the slide l^2 is immediately moved into the position shown, and steam is thereby admitted to the forward side of the small piston i , thus driving it backward, and carrying the pistons f, f^1 , into the position shown by the dotted lines, and causing the piston j^1 to be moved in the contrary or forward direction; firstly, by the passage of steam through the small passage n to the back of the piston, which, upon passing, and thus laying open the back port, is continued in its forward motion by the full volume of steam entering thereby, until upon the piston j arriving near to its forward stroke, the piston i is again moved, and the contrary action takes place. It is obvious that the frame, boiler, and general arrangements herein represented and described with reference to this engine may also be applied to engines having two or more cylinders and pumps.

Fig. 3 is a vertical section of the boiler; and Fig. 4, an enlarged section of one pair of the tubes detached. The fire-grate is of the ordinary or any other suitable construction, and is enclosed in a casing v depending from the water and steam space u, u^1 . From the tube plate x depend and descend into the furnace a series of tubes,

x^1 , curved or otherwise, as found most convenient for the economical employment of the heat generated in the furnace. These tubes, x^1 , contain other tubes, x^2 , which are notched, or otherwise made so as to be freely open at bottom, and are formed with enlarged trumpet-mouths at their upper ends, or are otherwise equivalently shaped, to deflect the steam and water ascending from the annular spaces contained between the inner and outer tubes, in such manner as to facilitate and not to interfere with the downward current of colder and solid water, descending by the inner tube to replenish that which has passed upward by evaporation or otherwise between the inner and outer tubes. This deflection of the upward current may be effected by various arrangements, differing more or less from the trumpet-mouth hereinbefore described and shown; as, for example, by the use of a dish or cup-shaped top to the inner tube, or by an annular disc or washer, both of which are substantially equivalent to the trumpet-mouth.

The steam, after passing through the engine, as described, is carried off by an exhaust pipe, y , which terminates in a box or chest, y^1 , having an opening opposite to the bottom of the chimney; from which opening the steam rushes upward, and increases the draught of air through the fire-grate; the lower sides or surface of the box or chest acting at the same time as a baffle plate, deflecting the flame and heated gasses, and preventing their too rapid escape up the chimney. The circumference of the tube plate x is bent downwards so as to form an annular pocket, x^3 , for the collection of mud or sediment thrown up and ejected from the tubes, and which, after settling in the pocket, may be got rid of when required by openings provided for that purpose.

The pump is double-acting, of $4\frac{3}{4}$ in. diameter, with a stroke of 12 in., the piston being moved direct by the steam piston: the water passages and valves are large and easy of access, and are placed beneath the pump cylinder: there is a simple method of supplying oil to the piston, so that it lubricates itself at each stroke.

The whole is mounted on a strong-wrought iron frame, pivoted over the fore carriage, and its total weight, made up for running, with hose, coals, water, &c., is 1 ton 18 cwt.

This engine was considerably reduced in weight, to bring it within

the 30 cwt.; even the coal bunkers and foot plate were taken off, rendering it for all practical purposes useless as a steam fire engine; yet still it was over weight, being 30 cwt. 1 qr. 12 lb., but it was allowed to work in the small class. Its performance will be noticed presently.

(Plate No. 7.)—The next engine was the one made by Messrs. Easton and Amos, from designs by Messrs. Lee, and was, therefore, to all intents and purposes, an American engine. It was called the "Sabrina," but was formerly known as the "Annihilator," under which name it appeared at Lambeth. At this time its weight was 3 tons 2½ cwt., but for the trial at the Crystal Palace was cut down to 2 tons 18 cwt. 3 qr. 12 lb.

Having been referred to Mr. Hodges' book for a description of it, by Messrs. Easton and Amos, the author would again borrow from those pages, *but must state that he did not endorse all there stated*. He considered the arrangements for working the slide valves of this engine—also those of Messrs. Merryweather and Sons—too complicated; there were too many working parts, very costly to make, and would no doubt, be found very costly to keep in repair. In this style of valve motion it was absolutely necessary to arrange for cushioning, and altogether it appeared to be improving backwards, going towards the tappet motion. This opinion was strengthened by the fact that Messrs. Lee (who having perhaps as much experience in steam fire engines or quick working engines) had adopted the eccentric for working the slide valves of the two engines they imported for the competition.

THE ANNIHILATOR.—Wellington Lee, of Brooklyn, New York, and London, inventor: Easton, Amos, and Sons, the Grove, Southwark, London, manufacturers.

The principal points in which this engine differs from others which have been already constructed and used in this country, comprise:

Firstly. A description of boiler of a novel and somewhat peculiar construction, having a central furnace surrounded by a shell or wall of vertical water tubes surmounted by a steam chamber or drum, which in ordinary work, is filled with water to about one-third of its

height ; from this chamber depends a flat water space, or "suspended slab," the connexion being made with the steam drum by means of a series of vertical tubes. Through these last proceed a series of internal tubes, by which the products of combustion pass in an intensely heated state to the smoke box, exposing, by this means, an annular water space to the action of the heat.

A series of short tubes pass, independently of these, through the suspended slab and the steam drum respectively, through which the heated current also passes ; and the entire arrangement is so adapted as to present the greatest possible amount of heating surface obtainable to the action of the fire.

A series of tubes pass from the suspended slab to the water bottom into which the bottoms of the outer shells of tubes are secured, thus maintaining the complete circulation of the water throughout the boiler.

The total amount of direct heating surface in the boiler is 228·5 square feet ; and of fire-bar ditto, 4·58 square feet.

Secondly. In the construction of the boiler, gun metal and steel, in conjunction with the best Lowmoor iron, are alone employed, with a view of obtaining the two essentials of lightness and compactness, in addition to the rapid generation of steam.

Thirdly. The steam cylinders are two in number, and are placed immediately forward of the boiler ; their diameter is $9\frac{1}{2}$ in., the length of stroke $9\frac{1}{2}$ in., and they work directly on the pumps without the intervention of any crank or rotatory movement, and, consequently, any centre or dead point to turn. The piston-rod of one cylinder, by means of a reducing lever, operates upon the slide valve of the other in such a manner that when one piston is at the end of its stroke, the other is at half stroke, and *vice versa*. This arrangement, while ensuring the correct action of the slides, for the admission and exhaustion of steam to the cylinders, is not of itself alone sufficient to issue the proper length of stroke, but to avoid the breaking of piston or cylinder cover, which might, perhaps occur. To guard against this, two supplementary parts are provided, so arranged that the exhaust is imprisoned shortly before the termination of the stroke, and the piston starts smoothly and evenly on its

return, and, however rapid may be the running, the motion is as certain and even as in two engines working with cranks at right angles upon one shaft.

Fourthly. The pumps are two in number, each $5\frac{1}{2}$ in. diameter; but the plungers and seats may be changed in about twenty minutes for others of a larger diameter, in case a greater quantity of water may be required. The length of stroke is $9\frac{1}{2}$ in., and being double acting, a steady and continuous stream is obtained from them. Each pump has eight suction and eight delivery valves, of india-rubber, working upon gun-metal guards, offering an effective water-way of 15 square inches (in four valves), or very nearly two-thirds area of the piston for the contents of one pump.

The largeness of the valve-ways, combined with the peculiar stop at the end of each stroke, which is a main feature of the steam-valve motion, causes the almost instantaneous closing of the valves, and the pumps run free from concussion or vibration at any practicable velocity. The net area of the suction-opening is 16 square inches, and, having a continuous stream passing through it, the hose remains steady and quiet when the pumps are running at their highest velocity; moreover, advantage is taken of the hollow spaces of the hand railing to connect them with the suction-valve chamber, so as to form a suction air vessel.

All the suction and delivery valves are readily accessible by means of suitable hand-holes, and are not easily choked.

Lastly. The framing of the engine is of wrought-iron throughout, forged entire. Fisher's busk springs, as offering the greatest elasticity and lightness, are employed, with relieving screws for locking them out of gear when working. The wheels are of a construction embodying great strength and stiffness with lightness, and wrought-rings and dowels are used for securing the spokes to the hubs.

The engine, besides a moderate quantity of coal, and several hundred feet of hose, carries the following staff: One driver, two look-out men (one on each foot-plate), and three assistants, who ride upon the tool chest (which, when in position, forms a foot-board behind), steadying themselves by the hand-railing.

The nett weight of the engine is 3 tons $2\frac{1}{2}$ cwt.

We will now consider the engines that made their first appearance

on the 1st of July, and it will be as well to take them as they appeared in the award of the committee: First, the "Sutherland," Merryweather, Sons, and Field. The weight of the engine was 2 tons 18 cwt.; it has two steam cylinders $8\frac{1}{2}$ in. diameter, with 24-in. stroke, the two pumps being $6\frac{1}{2}$ in. diameter, also 24-in. stroke. The boiler is similar to the "Torrent's," and is described as being vertical, tubulous, circulating, shell of homogeneous metal, $\frac{1}{8}$ in. thick full, double riveted; tube and top plate of Lowmoor iron, $\frac{1}{8}$ in. thick; stays of bowling iron, 1 in. diameter; tubes of solid drawn copper, height 60 in., diameter 42 in., and will contain from 30 to 90 gallons of water (a rather wide margin) when at work.

(Plate No. 8.)—The pumps are the same description as those in the "Deluge" and the "Torrent;" but the valve arrangements must have received an immense amount of consideration. It is thus described in the *Mechanics' Magazine* of July the 10th: "On the middle of each piston-rod is keyed a boss, carrying a short arm projecting horizontally. Parallel to, and at a short distance from, each piston-rod are fixed in suitable bearings, so as to revolve freely on their axes, two twisted bars, or quick screws, having a pitch of one turn in 16 in. At the ends of these twisted bars or screws, next the steam cylinders, are cut two strong square-threaded screws, having one turn in $1\frac{1}{4}$ in., on to which are fitted two gun-metal nuts, which nuts are received by the forked ends of the weigh shaft levers for moving the slide valves. To the short arms on the piston-rods above mentioned are attached two gun-metal sliding pieces, which clasp and move freely on the twisted bars or screws, and, having the same motion as the piston-rods, impart a slow, easy, reciprocating, rotating motion to the twisted bars, causing the gun-metal nuts and weigh shaft levers to be brought backward and forward with a slow, easy motion, thus moving the slide valves into the required position, viz. that of closing steam and exhaust ports shortly before the end of the stroke, thus preventing the possibility of striking the ends of the cylinders. It will be seen that by this arrangement each cylinder cuts off its own steam and exhaust, and is entirely independent of the other for forming the cushion required to stop the momentum of the piston; thus each piston brings itself to rest; but when at half-stroke, by means of a connexion between the weigh bridge levers, gives steam

to No. 2 cylinder, the piston of which brings itself to rest, and liberates No. 1 piston, and so on alternately."

To use the words of one of our advertising watchmakers, this looks very like the perfection of mechanism, but it would be found rather too much so for rough work. The author could bear witness that it did bring the pistons to rest most effectually at the end of the stroke, and very nearly so in the middle, giving anything but the easy motion claimed for it. He also observed when it was working at Lambeth, that every time this check occurred, the water pressure fell from 10 lb. to 15 lb. per inch, an irregularity he never before saw with a double-cylinder engine.

At the trials on the 1st of July, this engine was second to get steam to 100 lb. per inch, and show water, but was first into the hood, and, except being occasionally short of steam, worked very well during the day, but nearly came to grief by cracking the end of the pumps. However, this was repaired in the course of the night, the engine being taken off the ground, which the committee ought not to have allowed on any consideration. The engines should have remained upon the ground, and if incapable of going through the whole of the trials, should have been disqualified. *There could be no objection to anything that could be done readily on the grounds*, but certainly the engines ought never to have left the grounds until the trials had ended.

