INSTITUTION
OF
CIVIL ENGINEERS.

SESSION 1846.

SPECIAL GENERAL MEETING OF MEMBERS.

January 6, 1846.

SIR JOHN RENNIE, President, in the Chair.

The summons was read for convening the meeting, in conformity with clause 3, section 13, of the Bye-laws and Regulations, for the purpose of considering and deciding on certain proposed alterations in several of the clauses of the existing Bye-laws and Regulations of the Institution.

The clauses from section 1 to clause 11 in section 3, were separately discussed ; the proposed alterations were approved, and ordered to stand as part of the Bye-laws, and the meeting was adjourned until Tuesday evening, January 27th, for the consideration of the remaining clauses.

January 13, 1846.

SIR JOHN RENNIE, President, in the Chair.

No. 730. Description of the Machinery erected by Messrs. Maudslay, Sons, and Field, at the Minories Station, for working the London and Blackwall Railway. By Andrew John Robertson, Assoc. Inst. C.E.

Before entering upon the immediate subject of the paper, it will be necessary to give a general sketch of the railway, for the working of which the machinery in question is employed, and of the system upon which it is worked.

The London and Blackwall Railway is about $3\frac{1}{4}$ miles in length,

and is worked by stationary engines of the estimated force of 448 H.P. and 280 H.P.,* at the London and Blackwall termini respectively; the carriages being attached by grips to a rope, which is wound off and on to large drums situated at each extremity of the line. The greater power is required at the London station, in consequence of there being a total rise in the railway, in this direction, of between 60 and 70 feet;† the steepest inclination being 1 in 100. There are seven intermediate stations on this line; the Poplar, West India Docks, Lime-house, Stepney, and Shadwell stations, communicate with the Fenchurch-street terminus; whilst those of the Minories, Cannon-street, Shadwell, and Stepney, communicate with the Blackwall terminus. This arrangement is effected by appropriating a separate carriage from the termini for each intermediate station, communicating with the same; these are detached whilst the trains are moving, and by means of brakes they are stopped at their respective destinations; as soon, however, as the terminal train arrives at either end of the line, and the rope ceases its motion, these intermediate carriages are attached to the rope, whilst it is in a state of rest; so that when the engines are again started, the carriages are also simultaneously set in motion, and arrive successively at the termini, in the order and at intervals corresponding with the position of the places from which they started; as they arrive they are released from the rope, though in motion, by the sudden withdrawal of the grip iron, and then their momentum carries them forward to their proper places in the station. It will be perceived, that the intermediate traffic is by this means provided for, without causing any detention to the through trade.

The peculiar mode of working the line, and the circumstance of so many carriages being attached to the rope at different places, rendered it absolutely necessary to provide some quick and certain system of signals between the termini and the intermediate stations. These objects being deemed attainable by means of the electric telegraph, that system was adopted, although it was of greater extent than any which had been previously tried, and it was executed by Mr. Cooke, one of the patentees. The telegraphic wires are enclosed, for security, within welded iron pipes, with screwed joints

* The nominal power of these engines is, 224 H.P. for each pair at the Minories; and 140 H.P. for each pair at Blackwall. There are duplicate engines at each station, making 448 H.P. at the Minories, and 280 H.P. at Blackwall.

† 68 feet; average inclination, 1 in 248.—Whishaw's 'Analysis of Railways.'

like gas pipes ; there is a duplicate set of such wires and pipes, in case of one set being accidentally fractured. One pipe runs along each side of the railway throughout its length.

The machinery at the London end, for working the railway, is situated at the Minories station. The carriages in coming towards London are disconnected from the rope, a little before they arrive at the Minories, and they perform the rest of the journey to the terminus in Fenchurch-street by their momentum. The upward inclination of the rails at this place is 1 in 150.

When the down train leaves the terminus in Fenchurch-street, it descends the incline to the Minories by its gravity, where it is stopped by the brakes, to allow of passengers being received at that station, and to permit the attachment of the rope ; there the train remains for a short time, until signals have been received by the electric telegraph, from each of the intermediate stations, that the carriages are ready for starting, and are properly attached to the rope, in the manner already described. It being thus known at the Minories that all is ready, the signal for starting is sent from thence to Blackwall ; the engines there are then put in motion and begin to draw the rope with all the carriages towards Blackwall.