On the second day at the 18 ft. lift, this engine being primed, or rather the pumps and suction pipes, fetched the water immediately, from the simple reason they had no distance to fetch it, and filled the tank in 1 hr. 24 min. 55 sec., and against the water tower threw a $1\frac{1}{2}$ jet 180 ft. high, for a few seconds, and was awarded the first prize of 250*l*.

The next engine was by Shand, Mason, and Co., and is thus described: The boiler, vertical tubular; diameter at fire box, 42 in.; diameter of barrel, 32 in.; height, 60 in.; iron and brass tubes. This was the most brief description ever met with, but there is a full description of the boiler of the small engine, which is identical in construction, but of smaller size, in the *Mechanics' Magazine*, which will be referred to presently.

(Plate No. 9.)—The boiler of the large engine, by the same firm,

is almost precisely the same, in every respect but size, as that to be described, the number of tubes being 328, 1 in. in diameter outside, and 14 in. long, divided into four groups, in order to permit free circulation. The top plate of the smoke box is strengthened by eight tubular stays $1\frac{1}{4}$ in. in diameter inside, which suspend it from the boiler, being screwed into the smoke-box plate, and stopped by suitable screwed caps at the other end outside the shell. These stays act as additional heating surface, although there is no current through them. There are no very remarkable features presented by the engines or pumps, the dimensions of which have already been given.

The weight of this engine was 2 tons 17 cwt. 12 lb., and it had two steam cylinders of $8\frac{1}{2}$ in. with 9 in. stroke, and water cylinders of 7 in. diameter, also 9 in. stroke, and appeared to be two of the engines used in No. 10 (formerly described) placed side by side.

This engine was third to get steam to 100 lb., the time being 11 min. 45 sec., instead of 10 min. 51 sec., as stated in the report; the water in this boiler was very unsteady, as might be expected from the closeness of the tubes, about $\frac{1}{4}$ in. apart.

The engine plunged a good deal when working quickly, but the jet thrown was steady.

Upon the second day's trial, there was considerable difficulty to fetch the water at the 18 ft. lift, the pumps had to be primed repeatedly, they not having a foot valve in the suction pipe, the water ran away before the rose could be got into the water, but when they did get to work they went on very steadily. At the trial against the tower for height, this engine threw a very steady stream, the jet being $1\frac{3}{4}$ in., but from some cause did not long continue working. The cause was believed to be that the committee had said that was sufficient, and Mr. Shand being anxious to get back to his small engine, had drawn his fire; but there were some gentlemen there who had taken a very active part in assisting one competitor in particular, and who wanted more show, and so some of the engines were kept to work after Mr. Shand had left. Messrs. Shand, Mason, and Co. obtained the second prize of 100%.

The next engine mentioned in the awards was the one the author had the honour to exhibit, but which he did not intend to work in this class.

DESCRIPTION OF W. ROBERTS'S STEAM FIRE ENGINE "PRINCESS OF WALES." (PLATES 9, 10, 11.)

Plate No. 9 is a side view of the engine; Plate No. 10 a longitudinal section of the same; Plate No. 11 is a side view of the engine pump and boiler, and a front view of the engine. The same letters refer to the same parts in all the plates.

The framing consists of light angle and strip iron, and the hose box (c, fig. A) of plate iron; this is large enough to carry 800 feet of hose, beside buckets, tools, &c. The driver's seat will carry 4 branch pipes and rests, a stand-pipe, saw, and other tools, and the tool box (m) the whole of the spanners and tools necessary to take the pump or engine to pieces, also spare gauge glasses, &c.

The seat (A A) is capable of accommodating 16 men beside the driver, and the foot plate at least 2 more. Under these seats there is room for five 6-foot lengths of suction hose and three 6-foot ladders. This is the only steam fire engine that carries ladders.

The shell of the boiler is made of treble refined iron $\frac{5}{8}$ in. thick, the tube plates $\frac{1}{2}$ in. thick. The tubes are all best lapwelded steam tubes of No. 11 wire gauge, having one end swelled and screwed into the tube plates top and bottom, so that each tube forms a stay.

The fire box is also composed of best lapwelded steam tubes, the lower ends being screwed into a tube ring, and every alternate tube going straight up into the boiler, and every other tube bending inwards, as shown, and being screwed into a place left for it among the other tubes. The action is this: the feed water goes into the tube ring at the bottom, then rising through the tubes enters the boiler, in forty places, thus ensuring perfect circulation. The steam is taken off in a similar manner.

The water tank (D) is fitted round the boiler, and is supplied from the main delivery, the quantity being regulated by means of a ball valve.

The steam cylinder is of the ordinary style, with a plain piston and slide valve. The cross head (a a, Plate No. 11) is connected with the levers (c) by means of the rods (b b); these levers, one of which is a bell crank, shown in the side view, are securely keyed to the shaft (i) running through the pump, the short arm of the bell crank lever is connected by a rod (d) to the fly wheel, and by means

of the shaft an eccentric motion is given to the slide valve in the usual manner.

Upon (i) is a cross head, each arm of which is rather less than a fourth the length of the lever (c), so that the stroke of the pump buckets is rather less than one-fourth of the stroke of the piston; in each end of the pump, one above and one below, are the buckets, having a fork to each, which act as guides, and are connected to the cross head by links. It will readily be seen by this that as the piston travels up and down the buckets recede and advance; thus, as the lower bucket rises it lifts the water through the upper bucket, and discharges a volume due to the diameter of the bucket and length of stroke; upon the return stroke of the engine the upper bucket rises and delivers its volume of water, and at the same time fills the lower chamber ready for the next stroke of the lower buckets.

It will be seen by this that the water is constantly flowing through the suction pipes and pump in one unbroken line, giving as much as 20 per cent. over the theoretical quantity due to the pump when working with open delivery, and there is very seldom any loss under 25 to 30 lbs. per inch. Each bucket is a grating, having a disc valve of large dial and small lift, and the buckets, valves, forks, and links are duplicates of each other. The upper bucket is readily got at by taking off the air chamber, and the lower one by taking off the cap at bottom.

Every part of both engine and pump are easily accessible in case of need, neither the cylinder cover or steam jacket being covered.

The engine was first to get steam to 100 lb. and throw water, but from its position, being placed to windward of all the others, and its small size, it was of course beaten in quantity, but not in steady working.

At the 18 ft. lift it fetched the water immediately without priming, although a piece of canvas near half a yard square was afterwards found in the pump, and in the first hour's working it threw exactly the same quantity of water into the water temple that Shand and Co.'s large engine did, viz. 20 in. ; but shortly after this the head of a rivet came off, and the engine was worked easy for fear of breaking down altogether. At the trial at the tower (this rivet still being out of the stay) a jet was thrown quite as high as by any engine, the jet being $\frac{3}{4}$ in.

Throughout the whole of the trials this engine worked steadily, there was scarcely any oscillation, no priming, very little variation in either steam or water pressure, and, taking power into consideration, contrasts very favourably with the prize engines; thus, in the first trial the "Sutherland," with steam cylinders more than *five and a half times* the capacity, and water cylinders *six and three-quarter times* the capacity of the author's pump, it took 9 min. 42 sec. to do the work that it took 20 min. 24 sec. to do with his. The steam pressure at starting being the same, viz. 100 lb. per inch, or, in other words, two and one-quarter times the work was done with five and a half times the power. Again, in Shand, Mason, and Co.'s engine, the steam cylinders were more than twice the capacity of his, and the water cylinders three and a quarter times, and yet it took them 12 min. 19 sec. to fill the tank, or one-fourth longer than he should do it in, according to the time taken by his engine, and this, too, when, from its position, it had the benefit of all the spray from the other engines.

Again, take the third trial, which was, in fact, the principal trial. Merryweather's engine delivered 16,086 gallons in 1 h. 24 min. 55 sec., or say 189 gallons per minute, with an average steam pressure of 91 lb., and water pressure of 89 lb.; and the author's engine delivered in the first hour before the rivet gave way, 5560 gallons, or 92 per minute, just half its more bulky competitor, and this with an average pressure of 75 lb. both steam and water, and if the whole two hours are taken it brings it exactly the same as the first trial, viz. two and a quarter times the work for five and a half times the power; and as Shand's engine only delivered the same quantity in the first hour and not one-third more in the two hours, the author thought he had said enough to prove that the best engine did not obtain either the first or second prize, and if the trial at the water tower had been taken the case would not be altered.

Having previously described the "Annihilator," *alias* the "Sabrina," it is only necessary to say that it was fourth to get steam, and did very good work at the low lift, but could not accomplish the 18 ft. lift, and was finally withdrawn; the most noticeable point being that during the time it did work the average water pressure was only 41 lb. to 98 lb. steam.

The next was an engine called the "Victoria," built by the Amoskeag Company, of America, and imported by Messrs. Lee, but entered under the name of Butt and Co. This engine had a very light appearance, having just sufficient framing to carry the boiler and engine upon wheels; there was a seat for the driver and room on the foot-plate for two or three men, but no hose-box. The fore carriage would not lock to above 35 to 40 in.—a very serious objection to an engine intended for a place like London, with narrow streets. This engine had a vertical tubular boiler, with submerged smoke-box, made of iron and steel; diameter, $36\frac{1}{4}$ in.; height, 65 in.; height of fire-box, 20 in.; number of tubes, 313; diameter outside, $1\frac{1}{4}$ in.; distance between sheets of submerged smoke-box, $4\frac{1}{2}$ in.; length of submerged smoke-pipe, 16 in. The arrangement of the engine is similar to Shand and Co.'s No. 10, except that it is vertical instead of horizontal. The steam cylinder is $10\frac{1}{2}$ in. diameter, and the pumps 6 in., with a stroke of 12 in. The crank shaft is in a line with the centre of the frame, and the fly-wheel work across; this causes a very large amount of oscillation, and would be found very destructive, in consequence of the very rapid working of the machine. The engine was 17 min. raising steam to 100 lb., but when it did get to work it made up for it by filling the tank in 6 min. 48 sec. Upon the third trial this engine fetched the water immediately, but after working some little time got uneasy and fitful, and finally knocked the cylinder cover off. This was hastily, but not effectually, repaired in the night, and it would be unfair to refer to its performance at the water tower.

There was one other engine of which great expectations were formed—the "Manhattan," No. 8. This was sent over by the New York Fire Company, and was the crack engine there. This engine had the same fault in the locking carriage as the last, and in going to the place of trial capsized, seriously injuring one man. It was tried upon the second day, and considered fit for work by those in charge. It certainly threw a very good jet, but upon trying it the next day at the high lift and long range it soon became evident that it was unable to do it, and finally came to grief by bursting the boss of the remaining fly-wheel. This engine was repaired, and afterwards tried at the Shadwell entrance of the London Docks, but totally failed to maintain its reputation.

There was one other engine entered for this class, one made by Gray and Sons, of Limehouse. This had a rotating boiler, but was not got to work.

"Small class engines." Strictly speaking, there were none under 30 cwt. The "Torrent," as before observed, had its coal lockers and foot-plate taken off, besides other alterations. Shand, Mason, and Co.'s engine had no hose reel, although fitted for one; and Messrs. Lee's had some small parings to bring it to weight. The steam cylinder of Shand, Mason, and Co.'s engine was 7 in., with an 8-in stroke; the pump was of the combined bucket and plunger, the plunger being hollow. The crank shaft was placed fore and aft, and the fly-wheel athwartships, the connecting working in the hollow plunger. In the report the diameter of water cylinder is given as 9 in., but the diameter of plunger is not stated. The bucket has six and the foot-plate seven india-rubber disc valves, $2\frac{3}{4}$ in diameter. The boiler is thus described in the *Mechanics' Magazine*, July 10, page 448 :

"The upper part of the boiler is cylindrical, of Bowling 'best best' iron, one-fourth of an inch thick, welded, 2 ft. 1 in. in diameter outside, and about 2 ft. 6 in. high. The upper part, turned to a round flange, is bolted to a suitable plate, through which the up-take 8 in. in diameter passes. The lower part has a Bowling $2\frac{1}{2}$ in. angle iron ring riveted round it. The fire box shell is conical, 2 ft. 1 in. in diameter at the small end, which is fitted with a precisely similar angle-iron ring, and 2 ft. 10 in. in diameter at the larger, outside, giving a diameter of circular grate of 2 ft. $7\frac{1}{2}$ in. Both rings are accurately turned and faced in a lathe, so as to make a perfectly steam-tight joint, by the aid of a little red-lead, when bolted together. The inside fire box is of iron of the same thickness, the top, which forms the tube plate, excepted, this last being also of iron, but $\frac{1}{2}$ in. thick. The vertical tubes are 195 in number, 1 in. in diameter outside, 12 in. long, and No. 19 wire-gauge thick, fitted without ferrules by simply drifting. They are spaced only one-fourth of an inch asunder, and deliver the products of combustion into a smoke box about 5 in. deep, quite covered with water. From the centre of this smoke-box rises the up-take, surmounted by a handsome brass-topped stack, 2 ft. 9 in. high. The distance from the grate bars to the tube

plate is 2 ft., the height of the boiler over all about 4 ft. 6 in., the bottom clearing the ground about 15 in. By unscrewing the bolts which connect the angle irons, and those which unite the upper flange with the top plate, the entire cylinder shell can be removed, permitting access to every portion of the interior of the boiler tubes, smoke box, &c., an advantage of the last importance. A space of some 4 in., however, unavoidably remains between the boiler shell and the outer tubes, because the shell could not be drawn over the smoke box if its diameter were narrowed in order to approach the tubes. An unnecessary body of water would, of course, remain here, but for the following ingenious expedient: A species of copper 'pocket'—we cannot think of a better name—descends nearly to the crown of the surface all round and between the shell and the outer tubes, displacing the water, and supplying so much additional steam space, for the upper edges of this pocket are considerably above the water line—the boiler, in fact, carries steam below the water. Of course no pressure except that due to the gravity of the liquid, is exerted on the sides of the pocket, which are traversed by the pipes leading to the gauges. The contrivance is extremely simple, and answers its purpose admirably. A copper ring, drilled with a multitude of holes, surrounds the up-take, and supplies the steam to the cylinder through a copper tube $1\frac{1}{2}$ in. diameter, fitted with expansion joints. The exhaust steam pipe is $2\frac{1}{4}$ in. diameter, terminating in a variable exhaust, not easily described without drawings; suffice it to say that the orifice can be enlarged or contracted by means of a hand-screw, being equivalent in area to a circle $1\frac{1}{4}$ in. in diameter when full open, and to one of $\frac{3}{4}$ in. when shut.

"The fire box is provided with two fire doors—one behind, and the other at an angle of 45 deg.—just in front of the hind wheel. A person standing on the foot plate behind can fire the boiler when proceeding through the streets. The 24 ft. of suction which the machine carries ready screwed on, being coiled round the engine out of the way. On reaching the fire this door is shut, and the front wheels locked round; the other door then becomes easily accessible, a small coal bunker being hung from the front axle, in a convenient position for the stoker. The weight of this engine as entered for the trial was 1 ton $9\frac{1}{2}$ cwt."

EXPLANATION OF VERTICAL SECTION OF MESSRS. SHAND AND MASON'S
PATENT STEAM FIRE ENGINE. (PLATE, NO. 12.)

The boiler is constructed with a conical fire-box, A, vertical tubes, C, and a submerged smoke-box, B. The steam-jackets, D, communicate with the steam space in the upper part of the boiler by the open pipes, E, and they have small cocks at the bottom to draw off any water that may find its way in. The boiler can be taken apart for repairs by the bolted joints at F, G, and H.

The engine is made with an inverted steam cylinder, I, placed above the pump, K, which are framed together by the four bars, L, that also carry the crank bearings. The pump is fitted with a hollow plunger, N, and bucket, O; at the bottom of the barrel is the grating, P, which, as well as the bucket, is fitted with india-rubber valves. The head of the pump, K, is fitted with an air vessel, Q, and nozzles to take the hose at R; over the openings at S is fitted a valve, shown in plan at Fig. 3, which is so made that it is impossible to shut off both hose at once, which might burst the air vessel. The connecting rod, T, is jointed to the plunger, which is attached to the steam piston by two piston rods, between which the crank works, as shown in Fig. 2. Upon the end of the crank shaft is an eccentric, which works the slide and the feed pump, V.

Fig. 4 is a section of the governor, which is composed of a small cylinder, the piston of which is connected to the steam valve: the pipe, W, leads to the steam chest, and the pipe, X, to the pump head; any change of pressure in the pump will allow the piston to be moved by the steam, and so regulate the speed of the engine.

This engine got up steam to 100 lb. in 11m. 36s., and filled the tank in 5m. 24s.; on the third trial steam was got up about ten o'clock, but the engine could not be got to work, first some shaving got into the pump and stopped, or rather prevented its working, then something else went wrong, and finally it was got ready to start at 7 p.m., yet in the report the remark is "worked well throughout;" the report also states that the average pressure of steam was 146 lb., and the water 80 lb., but certainly when the author saw it at work the water did not exceed 60 lb. Now there must have been something very wrong here, 146 lb. of steam and 60 lb. only of water. His engine with the same size

jet, the same length of hose, the same lift, in all things similar (except the wind, which was blowing strong when his engine was tried, and a dead calm when Shand's was tried), with 75 lb. of steam gave 75 lb. water. Lee and Co.'s "Victoria," with 78 lb. steam, gave 78 lb. water; the "Sutherland," with 91 lb. of steam gave 89 lb. water (again nearly equal); Shand's large engine, 96 lb. steam, 62 lb. water (one-third less); Easton and Amos, 98 lb. steam to 41 lb. water; this was worst of all; the "Torrent," 86 lb. steam, and 45 lb. water; and the "Alexandria," 80 lb. steam, 60 lb. water.

During the trial the fire was from one to two feet above the top of the chimney, a state of things no boiler with tubes made of 19 guage, and spaced a fourth of an inch apart, could long stand. The oscillation of this engine was also fearful.

The "Alexandra," also made by the Amoskeag Company, and imported by Messrs. Lee, was in every way similar to the "Victoria," but smaller, having a $7\frac{3}{4}$ in. steam, and $4\frac{1}{4}$ in. water cylinder, with a $9\frac{1}{2}$ in. stroke; this engine got steam in 11m. 55s. and filled the tank in 6m. 3s., and at the long lift and range fetched the water directly, and worked on its allotted hour without stop, and obtained the second prize of 100%.

Having fully described the "Torrent," it is only necessary to say that it got steam to 100 lb. per inch in 12m. 15s. and filled the tank in 9m. 15s.; at the third trial very great difficulty was found to fetch the water—in fact it was not until it had been repeatedly primed that it succeeded, but after it did get to work it went on very steadily.

With regard to the committee, the author believed every member was actuated by the best motives, and thought they deserved the best thanks of society for the trouble they took in this matter; but they were unfortunately in the position of the man who tried to please everybody, and so pleased nobody; had they stuck to their rules, and carried them out to the letter, they would be just as well thought of.

In bringing this matter before the Society, the author had carefully avoided anything like imputing motives, or of personalities, and he hoped that all who might take part in the discussion would bear in mind that personalities were not arguments; but he could not con-

clude without expressing his belief, that had the engines been subjected to the whole of the tests, a very different result would have been obtained; some of the engines were mere racers, never intended for, or at least capable of, continuous hard work; some would carry scarcely any hose or gear—all points that should have been strictly inquired into, but which appeared to have been lost sight of.

DISCUSSION.

The CHAIRMAN was sure the members would readily accord their thanks to Mr. Roberts for the carefully considered paper he had just submitted. The reading of the paper having occupied a longer time than usual, the period allotted to discussion had been reduced, but at the same time it was desirable that the discussion should be opened, and so continue it at the next meeting of the society, and he hoped the members would come to the next meeting prepared to join in the full discussion of the question.

Mr. J. D. HUMPHREYS begged to correct some of the remarks made by the author in his paper concerning Messrs. Shand and Mason's small steam fire engine. In the first place, as to the thin iron tubes spoken of as being likely to be soon destroyed, he would state that there were no iron tubes in the boiler, but that the tubes were made of brass, as was distinctly stated in the report of the committee. The fact of there being no hose reel did not render this engine more incomplete than the other engines, as none had them. The deductions the author drew from the great disparity between the steam and water pressures were erroneous, as the steam gauge was not fixed upon the steam cylinder, but upon the boiler, thus showing that the steam was bottled up, for, the foot valve having been strained in the morning, in snatching for water when the shavings were in the pump, and the inner coating of the suction pipe collapsed, the engine was worked as gently as possible, knowing from the gauge, minute by minute, that she was doing double the work of either of her antagonists.

Mr. OLBICK said, before entering upon any detailed remarks, he wished to make a few general observations that applied to all steam fire engines. In the first place there was no doubt that all the English engines beat the American in getting steam up quickly, and this

fact is entirely owing to the fact that the English engines are provided with a steam jet in the chimney, which neither of the American engines have. It had been urged that this was a point of less importance, but he (Mr. Olrick) considered it of great importance, as often five or ten minutes difference in commencing to pour water upon a fire will have the effect, that valuable property, otherwise lost, would be saved. Next he had heard the injector objected to, indeed he had seen it condemned himself, but simply for want of proper management, because when he himself set it to work, it worked very satisfactorily. Therefore the question was simply as to the manner in which it was worked. The injector was not more liable to derangement than any other pump. The next point was the trial of lifting the water from a reservoir 18 ft. below the pump, which he considered of great practical importance. But there was another trial, which was entirely omitted in the Crystal Palace, viz. the test of ascertaining the actual delivery, in a tank close by the engine, compared with the theoretical. The "Torrent," for instance, he had seen at a former trial for quantity, deliver more water than it ought to theoretically, which could only be explained by the momentum of the water forcing water through the valves, when the pump piston was at its two dead centres. Many objected to the trial of throwing water into a hood elevated to a certain height, and did not consider it a good test, he (Mr. Olrick) did, because if a fire commenced at the top of a very high house it was not of the slightest use for an engine only to be able to pump a quantity of water into the cellars, therefore, if a fire commenced high up, it certainly was a very good test of the quality of an engine if it delivered water upon the spot on fire. As regarded the wind affecting the delivery of the stream, he certainly was of opinion that each engine ought to have its turn of exposure to the action of the wind. Before proceeding to make any detailed remarks as to the trials at the Crystal Palace, it was right, he thought, to say that members of a society like this, when discussing such questions as that now before the meeting, ought to come forward and speak their minds freely without fear of being looked upon unpleasantly by those whose work they were obliged to criticise. In the first place, he had to complain of the official printed report, because it contained several inaccuracies. For

instance, with respect to raising the steam, it stated that Messrs. Merryweather and Sons, and Messrs. Shand and Mason's raised steam in respectively 10 min. 25 sec. and 10 min. 51 sec., and Mr. Roberts's in 11 min. 40 sec., whereas it in reality was respectively in 10 min. 15 sec., 11 min. 45 sec., and 10 min. 17 sec. It had also been stated in the official report that Messrs. Easton, Amos, and Sons filled their tank first in 19 min. 30 sec. Now he (Mr. Olrick) had an excellent opportunity of noticing what happened, and he saw that the Messrs. Merryweather filled their tank first, at least a quarter of a minute before any of the other tanks were filled. With reference to the next trial of filling the large tank, able to contain 16,086 gallons, in two hours, which trial was only completed by Messrs. Merryweather and Son's engine, "Sutherland," in 1 hr. 24 min. 55 sec.—it was certainly true that Messrs. Shand's engine worked at this trial under very unfavourable circumstances, as the wind blew very hard. But in comparing it with Messrs. Merryweather and Son's engine, "Sutherland," he (Mr. Olrick) had allowed, on account of the wind, 20 per cent. in favour of Messrs. Shand's, but even then the result of the trial gave 50 per cent in favour of Messrs. Merryweather. This latter engine had also this great advantage, that it could be worked at any speed to adapt itself to the quantity of water present. If this was not the case, such large engines would in many instances be useless, where the supply of water was rather scanty. A feature worth noticing in the "Sutherland" was, that however quickly it worked, it was always extremely steady. This was very unfavourably contrasted by Messrs. Butt and Co.'s engine, that shook frightfully during its working, and at last broke to pieces simply on account of that shaking. Otherwise its performance was highly satisfactory. It had been said that the "Sutherland" prize engine was primed, or more plainly that it was charged with water in the suction hose. That was not correct as he (Mr. Olrick) was present at the time. In respect to the trials for height at the tower, the official report gives the height of stream thrown by the engines of Messrs. Merryweather and Son's, and Messrs. Shand and Mason's, as 180 ft. without any remarks, but it ought to have been remarked that the "Sutherland" maintained that height for upwards of 10 min., and then a stream of 160 ft. for about 25 min., in fact, the "Sutherland," after having changed