At the same time that the down-train leaves the Minories, the up-train leaves Blackwall. The arrangements being similar to those above described, the train runs by gravity from the Blackwall station to beyond the engine house, where it is stopped by the brakes, in order to attach it to the rope, and as soon as signals have been received at Blackwall, from each of the intermediate stations, that all is ready, the signal for starting is sent from Blackwall to the Minories, and the engines there are put in motion, and begin to draw the rope and all the carriages towards London. The machinery at the Blackwall end is situated a little way along the line from the terminal station ; the distance from thence to the place where the carriages going to Blackwall are disconnected from the rope, being somewhat farther from the station than the engine house, and the carriages run that distance by momentum, in the same manner as at the London end ; the rise towards the Blackwall station being there also 1 in 150. During the winter the railway is worked from half-past eight o'clock in the morning until nine at night ; and in the summer, from eight o'clock in the morning until ten at night. A train leaves each end every quarter of an hour,* the whole time occupied in passing between the termini is thirteen minutes ; but

* Giving in winter 51 trains, and during summer 57 trains, per day.

the engines are at work only from eight to nine minutes. The engine house at the Minories is situated beneath the railway. It is 48 feet long by 72 feet wide, and the extreme length, into the recess in front of the drums is 69 feet. The rails are carried over the machinery on cast iron girders, which are supported at two intermediate points by cast iron pillars. The flooring over the engine house is carried in like manner upon girders.

Beneath each line of railway there is a large drum for the rope, and on the axis of each drum is a mortice spur wheel, which is driven by another iron spur wheel of larger diameter, on a prolongation of the axis of the cranks of the steam engines; the prolongation forming a line of shafting which extends all across the engine room, with a pair of engines at each of its extremities. Only one pair of engines is worked at a time, the other pair being disconnected at the cranks. Under ordinary circumstances one pair is worked for about six weeks, and then the other pair for a similar period; the object being to secure the traffic from interruption, by having a duplicate pair of engines always ready to be connected at all emergencies and in case of any accident happening to the other pair, as well as to give time for the ordinary cleaning and repairing of that pair of engines which is not at the time in use. When one pair of engines is connected to the axis of the two large spur wheels the other pair must be disconnected from it. This is done by removing the pin of the crank on the extremity of the said axis, and also removing the drag-link, by which that pin is connected with the pin of the engine crank, on which latter pin the connecting rod is jointed. The rope on one line must be wound up round its drum, whilst that on the other line is allowed to unwind from off its drum, so that the two drums will revolve in contrary directions. The trains travel alternately backwards and forwards on the same line of rails, instead of one line of rails being always travelled over in one direction and the other line in the contrary direction, as is the case on other railways. For instance, if the first train in the morning goes down from London to Blackwall along the north line, the second train down in the same direction will go along the south line, and the third train down along the north line, and so on. One end of each rope is wound around one of the drums at the Minories, and the other end of the same rope around a corresponding drum at Blackwall; and whenever one of those drums is turned round by its engines for winding up that end of the rope, the drum at the other end of the same rope must be disconnected, and left free to turn round as the rope is pulled off it.

This requires some ready means of disengaging either of the drums from the engines, which is done by withdrawing the pair of spur wheels from each other until their teeth become disengaged. The plummer blocks, in which the two ends of the axes of each of the drums revolve, are mounted on rollers, and are capable of being moved horizontally by screws, until the spur wheels are out of gear. The two screws for the plummer blocks of the same drum, are moved simultaneously by gearing, worked by a handle on the platform in the recess in front of the drums; so that a man, by turning that handle, either connects or disconnects the gearing, as may be required.

The main axis upon which the two large spur wheels are mounted, may be considered as a single axis, but is, in fact, two lengths of shaft, connected together by cranks and drag-links at the mid-length of the prolonged axes, which two lengths can be disconnected at pleasure, by removing the drag-links and the crank pins. Hence there are two sets of machinery exactly similar, and capable of being connected and disconnected in such manner, as to admit of either of the two drums being worked by either of the two pairs of engines, whilst the other drum is wholly disconnected; each line can thus be worked by either pair of engines, independently of the other line or pair of engines. The engines always revolve in the same direction, causing the drums to wind up the ropes around them; but when the drums turn round in a contrary direction for unwinding the ropes, they are disconnected from the engines. A wheel is attached to each drum for the purpose of being acted upon by a brake, not only for stopping the motion of the drum, after the arrival and stoppage of the down train at the Blackwall end of the line, but also for maintaining a suitable degree of tension on the part of the rope behind the train, whilst it is in motion. The object of keeping the tension on the rope is to prevent it from being unwound from off the drum, faster than the train proceeds, and to secure the rope against the risk of breakage, to which it would be liable, if it were allowed to become slack and then to be suddenly tightened, by the acceleration which takes place in the motion of the train, after it has commenced the descent of a steeper gradient than that on which it was previously travelling.