nozzle, never ceased to work until the trial was over, whereas the others stopped repeatedly. It ought likewise to have been remarked that Messrs. Shand and Mason's engine only gave one spurt of 180 ft. and then stopped altogether. Several remarks might be made as to what was stated in the official report about the trial of the small engines, when filling the 1000 gallon tank. It states, for instance, that Messrs. Shand and Mason's engine, upon the third trial, threw nearly double the quantity of water of either of the other engines. Now, how was it possible the measurement could be correct? At any rate, upon the second trial, there was only one second difference in filling the tank, between the engines of Messrs. Shand and Mason and Messrs. Lee and Co. As regards the report of the trials which appeared in the *Times*, that certainly was a great curiosity. In describing the "Sutherland," the reporter of the *Times* states "*that the upper part of the boiler is fixed with wrought iron valves to carry off the smoke and to create a draught.*" Of course no engineer would be misled by such a statement as this, but it showed what little dependence could be placed upon newspaper reports. The reporter of the *Times* employed to describe such things as these ought to be certainly an engineer. Captain Shaw, in his report in 1862, stated that the insurance offices would save 1000%. by each steam fire engine, but instead of that it had cost 3500%. more than the average expenses for the four steamers, and instead of a saving of men which was anticipated, they have 34 men more now than formerly. He thought it would be very interesting to know the cost of all the breakdowns of the brigade steam fire engines in London. Messrs. Merryweather produced an engine that would throw 700 gallons 190 ft. for 790%, while Messrs. Shand and Mason charged 800%. for an engine that would throw only 550 gallons 160 ft. high. For 400%. Messrs. Merryweather would produce an engine that would throw 250 gallons 150 ft. high, while for the same price Messrs. Shand and Mason produced an engine that would throw only 180 gallons 140 ft. high. He (Mr. Olrick) thought when they were speaking of the relative merits of an engine they should also consider whether one cost 50 per cent. more than another. As to the trials at the Crystal Palace, he had no doubt the Committee did everything in their power to make it a fair trial but at the same

time he could only say from experience that he knew what trial trips were; he had often tried and succeeded in making a vessel run much faster during a short trip than really could be accomplished during an ordinary journey. And with respect to these trials at the Crystal Palace, there were several engines he saw brought on to the ground which could be compared to nothing but racehorses, against ordinary horses. He could only say that the "Torrent," which had been hard at work for ten months, could not be expected to compete with an engine that had been made for a specific object. The "Torrent" had been present at all fires for some considerable period that had occurred within reach of Messrs. Hodge's Distillery, consequently, an engine that had done such a large amount of work, could not fairly compete with an engine made for a special purpose, with for instance tubes of only 19 Birmingham wire gauge or .042 in. in thickness and $\frac{1}{4}$ in. apart, whereas the tubes in the "Torrent" are of 13 B.W. or .095 in. in thickness, and more than $\frac{1}{4}$ in. apart. Such thin tubes will of course give excellent results, while new and clean, but how long will they last. There is no credit due to the engine that under such circumstances can beat the "Torrent," and it was no reflection upon the "Torrent" that it was beaten by a racehorse. He thought they should not, as engineers, look upon such trials as decisive, but merely as exhibitions.

November 2nd, 1863.

R. M. CHRISTIE IN THE CHAIR.

STEAM FIRE ENGINES, AND THE LATE TRIALS AT
THE CRYSTAL PALACE.

BY W. ROBERTS.

ADJOURNED DISCUSSION.

Mr. OLBICK said that since the last meeting he had had an opportunity of reading Mr. Roberts's paper. He found that it contained a great deal of valuable information, but, at the same time, there were

many points in it with which he (Mr. Olrick) could not agree. There were omitted, too, several points which it might have been expected would have been referred to, such, for instance, as the points which are indispensable in a good steam fire engine, and also the points which should be avoided. Now, Mr. Roberts had referred to the "Sutherland" in a way with which he (Mr. Olrick) did not agree. He believed the "Sutherland" was looked upon by all engineers as the best fire engine produced. To prove that the "Sutherland" was the best engine, he mentioned the facts—first, that it was the only engine that completed the very severe trial of raising water from a basin 18 feet below the engine, and in filling a tank containing 16,000 gallons, not in 2 hours, as stipulated, but in 1h. 24m., and that without being primed. Secondly, it was the only engine which, during the trials at the tower, threw the water 180 ft. high continuously for at least 10 min., and continued to throw a stream 160 ft. high for more than 25 min.; this was not done to make a show merely, because it never ceased until after the trials were over. He had no hesitation in saying that Mr. Roberts's engine showed great power, for it threw a stream 160 ft. very steadily for a long time. He was quite willing to give Mr. Roberts's engine every credit as being one of the best on the ground; but not "*the best*." As regards Mr. Roberts's remarks about the "Sutherland" being taken off the ground for repair, he (Mr. Olrick) did not see any harm in that, because, "one stitch in time saved nine," and if fighting men could be patched up and brought up within the time, it was considered quite fair, and so it was with the "Sutherland." Mr. Roberts made a remark to the effect that on account of the "Sutherland" having been taken off the ground it should have been disqualified. Now he (Mr. Olrick) considered that would have been too severe, the more especially as the engine had completed its trial at eleven o'clock in the morning, and was then repaired during the night. It was true that Messrs. Shand and Mason's small engine did not leave the ground, but the case was altogether different, for it started the first time for the third trial at 10 o'clock, and although primed repeatedly, could not draw the water, and at last was withdrawn at 11 o'clock to be repaired, and did not work until 7 in the evening. In the morning it could not draw the water from 18 ft. below the pump,

although it was repeatedly primed. In the evening it was said to draw the water at once without priming—rather improbable—and he (Mr. Olrick) would have preferred to have seen it himself, as very few were present when the trial commenced, on account of the trials at the tower not having been finished, when this began. If any engine should have been disqualified it was that, because it could not come up to time when called upon. He was quite sure everybody would agree with him in thinking that Mr. Roberts's engine worked under very unfavourable circumstances, for it was too large for the small class, and too small for the large class; but who could help that but Mr. Roberts? as the engine was designed by Mr. Roberts especially for the trial, and he (Mr. Olrick) was willing to give every credit to the engine; but it could not come up to the large class, and did not work with the small class. He (Mr. Olrick) thought it right to examine which was the most complicated, and he could not compliment Mr. Roberts upon his being less complicated in working the slide than the "Torrent." In the latter there were only four pieces to drive the slide rod; but in Mr. Roberts's engine there were nine pieces, consequently the "Torrent" was not so complicated as Mr. Roberts's engine. The eccentric rod was so short that it gave a very bad slide motion, and he (Mr. Olrick) believed that arrangement would ultimately knock itself to pieces. Consequently, it would be a costly affair to keep in repair. In answer to Mr. Roberts's remarks that his engine did proportionally more than the "Sutherland," he (Mr. Olrick) would apply the test of the gallons of water delivered per minute per square foot of heating surface, and they would find that upon the first trial the "Sutherland" delivered '49, and Roberts's engine '34; upon the second trial the "Sutherland" delivered 1'55, and Mr. Roberts's did not fill the tank; and upon the third trial the "Sutherland" delivered 1'04, and Mr. Roberts's '64 gallons per square foot of heating surface. If the test were applied of gallons delivered per pound weight of engine, the "Sutherland" also gave better results than Mr. Roberts's engine, viz. upon the first trial, "Sutherland" '0158, Mr. Roberts's engine '0111; second trial '049, Mr. Roberts's did not fill the tank, and upon the third trial "Sutherland" '033 against '020 gallons delivered per lb. weight of engine. Query: "Did or did not the best engine get

the 250%?" Of all the small engines upon the ground he should have selected the "Torrent," and for this reason, that it has a horizontal cylinder and pump, and is altogether less complicated than the prize engine; and the "Torrent," and engines like it, can be driven at any rate of velocity, and consequently can accommodate itself to the quantity of water present, which is not the case with the crank engines; and the boiler (one of Field's) requires only between two and three square feet of heating surface for one horse power, whereas in common boilers there are ten; in addition to this the violent circulation of the water prevents any sediment collecting in the tubes. Another noticeable point was the pump. The "Torrent" has a horizontal pump, the advantage of which is, that no foreign matter could remain in the cylinder, and no water was allowed to stop in the valve-box, which was a very important point in cold climates, because the water could not freeze. He believed that when the small prize engine was stopped at the trial, the pump was choked with sand. At the last meeting, he referred to the relative cost of the engines, which he considered to be of the greatest consequence when the difference was as much as 50 per cent. As regards the accident to the "Manhattan," the American papers stated that it was not an accident, but a design set on foot by Lord Palmerston. This was, of course, absurd, but although it was not the fault of Englishmen, it was the fault of one Englishman, because the engine required certainly more than five men to get it down the hill. In conclusion, he would call attention to a few points indispensable in a good steam fire engine, the cylinder and pump should be horizontal. A most important point was long-stroke pumps and a moderate velocity. There should be wide and straight water passages, and no sudden enlargements, and there should also be good large air vessels and steam jets to get up steam quickly. The points to be avoided in steam fire engines, were, first, the contraction of the water in entering the suction, from this into the pump, and thence into the hose. Secondly, bends, twists, or sudden changes of form. Thirdly, the meeting of two separate currents, as by the delivery of two alternate streams into a common passage from the two pumps. Fourthly, sudden enlargement of the water passages and all unnecessary friction, as the mere roughness at high velocities has been greatly overlooked. The points

requiring determination in order to judge of the efficiency of steam fire engines as hydraulic machines, are the following: 1. The extreme vertical height the water could be thrown. 2. The volume delivered in a unit of time *to that height*. 3. The total power given out by the engine, and consumed in performing that work in the unit of time. Having these elements we can determine the relation between the work wasted and that consumed in useful effort, and the ratio of these is the true measure of the merit of the fire engine as a hydraulic machine. In any future trial the only thing required would be to have a sort of tower in such a position as to screen the stream entirely from the wind, and where the quantity of water and height of stream could be accurately measured, and every engine should be made to use the same branch pipe, nozzle, and hose. At the recent trials at the Crystal Palace, the mean velocity of the piston was not recorded in a single instance, and this point is certainly the starting point for ascertaining the amount of useful and useless power expended. And he (Mr. Olrick) thought that at any future trials the judges would do well to take notice of these points, as they would show beyond doubt, which fire engine was really the best hydraulic machine, without which it could not be a good steam fire engine.

Mr. F. YOUNG said, there could be little reason to doubt the superior economy and advantages of a well-made steam fire engine. From what he had seen of these machines during the last three years, having been present at the greater part of the trials of them, he was convinced that a slow, steady, reciprocating motion is the right thing, and far superior to any fly-wheel or crank arrangement. The slow speed of the pumps is important, as it gives a full pump, and is especially valuable in using (as frequently happens) gritty or sandy water, and the higher the speed at which the engine is run, the more necessary does the slow motion become. Messrs. Shand and Mason's engine, when tried for height at the tower of the Crystal Palace, ran so hot in the pumps from the speed at which it worked, that it had to be stopped, and cold water bucketed over the pumps. He preferred the horizontal arrangement of the pumps and steam cylinders to the vertical, as conducive to greater steadiness, and better in all respects. He thought Mr. Field's boiler best in all respects; and, next, that of Mr. Roberts. Much had been debated about the non-importance of

getting up steam quickly in steam fire engines ; he considered it was of the greatest importance to have the power of being ready to work in the shortest possible time, and of keeping the working pressure steadily, as the sooner a fire could be taken in hand, the more easily it could be controlled. He had carefully noted the time occupied by the several engines in getting up steam, which was :

Messrs. Merryweather and Sons . . .	10 min. 15 sec.
Mr. Roberts's	10 „ 17 „
Messrs. Shand and Mason's	11 „ 45 „
“The Sabrina”	14 „ 0 „
Mr. Lee's	17 „ 0 „

The author of the paper had described the steam float on the Thames. He (Mr. Young) had examined it, and seen it at work, and thought that the complicated machine was utterly disproportioned to the work done by it, and that the “Sutherland,” lately purchased by the government, would do almost as much. It had been remarked that, “in the trials in Hyde Park in 1862, the ‘Deluge’ bumped in an unpleasant manner, bumping backward and forward; and this was stated to be the cause of its failure.” He had noticed the causes of the two accidents. In the first, the nut of the piston-rod worked loose and bumped; this was soon remedied by removing the cover and screwing it up; the other was the splitting at the seam of the brazed copper-pipe to which the discharge hose was attached, an occurrence not unfrequent in the brazed copper feed pipes of locomotives. This engine had steam of 100 lb. from cold water, and started to work in 11 min. 50 sec., filling the tank in 2 min. 15 sec. the first time, and 2 min. 50 sec. the second time, the wind blowing very fresh; Shand and Mason’s engine filled theirs in 3 min. 15 sec. the first time, and 3 min. the second, *their* tank being to leeward. The author objected to the method employed for working the slides in the engines of Messrs. Merryweather, and the “Sabrina” of Mr. Lee, and stated that Mr. Lee used the eccentric in the two engines he brought to the Crystal Palace trial. He (Mr. Young) thought, that where there is a rotary motion in an engine, the eccentric is as simple and good a plan for working the slide as any; and he did not see how a more simple one could be devised than that used by

those gentlemen, and he did not see that the author had suggested any other. The American engines brought over for the Crystal Palace trials were some of the finest pieces of workmanship he had ever seen; he would say nothing about their design, as he believed they had been constructed to meet the requirements of their users. So far as he knew, the American engines are of two descriptions; rotary pump and rotating slotted cross head; what these engines can do has been shown by the working of Mr. Lee's small engine that was in the Exhibition, and the "Alexandra," at the Crystal Palace. Mr. Young then referred to the late trials at the Crystal Palace, remarking that he had had difficulty in obtaining information as to the order of the arrangements, that the order was frequently not adhered to, and thought that more assistance was permitted to some engines than was consistent with strict adherence to the rules, which limited the number to be with each engine.

Mr. J. D. HUMPHREYS did not consider Mr. Roberts's comparison between Merryweather's beautiful engine and his own to be a fair one; for who would say that the donkey engine in some tug-boat was a superior hydraulic machine to a Cornish engine, merely because through fast running the steam cylinder was smaller in proportion to the work done; but there are comparisons that may be drawn, such as the proportion of the steam cylinder to the pump, which gives nearly the duty of the engine, as the one is the power expended, and the other the work done; and he found that Messrs. Merryweather and Son's had 2.802 cubic inches of steam cylinder to 1410 inches of water cylinder, or two to one; Mr. Roberts's, 500 inches steam to 221 inches water, being more than two to one; and Messrs. Shand and Mason's, 307 inches steam to 254 inches water, being only one-fifth more; again, in the hour's work, Messrs. Shand and Mason's small engine, weighing only 1 ton 9 cwt. 2 qrs., and having 62 ft. of heating surface, delivered 8142 gallons; Mr. Roberts's engine, weighing 1 ton 19 cwt. 1 qr., with 141 ft. of heating surface, that is, weighing half a ton more, and having double the boiler power, yet only delivered 5500 gallons to Messrs. Shand and Mason's 8142 gallons; and Messrs. Merryweather's engine, weighing 2 tons 18 cwt., and having 207 ft. of heating surface, being double the weight, four times the heating surface, and nine times the

cylinder capacity, yet only delivered half as much again more water, having pumped 12,800 gallons to 8142 thrown by Messrs. Shand and Mason's small engine; now, this is a simple calculation from the published report, which any one could make, but no one can deny. As to her being a mere racehorse, if the weight be taken in comparison with the cylinder and boiler power, she was more substantial than either of her competitors, for she had only 307 inches of cylinder and 62 feet of heating surface; while Messrs. Merryweather's engine, of about the same weight, had 397 inches of cylinder and 64 feet of heating surface; and the American, 446 inches of cylinder to 106 feet of heating surface, nearly one and a half times the steam power to the same weight; but in Messrs. Shand and Mason's engine the surface was more effective and the duty higher. He considered every working part to be fairly up to its strength, and Messrs. Shand and Mason were now making engines to the same drawings. Mr. Roberts says Messrs. Shand and Mason's first engine with the crank and rods in the water worked badly; but with such experience before him, he was surprised to find him now using the same pump, with the exception that he had the levers and slings instead of the crank and rods in the water. The main points that enabled Messrs. Shand and Mason's engine to do such duty, were in the boiler, the conical fire-box giving a large fire with inclined instead of vertical surface, the small and short tubes combined with the internal pockets, replacing a mass of water by steam room. The engine was direct acting, no loss by transmitting the power through shafts, as in Mr. Roberts's, and the American with the rotary pump, and having a crank motion, it ran with certainty close to the covers at every stroke; the pump had a constant delivery in one direction, avoiding waste of power in changing the motion of the water at each stroke, as in ordinary double-acting pumps, and it was as large as the piston could drive, so as to give out its full power at a moderate speed.

Mr. D. SIEBE said, it would be soon found out in practice which steam fire engine was the best, and which would last the longest. At the trial he observed one very good feature in the "Sutherland," that there was the least oscillating movement, but did not think Exhibition trials were much to be depended upon, as an engine or

machine might show very good results for a few hours, but in practical use prove inferior to others. As regards rotary pumps, he could not say much in their favour, unless all the working parts were compensating for each other. He believed the rotary pump on the "Manhattan" was the invention of his father (A. Siebe) about forty years ago, even to the screw gland which was included in his patent. This same rotary pump was tried as a steam engine, but it was found that the difference of expansion caused such a large amount of leakage of steam as to make it practically useless. Water pumps with a long, slow, and steady stroke were far less likely to get out of order, and as durability is one of the primary objects to be attended to in a steam fire engine, such pumps deserve great consideration. One great feature in Field's boilers was the great facility with which they could be repaired; for a tube could be taken out and replaced in about half an hour, whereas a Cornish boiler takes some weeks even to repair. Also, the circulation being so complete, all deposit was thrown into the mud pocket, which was not exposed to the fire.

Mr. MERRYWEATHER stated that the pumps of the "Sutherland" at the trial were not primed, in which fact he could be borne out by many gentlemen present, who witnessed the trials at the Crystal Palace; and to assure the committee that the pumps or suction-pipes were not primed, the pump covers were removed twice in their presence. Some water was in the tank for feeding the boiler, and while the pump covers were off, one of the committee asked if the pumps could be primed from the feed-tank; the engineer in attendance showed this gentleman, by running a little water through, and this, when shown to the committee, was highly approved of as a ready way of charging the pump, if ever needed. Captain Shaw then, to avoid anything being said or thought about priming the pumps, had the tank emptied, and made the remark, "that should we require water for the boiler, he would put a few bucketsfull in the tank for us." With reference to the suction pipes being filled with water, he would state that this was impossible, as the pipes had no foot valve at the time of trial; although one was on the ground, it was decided by Captain Shaw that it should not be used. At the trial on the first day we found that our pump leaked slightly, caused by a cold

run in the metal, although it had previously stood twice the pressure. This was rectified and approved by the committee before going to work the next day. The engine then went through the heavy trial of lifting and forcing the water, and was the only engine that completed that most decisive trial, and also the severe test of throwing a vertical jet against the water tower. The author states our engine to be four or five times the power of his own, this was admitting the superiority of our engine, it was, in fact, a question of an engine of 39 cwt. against 58 cwt., or, in a weight just half as much again, we have produced an engine of 4 or 5 times the power, as was proved against the water tower, where the "Sutherland" projected a $1\frac{1}{2}$ stream, steadily to a height of 180 ft., and Mr. Roberts's engine a $\frac{1}{2}$ stream to a height of 150 ft. At the trial in Hyde Park, steam was got up in the "Deluge" to 100 lb. pressure in 11 min. 50 sec., or half the time occupied by either of Shand's engines, and pumped a large quantity of water that would have put out a considerable fire before the other engines started. This engine has the same means of cushioning as the "Torrent," and having been slightly altered since that trial, has worked very successfully at many fires and trials. To account for so many of their engines being in the Exhibition, and for the prominent position they were placed in, he would state that they offered the use of their engines gratuitously to the commissioners for service in case of fire, during the erection of the building, and for the whole time the Exhibition lasted, and he believed Messrs. Shand and Mason did the same, and hence the engines being on service, were placed in different parts of the building. The author advocates the use of fly wheels, and short strokes with high speeds; by our arrangements the length of stroke is indefinite, and always direct acting; he thought the best system was that in which the valves opened and closed the fewest number of times in a minute. With reference to the capacity of our boiler, Mr. Roberts considers 30 to 90 gallons of water a wide margin; but even when 90 gallons are in, there is more steam room left than in any other boiler; this makes it much easier and more certain work for the stoker, and if the feed pump or injector should fail, there is plenty of water in the

boiler to fall back upon, whilst getting the feed set right; with the exception of Messrs. Butt and Co.'s boiler, the "Sutherland," had boiler capacity (steam and water) of nearly twice as much as any of the boilers of engines of other makers.

The boiler capacity of Messrs. Butt and Co.'s engine was 113 gallons

" " Merryweather and Son's 144 "

As regards the rapidity of raising steam to 100 lb. pressure, the difference between ours and Mr. Roberts's was very slight, his engine having a fly wheel started a few seconds after ours, with a rush, and having less hose to fill, had water running out at the nozzle first, ours being a direct acting engine, started a few seconds in advance, slowly and steadily, and was many minutes ahead in getting the first effective stream of water into the canvas hoods. Our steam did drop to 40 lb. pressure during the first trial, for this reason, as soon as we started the gauge glass broke, and being anxious to keep water in the boiler we kept the feed on, and with this 40 lb. pressure we were the first to fill the tank. The "Sutherland" threw a stream of water against the water tower to a height of 180 ft. for 25 minutes, and not only for a few seconds, as mentioned by the reader of the paper. One of the officials of the Crystal Palace, having at this point requested us to stop as we were inundating the cellars. He could not see how Mr. Roberts could compare the steam and water pressures of engines, without fixing pressure gauges to the steam cylinders—there were none so fixed at the trials. With reference to the "Torrent" being 40 lb. over weight, this was caused by some water being in her boiler, and as this could not be easily removed on the ground without suitable tackle for the purpose, we removed the coal bunkers and foot plates to bring it to the proper weight, but this he considered did not render it a less efficient steam fire engine; many of the American steam fire engines are without coal bunkers, as was the case with the American engine in the Exhibition.