The engines being only worked for eight or nine minutes out of every quarter of an hour, the vacuum in the condenser might during the remaining six or seven minutes become imperfect from leakage, or from air contained in the injection water; in which case the re-starting of the engines would be difficult, except by previously

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blowing steam through the condenser to displace the air,—for the greatest power is required at starting, when the machinery, the drums, the rope, and the train, have all to be set in motion from a state of rest, and there must be a good vacuum in the condenser to enable the engines to start promptly. For this object an engine of 12 H.P. is provided, and constantly works two auxiliary air pumps, which maintain the vacuum in the condensers of the large engines, independently of the action of their own air pumps.

In the arches upon which the railway is carried to pass over the engine-house, eight water-tanks are placed, all connected together by pipes. The overflow of waste water from the hot cisterns of the engines, is conducted from the usual overflow pipe into the most distant of the eight tanks. From that tank the water passes into the next, and then to the next, and so on to the last of the eight tanks, in which it is mixed with fresh cold water, and the mingled water is then conveyed into the engine-room, for supplying the injection cocks of the engines. The surface of the water in the eight tanks is exposed to the atmosphere, and the hot water thus becomes cooled in passing through them. At first there were only three tanks, in which, as they exposed a large surface to the air, it was expected the cooling of the water would proceed with sufficient rapidity to render it fit for injection upon arriving at the third tank, and being there mixed with fresh cold water; but, as it was found that there was not a sufficient cooling effect, five more tanks were added, and the eight tanks now in use are scarcely sufficient for cooling the water to the extent required. The supply of cold water, for mixing with the water in the eighth tank, is pumped by the 12 H.P. engine from a well in the adjoining part of the building, and, in addition to this supply, a small pipe is laid on from the main of the New River Company. The temperature of the injection water in summer is about 80° , and often higher, and the vacuum then obtained is about 24 inches of mercury; in winter there is no difficulty as to the temperature of the water, and the mercury stands at from 27 inches to 28 inches. Each of the tanks is $24\frac{1}{2}$ feet square and 6 feet deep, so that the capacity is 3600 cubic feet, and the surface of water exposed is 600 square feet in each tank.

The steam pipe from the boilers passes through the wall, and is carried inside the engine-room to the right and left to each pair of engines, with a valve-box, from which two branches proceed to supply each engine. The valve in the box is opened and shut by a screw, worked from below by a handle, by which the engine-man regulates the speed of the engines.

The governor is placed beyond the outer frame of the pair of engines, and the number of its revolutions is to the number of strokes made by the engines as 3 to 2. It is worked from the crank of the engines by a pair of bevil wheels on a small axis passing through the outer frame. The governor acts upon a throttle valve placed in the steam pipe, immediately beyond the shut-off valve. The resistance the engines have to overcome varies so much, that the governor was found not to be capable by itself of regulating the speed, and therefore it was assisted by the man closing the shut-off valve by its screw handle; but latterly the governor has been disconnected, and is not now used.

To avoid snatching the rope, by which it might be broken, great care is taken to start the engines as gradually as possible, in order that all the slack of the rope may be gathered up around the drum, and then the train be started slowly and gradually accelerated to the full speed. The valve is therefore only partially opened at first, and is afterwards opened fully by degrees; as the engines acquire speed, the valve is closed again gradually, to restrain the speed, as the carriages arrive one after another, and the resistance diminishes.

The boiler house is beneath the railway, the five boilers being placed under the arches on which the continuation of the railway is carried beyond the engines. Two of them are square marine boilers, with the ordinary internal furnaces and rectangular flues; the other three boilers are constructed on the Cornish system, being circular, with two internal tubes through their entire length, and the furnaces in the front ends. The two marine boilers, which are equal in power to the three Cornish boilers, are capable of supplying steam for one pair of engines. The two marine boilers, or the three Cornish boilers, are worked together as a set, the two sets being used alternately in the same manner as the engines, but for about three months at a time. The chimney is situated between the two sets of boilers. The flue from each separate boiler, enters into a main flue, which extends along the back of each set to the base of the chimney; each is provided with a separate damper, and there is another damper at the end of each main flue, where it joins to the base of the chimney.