Mr. Z. COLBURN unfortunately did not hear Mr. Roberts's paper read but he had perused it, and he considered it a very carefully-prepared production. He (Mr. Colburn) had thought that some reference might have been made to Captain Ericsson's share in the application of steam to fire engines. In an early volume of the

Mechanics' Magazine reference was made to an engine as being that of Mr. Braithwaite's, but it was only a matter of right to state that it was the joint production of Captain Ericsson and Mr. Braithwaite. In New York Captain Ericsson received a prize for a design for the application of steam to fire engines when very little was known about it. This design was not, however, carried into execution, and Mr. Colburn believed that the first working engine was started in Cincinnati.

Mr. PERRY F. NURSEY said, it occurred to him that there was one point in connexion with steam fire engines the importance of which had not been sufficiently dwelt upon, namely, the getting up of steam quickly. He had recently taken some pains to collect information with regard to the efficiency of peat as fuel. He believed the condensed peat made under Buckland's patent would be found to possess every quality necessary to constitute a fuel adapted for steam fire and other engines. The cost did not exceed that of coal at the pit's mouth; it had been found in repeated trials to generate steam in half the time, and would do double duty as compared with coal. The absence of smoke and of clinkers were additional advantages. The only alteration necessary to its use in furnaces constructed to burn coal was that the fire bars would require to be made with lesser spaces between them,

Mr. LEE thought too much importance was attached to the fuel used in a steam fire engine, as from the amount of blast that could be obtained, either wood or the hardest coal could be used. The question of getting up steam quickly depended upon the quantity of water there was to heat; he, in the first instance, used three minute boilers, and found no difficulty with them; he had seen water thrown from an engine having one of these boilers in 3 min. 10 sec. It was found, however, that these boilers were rather sensitive, and that there was a difficulty in keeping the water at the proper height, and it was also found that these boilers were not required. He afterwards tried six minute boilers, then eight minute, and lastly twelve minute boilers, which were found to be quick enough, and were less liable to accident when left in unskilful hands. With reference to self-propelling fire engines, he had made several, and found no diffi-

culty in steering them, and could travel at any speed in the streets, faster and with greater safety than any engine drawn by horses; they could be easily turned from one street into another by one man, with perfect accuracy.

Mr. ROBERTS, in reply, stated, that he would endeavour to answer each speaker as briefly as possible. First, with regard to Mr. Humphreys, he begged to say that it could not be gathered from the report that the tubes were brass. Mr. Humphreys objected to the word *destructive* action, and stated it should have been *galvanic* action that took place between the iron shell, the copper pockets, and the tubes; but having lately seen a $\frac{3}{8}$ in. iron plate quite destroyed where it was in contact with copper, in less than four months, he still thought destructive a proper word. With regard to hose reels, he would simply say that Shand's was the only engine made to carry its hose upon a reel, and as it did not have the reel it could not be complete, but with regard to the steam being *bottled up in the boiler*, he did not consider Mr. Humphreys's explanation satisfactory, as they had to so urge the boiler that at times the chimney was nearly white hot and the flames nearly a yard above the top. With regard to the pressure gauge, Mr. Humphreys states that by looking at it they could see, minute by minute, that the engine was doing double the work of either of her antagonists. He (Mr. Roberts) had paid particular attention to the water pressure, having more faith in that than the quantity of water delivered into the tower. In consequence of the wind, during the whole time Shand's small engine worked in his presence, the water pressure never exceeded 70 lb. per inch with a $1\frac{1}{8}$ in. jet, and 60 to 65 with a $1\frac{1}{4}$ in. jet; this was exactly the same as the "Alexandra," and a trifle more than the "Torrent," as that kept 60 lb. with a $1\frac{1}{8}$ in. jet, and the "Princess" kept from 75 to 80 lb. with a $1\frac{1}{4}$ in. jet, and this, too, with a *half yard of canvas* under the lower bucket, while Shand and Co.'s engine was quite disabled by a *few pieces of shaving*. Mr. Humphreys had given some figures to show that several of the pumps had areas only equal to half the cylinder, and claimed as a superiority for Shand's engine that the area of their pump was only one-fifth less. He (Mr. Roberts) had no doubt that was the *secret of the bottling up of the steam*; the

areas of pumps and cylinder being so nearly equal, a very much greater pressure of steam had to be kept, nearly two to one, and in the engines having the pumps of half the capacity of cylinder, steam and water were nearly equal, and in some of the American engines, where the pumps were only about one-fourth the area of cylinders, the water pressure frequently rose above the steam; he ventured to say that had the wind been blowing when Shand's engine was tried, as it did when the others were, instead of being a dead calm, the state of the figures would have been at least reversed. Mr. Humphreys had very properly described the action of Shand and Co.'s engine as *snatching* at the water, when it is remembered that the pump is a single acting lift, and *snatches* up as much water with the up stroke as it delivers with up and down—in other words, a column of water (if the suction hose is $3\frac{1}{2}$ in. diameter) of 53 in. high is started, and stopped at every stroke perhaps 150 to 200 times a minute, he thought it would be seen that it carried an element of destruction that must very quickly bring it to grief. With regard to his (Mr. Roberts's) pump being like Shand's: first, a glance at the drawings would show that there was no similarity whatever, as in Shand's the buckets were not placed over each other, and the angle made by the connecting rods was from 40 to 45 deg., and in the author's pump the buckets were placed quite over each other, and the angle made by the slings never more than 2 deg. One word more: a glance at the drawings would show that his (Mr. Roberts's) engine was as direct acting as Messrs. Shand's, the only use of the shaft in his being to work the slide, while Messrs. Shand's had to work their feed pump in addition. With regard to Mr. Olrick's remarks, he would not attempt to follow him through all of them, but there was no doubt if the wind had not blown at all during the trials, but had been as quiet as it was when Messrs. Shand's small engine was tried, that the trials would have been of infinitely more value than they were; but the wind did blow, and that with a continually varying force. To show the effect of the wind he might state, that Shand's large engine threw in the first hour into the tower $20\frac{1}{2}$ in., his (Mr. Roberts's) engine the same exactly; the second hour the wind did not blow so much for Shand, and the engines delivered

25 in., and the reverse having taken place during his (Mr. Roberts's) second hour he only delivered $15\frac{3}{4}$ in. With regard to the injector, perhaps Mr. Olrick had not much experience in the working of it. He (Mr. Roberts) had two at work for months, sometimes they would go well for weeks and then fail, and for hours give trouble, and then go on again; he had tried several others, and must say that for small boilers and very high pressure he would not trust them, but always fit pumps. With regard to the complication of gear to drive the slide rods, Mr. Olrick stated that there were only four pieces to drive the slide valve in the "Torrent," and nine in his (Mr. Roberts's). The author, by referring to the diagrams, showed there were nine pieces in his engine, including the slide valve, and no less than *fourteen* in the "Torrent" instead of *four* only, besides this the small valve *v*², fig. 2, is started with a jerk, when the adjustable stops upon the disc *s* come in contact with the tongued lever *t*, thus, as before stated, going back to the tappet motion; besides this there are the extra ports and cocks for cushioning, without which this class of engine would not work an hour, but which is all unknown in the author's engine. There were only two other remarks of Mr. Olrick's he would notice: first, Mr. Olrick stated the "Sutherland" was the only engine that lifted the water the 18 feet lift; this was quite incorrect, as several others did it, among them the author's engine, although it had the piece of canvas in it; the other, that the pumps should have long strokes and moderate velocity, but how did his pet engine answer in these points? The stroke of the "Sutherland's" pumps was 2 ft., this, with 80 double strokes per minute, gives a speed of 320 ft. per minute, and his pump $3\frac{3}{8}$ inch stroke with 200 strokes, gives a speed 104 ft. per minute, or about $\frac{1}{3}$ the speed of the "Sutherland." This would also apply to the remark of Mr. Young, who said he was convinced that a slow, steady, reciprocating motion is the right thing (and leaving out the next sentence, he says), the slow speed of the pumps is important, as it gives a full pump, and is especially valuable in using (as frequently happens) gritty or sandy water, and *the higher the speed at which the engine is run the more necessary does the slow motion become.* All this he (Mr. Roberts) fully agreed with, and, as in all the engines tried, the speed of pistons and the speed of pump

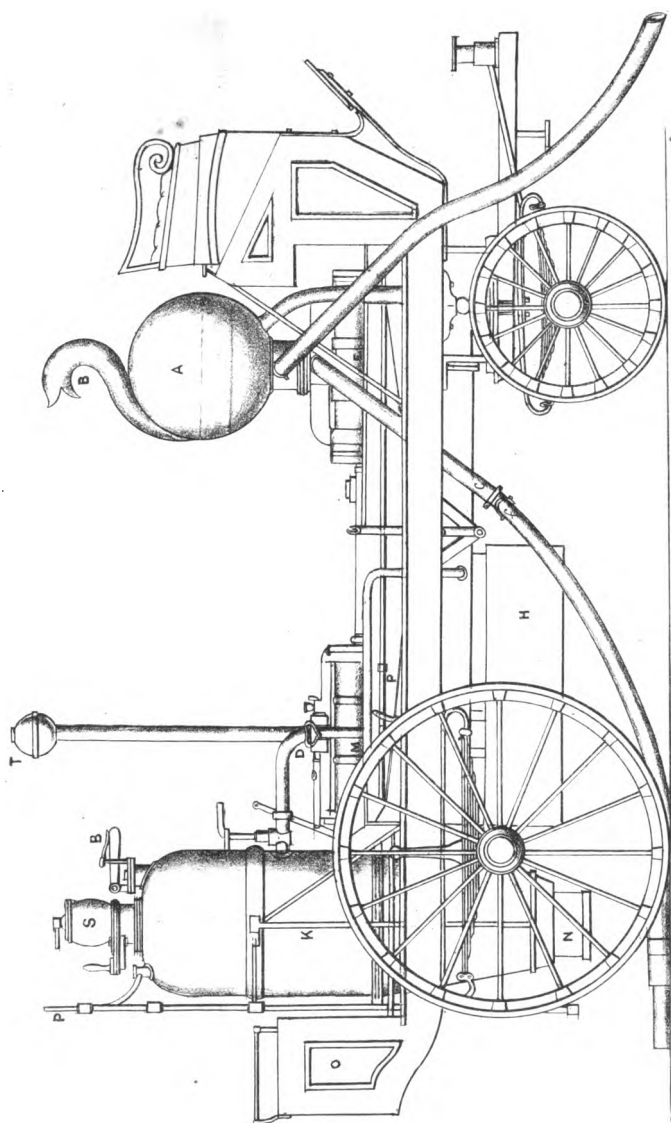
plungers was the same, except the author's engine, in which the stroke of pumps bucket is not quite one-fourth of the piston, he must conclude that Mr. Young was alluding to his engine ; although he does not approve of crank or fly-wheel, he thanked Mr. Young for giving the correct time of getting steam by his (Roberts's), 10 min. ; Merryweather, 10 min. 15 sec. ; Shand, 11 min. 45 sec. ; Easton and Amoss, 16 min. ; and Lee, 17 min. With regard to Mr. Field's boiler, he had no hesitation in saying he considered it a first-rate boiler, but was afraid a careless stoker might break off some of the tubes, and he must say he preferred his own, because it got steam quicker and kept it more steadily, there appeared a more perfect combustion, and there was no fear of the tubes being injured, besides which it had perfect circulation and no priming. With respect to Mr. Lee's remarks upon self-propellers, he had no hesitation in saying he could go quite as safely at 18 or 20 miles an hour as horses could be driven at 12.

The CHAIRMAN said that he thought Mr. Roberts deserved the thanks of the meeting for a very carefully prepared paper, which had been listened to with attention ; he thought that care had been taken with the paper, and likewise with discussion, to avoid personalities ; it had been hinted that the class of paper was objectionable on account of the inducement offered to indulge in deprecation of one manufacturer's machine as compared with another's, thereby leading to personalities, so desirable to be avoided—this class of paper certainly allowed opportunities for this, as had been too distinctly shown during some parts of the discussion, but still the Chairman was of opinion the good such papers did to the society, and their importance generally to the profession, much counterbalanced any evil resulting from the ebullition of feeling on the parts of those interested in the different machines which the society had under discussion, and he felt assured the good practical sense of the members would always avoid extremes and disagreeable personalities in discussion on this class of paper. As far as the paper and discussion went, it certainly tended to show the great difficulty the committee at the Crystal Palace had to contend with in determining the most efficient machine ; but there was nothing brought before the society that tended to

upset in any way the judgment of the committee: that the committee were gentlemen, who would give a most fair and impartial judgment, he thought no member of the society for a moment could doubt. Some members had asserted that the American engine had not been fairly dealt with, in fact, that the accident to the "Manhattan" was intentional; he would not allow that any body of Englishmen, more particularly those connected with the engineering profession, would be guilty of such highly disreputable, and reprehensible conduct, he believed such statements utterly groundless. In conclusion, the Chairman stated that he hoped this discussion would lead to good results, in the profession turning their attention to making a more perfect steam fire engine than had yet been produced.

THE END.

C. WHITING, BEAUFORT HOUSE, STRAND.

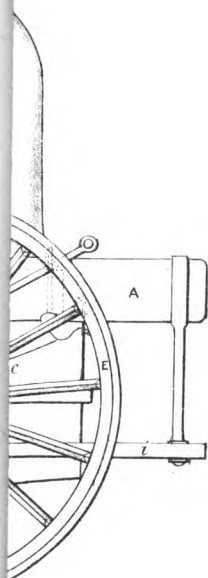


BRAITHWAITE & ERICSSON'S STEAM FIRE ENGINE. 1829.

E. AND F. N. SPON, RUCKLESBURY, LONDON

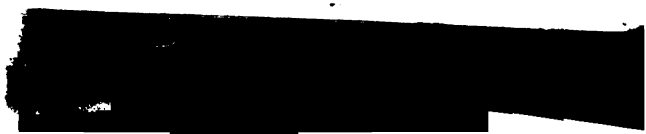
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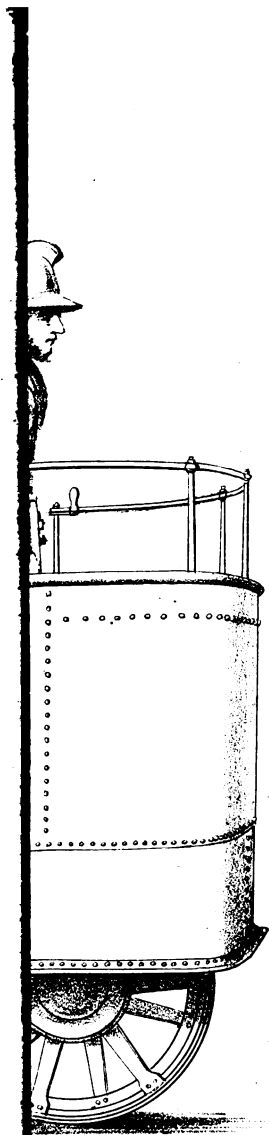
Nº 2.



E, 1858.

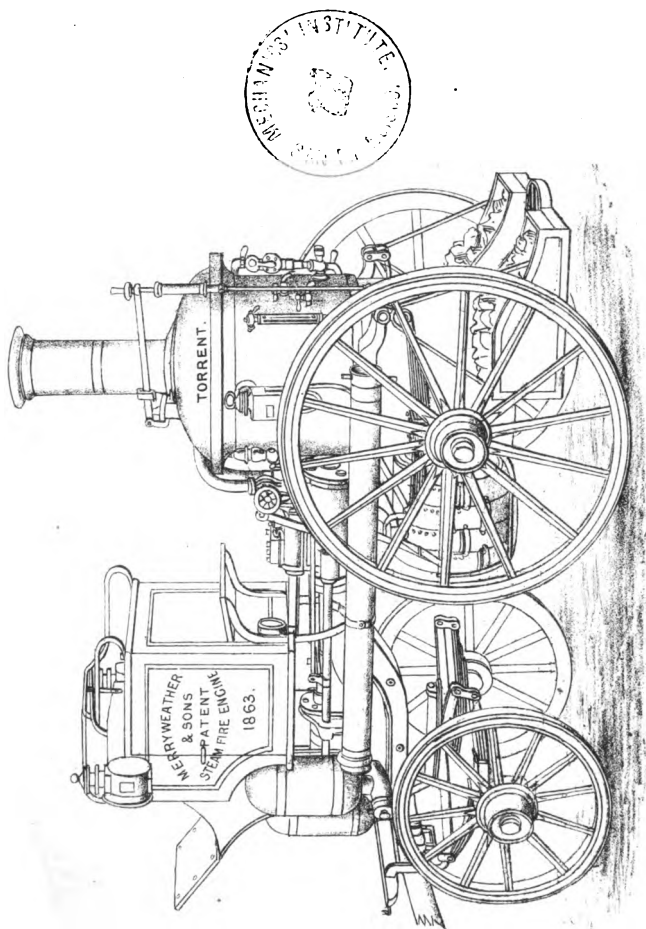
Uplfield Green, Litho





Upfield & Herr, Lith.





MESSRS MERRYWEATHER, SONS & FIELD'S LIGHT STEAM FIRE ENGINE "TORRENT."

E. AND F. N. SPON, BUCKLESBURY, LONDON

Lloyd Green, Litho.



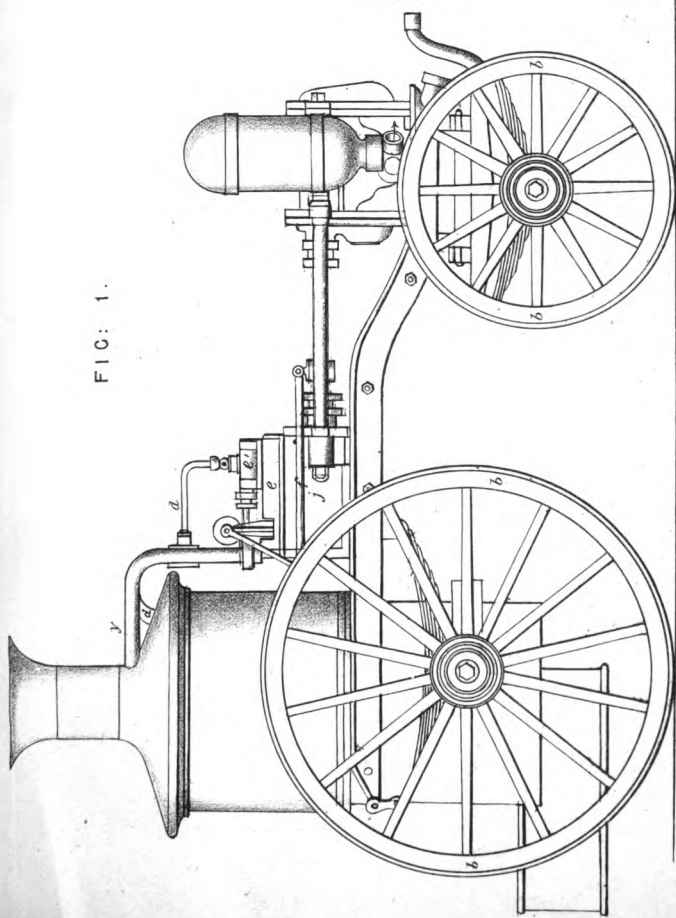
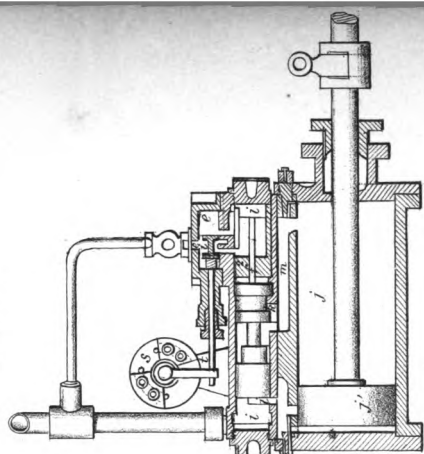


FIG. 1.

FIG. 2.



SECTION OF CYLINDER.

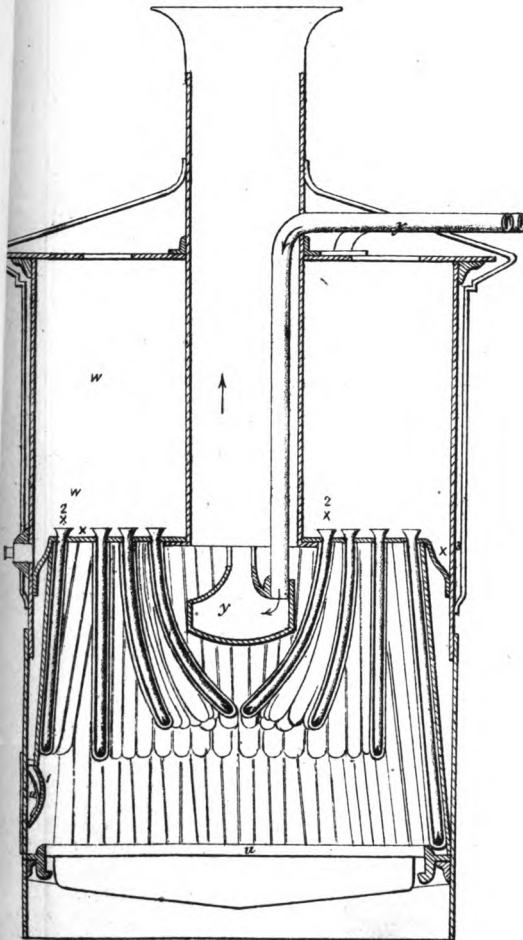
MESS^{RS} MERRYWEATHER, SONS & FIELD'S PATENT STEAM FIRE ENGINE "TORRENT".

E. AND F. N. SPON, BUCKLESBURY, LONDON.

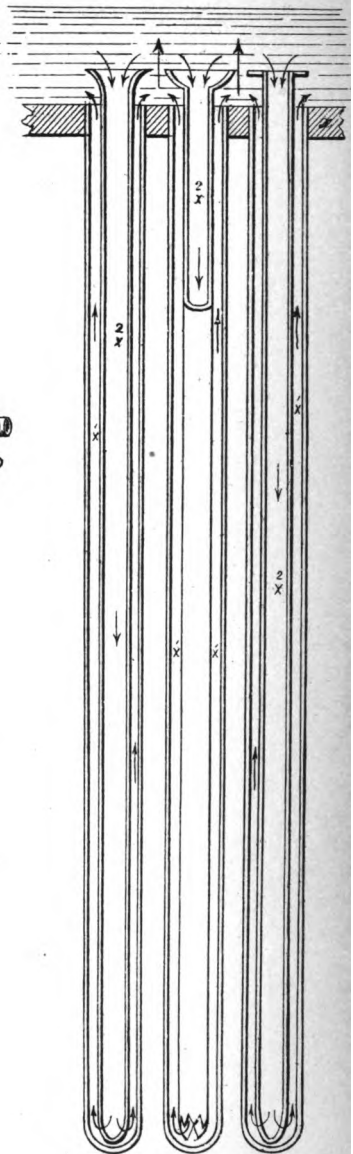
Typical Green Litho.

FIG: 4 .

FIG: 3.



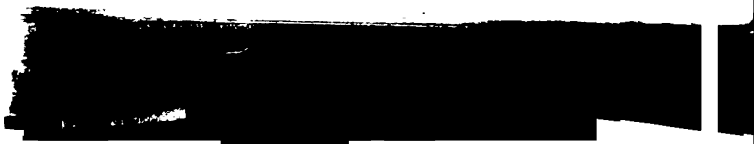
SECTION OF BOILER.