On the top of the steam chest of each boiler is a shut-off valve box, joined by a branch to the main steam-pipe, which leads to the engines. By these valves, any boiler may be shut off from the rest, in case it is required to be cleaned whilst the others are at work. At the mid-length of the steam pipe are two safety-valve boxes, each having an aperture of 12 inches diameter; they communicate with

each other, and from one of them a discharge pipe proceeds into the chimney; one of these safety valves is out of the control of the men, but the other may be lifted by means of a lever worked from below, in order to discharge the steam at the end of the day's work.

The feeding of the boilers is effected from a tank situated above the arches, at the side of the chimney, at such a height as to give the column of water entering the boiler a greater pressure than that of the steam. This feeding tank is 10 feet in diameter, by 6 feet high, and is capable of holding 471 cubic feet of water. The water is raised into this tank by the pumps of the engines, and feed pipes proceed from the tank to the feed cocks in the pipes, at the front of the several boilers. During the time the engines are at work, no water is admitted to the boilers, but as soon as they are stopped, the feed cocks are opened, and the water is allowed to flow in until the proper level is restored. At the same time a fresh supply of coals is thrown on the fires, to raise the steam for starting. This is so managed as to waste very little steam by blowing away at the safety valve.

The chimney is 6 feet square inside, at the base, and 4 feet 3 inches diameter at the top, and is 164 feet high from the foundation. The draught is exceedingly good. The spaces opposite to the row of furnaces of the five boilers are stores for coal. Beneath the centre of the passage, in front of the row of furnaces, is the drain for carrying off the waste water.

The steam-engines, of 112 H.P. (nominal power) are on the marine construction, with side levers, the same as Messrs. Maudslay, Sons, and Field made for steam-vessels a few years ago. That construction was adopted, as it was requisite that the centre of the shaft should be elevated. The diameter of the cylinders is 56 inches; the length of stroke is 5 feet; and the average number of strokes is 22 per minute. The motion of the piston is therefore 220 feet per minute. The plunger feed pump is $6\frac{1}{2}$ inches diameter, and 2 feet 6 inches stroke; only one pump is worked at a time. The cranks are all of cast iron, with axes of wrought iron, 12 inches diameter in the bearings.

The large spur wheel on the main axis is 17 feet in diameter at the pitch line, with 120 teeth; the pitch of the teeth is $5\frac{1}{4}$ inches, and their breadth is 23 inches. The centre boss of this wheel consists of two circular pieces bolted together externally, including between them, and closing over the roots of the arms, which are eight in number, cast separately, and bolted to one another, and to the boss. The rim is in eight segments, each having 15 teeth, and the junctions of the

segments are made at the ends of the arms. The weight of the wheel is $16\frac{1}{2}$ tons; that of the rim by itself being 8 tons 13 cwt. The drum is 23 feet in diameter outside, and $16\frac{1}{2}$ feet in diameter at the bottom of the V shaped groove, wherein the rope is coiled. The width of this part, at the bottom, is 1 foot 6 inches, and at the top 3 feet 2 inches; when all the rope is wound on it, the diameter of the outside coil of the rope is 20 feet.

The brake wheel at the side of the drum is 14 feet in diameter, and 1 foot broad.

The mortice spur wheel, on the axis of the drum, and at the same side as the brake, is 11 feet in diameter at the pitch line: it has 78 cogs, which are also 23 inches broad.

Although the drum, the brake wheel, and the mortice wheel, have hitherto been mentioned as separate, they are in fact all framed together so as to form one combination. The total weight is 30 tons. The axis of the drum is of wrought-iron, 12 inches diameter in the bearings. The cogs of the mortice-wheel are made of hornbeam.

The brake is formed of two straps of wrought iron, side by side, each 5 inches wide, to which are rivetted plates of copper in lengths of 3 feet each, 12 inches wide and $\frac{3}{4}$ inch thick; the copper applies to the lower half of the circumference of the brake wheel. One of the extremities of the brake is suspended by rods from the girder above, and the other end is connected to the hoop around an eccentric wheel, the axis of which is mounted in a frame fixed to the girder. On the axis of this eccentric wheel is a spur wheel, into which a pinion works, and on the axis of the pinion is a ratchet wheel, to be worked by a lever handle and click, by a man standing on the platform over the engine room, the handle end of the lever passing up through the platform. The length of this lever handle is 6 feet; the diameter of the pinion is $11\frac{1}{2}$ inches, and that of the wheel is 16 inches; the eccentricity of the eccentric wheel is $2\frac{1}{4}$ inches. Hence the force of the man's arm applied at the upper end of the lever handle is multiplied about 36 times,* when the leverage is the least—namely, when the eccentric wheel has made a quarter of a revolution; but for obtaining a greater power on the brake, a piston is fitted into an air cylinder 10 inches in diameter, which is fixed under the girder; one end of the cylinder is open to the atmosphere, and the other is closed, but communicates by a pipe with the condenser of the steam engine