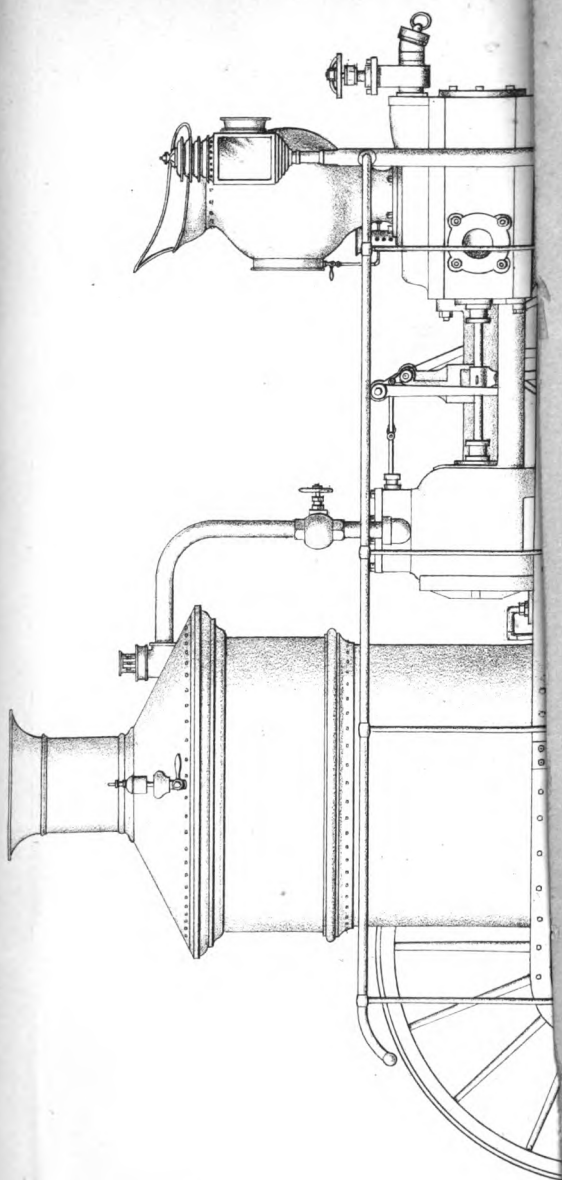


ENLARGED VIEW
OF BOILER.

E. AND F. N. SPON, BUCKLERSBURY, LONDON

Upfield Green, Litch



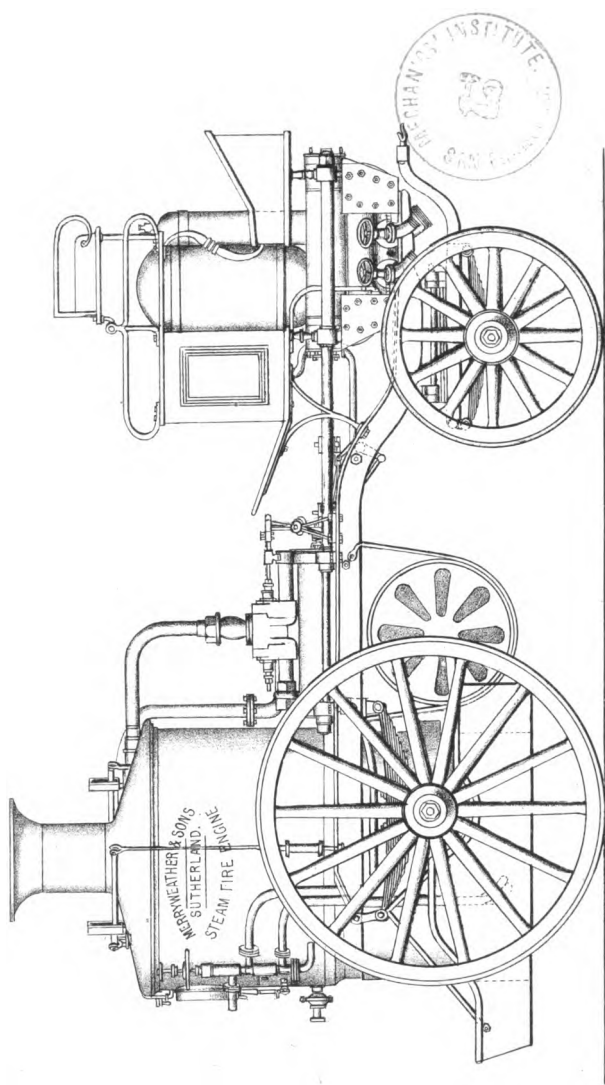


MESSRS. MERRITT, WEAVER & SONS' STEAM FIRE ENGINE, "SUTHERLAND".

E. AND F. N. SPON, BUCKLESBURY, LONDON.

Lytfield Green, Litch.





MESSRS MERRYWEATHER & SONS' STEAM FIRE ENGINE, "SUTHERLAND".

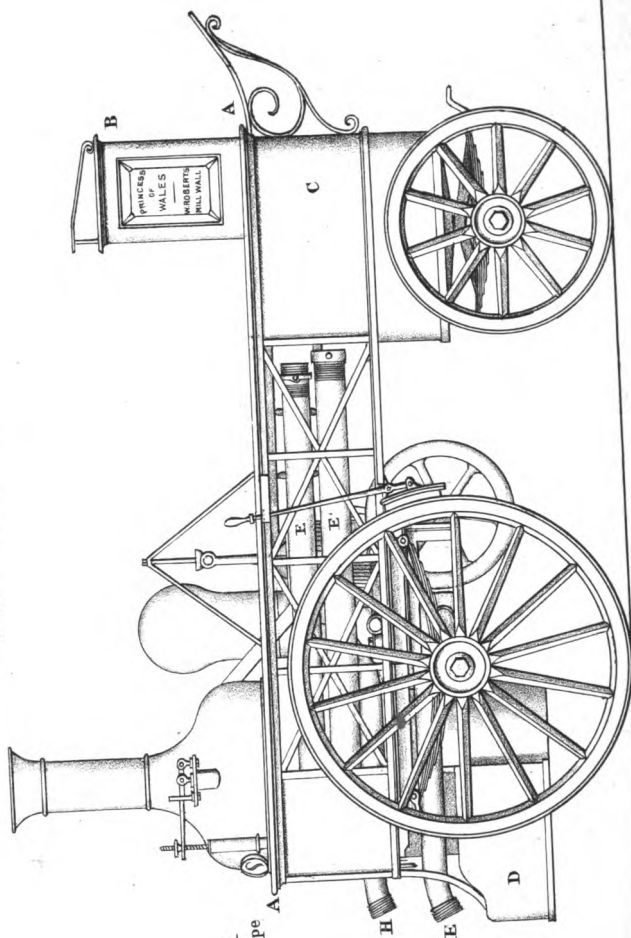
L. & CO. LONDON

Typical Green, Litho



W. ROBERTS' PATENT STEAM FIRE ENGINE.

SIDE ELEVATION.

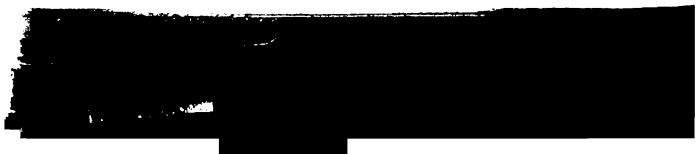


REFERENCE.

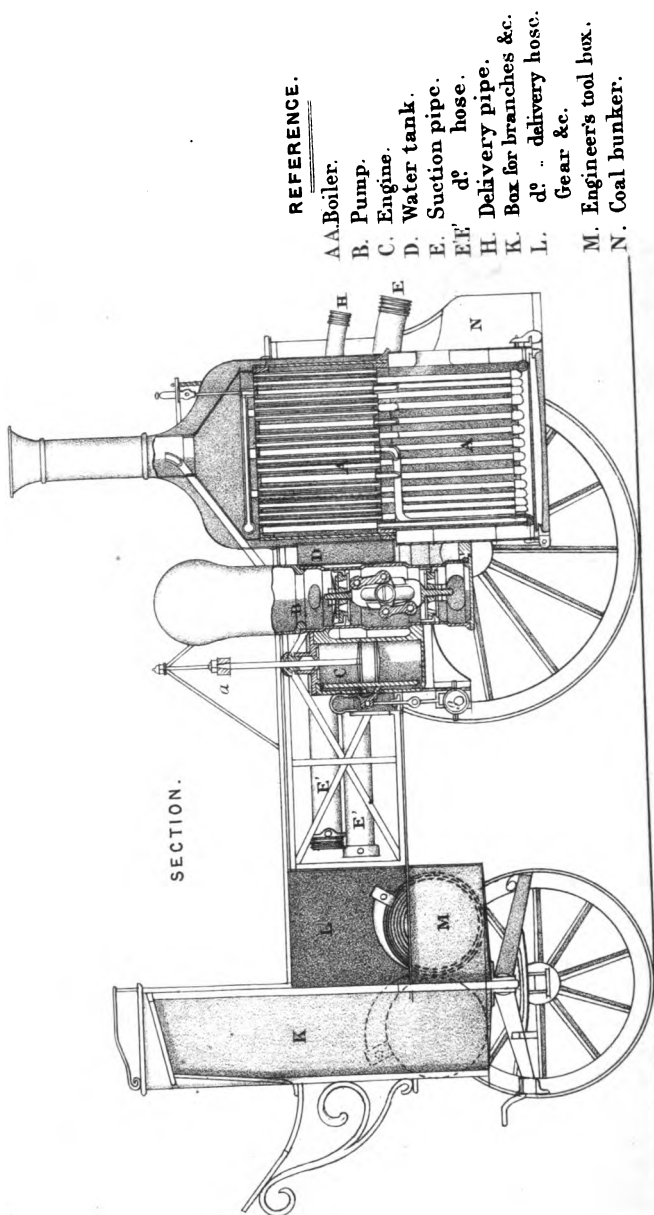
- A. Fireman's Seat.
- B. Driver's Seat and box for branch pipe &c.
- C. Box for hose buckets &c.
- D. Coal bunkers.
- E. Suction.
- E'. Suction hose.
- H. Delivery.

Upfield Green, Litho

E. AND F. N. SPON, BUCKLESBURY, LONDON.



W.ROBERTS' STEAM FIRE ENGINE "PRINCESS OF WALES."



Upfield Green, Litho.

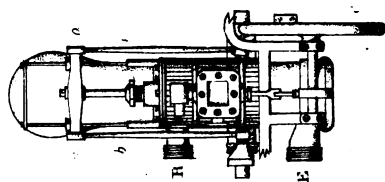
E. AND F. N. SPON, BUCKLESBURY, LONDON.

W. ROBERTS' PATENT STEAM FIRE ENGINE.

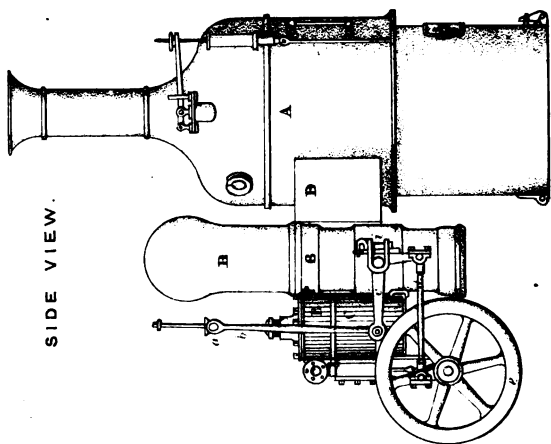
1871

ENGINE & PUMP.

END VIEW.



SIDE VIEW.



REFERENCE.

- A. Boiler.
- B. Pump.
- C. Steam Cylinder.
- D. Water Tank.
- E. Flywheel.
- F. Delivery Pipe.



N^o 12.



VERTICAL SECTION OF MESS^{rs} SHAND & MASON'S PATENT STEAM FIRE ENGINE.

E. AND F. N. SPON, BUCKLESBURY, LONDON.

Litho. Green, Litho.

4



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