$$* \frac{72 \times 16}{2.75 \times 11.5} = 36.4$$

below. In this pipe is a cock, which can be opened by the brakesman when necessary; a chain connected to the rod of the piston of the air cylinder, is carried round the spur wheel and fastened to it. If the brakesman opens the cock to establish a communication with the condenser, the air is exhausted from the air cylinder, and the pressure of the atmosphere on the area of the piston acts by the chain on the circumference of the wheel. Supposing the vacuum to be 27 inches of mercury, this pressure is 1,060 lbs., equivalent to about 100 lbs. applied to the upper end of the lever handle.

Each of the moving plummer-blocks, in which the drum shaft revolves, is mounted on six rollers; three on each side. Beneath the plummer-blocks and attached to it, in the space between the rollers, is a long nut in which a screw 3 inches in diameter works; the pitch of this screw is such as to move the nut and the plummer-block 3 inches by seven revolutions. The axis of the screw is prolonged by a shaft to reach to the platform, and this prolongation has on its end a bevil wheel 2 feet in diameter, into which works a bevil pinion 6 inches in diameter; the cross axis of this pinion extends across the breadth of the drum, parallel to its axis, and carries another such bevil pinion of 6 inches diameter, which acts in another bevil wheel of 2 feet diameter, on the prolongation of the axis of another screw beneath the plummer block, for the other end of the axis of the drum. By this connexion both screws are turned round simultaneously and act on both plummer-blocks alike. On the cross axes of the two bevil pinions is a cog wheel 2 feet in diameter, into which works a pinion 16 inches diameter, on the axis of which is a winch handle, so that to produce one revolution of the screw the winch handle must make six revolutions. The thread of the screw making seven turns in 3 inches, and the winch being 10 inches long, the pressure applied to it is multiplied 868 times. The winch is worked by one man, and the time occupied in disconnecting one drum and connecting the other is little more than a minute.

The rollers on which each plummer-block moves, are made of wrought iron, case hardened, $3\frac{1}{4}$ inches in diameter and $2\frac{1}{2}$ inches broad. At first, the rollers worked against the cast iron surfaces of the frame and of the plummer-block; but after having been at work two or three years, the pressure had caused so much indentation into the two surfaces of cast iron, as to render it difficult for a man to connect and disconnect the large spur wheels. To remedy this defect, a strap of steel was let into the frame and another into the underside of the plummer-block for the rollers to act against,

and no inconvenience has since been experienced. The weight upon each of the rollers is about 5 tons.*

When all the train is in motion, the engines making 22 strokes per minute, the pressure of the steam on entering the cylinder being $2\frac{1}{2}$ lbs. above that of the atmosphere, and the mean pressure 9.95 lbs. per square inch, the power for the engines, rope, and train, is 323.74 H.P.

When the rope, without any carriages attached to it, is drawn by the engines making 24 revolutions per minute, the pressure of the steam being 6 lbs. above the atmosphere, and the mean pressure 7 lbs. per square inch, the power expended on the rope and machinery is 250.76 H.P.

When the drum is disconnected from the engines, and they are allowed to make 22 strokes, the pressure being $13\frac{1}{2}$ lbs. above the atmosphere; and the mean pressure 8 lbs. per square inch, the power expended on the friction of the engines unloaded, is 26.09 H.P.

Since the power expended on the engines, rope, and train, is 323.74 H.P., and on the engines and rope, 250.76 H.P.; the difference, namely, 72.98 or 73 H.P. is due to the train alone.†

The number of revolutions made by the engine shaft per minute being 22, the number made by the drum in the same time is 33.84. The circumference of the drum when the rope is off is 52 feet; when all the rope is wound on, it is 63 feet; the velocity of the rope will therefore vary from 1760 feet per minute, to 2132 feet, that is from 20 miles to 24 miles per hour.

When the railway was first opened, the rope employed was of hemp, $5\frac{1}{2}$ inches in circumference, or $1\frac{3}{4}$ inch in diameter. After it

* The weight of the drum brake wheel and mortice wheel being 30 tons, and of the axes 3 tons 7 cwt., the rope remaining on the drum when unwound 1 ton, and the additional weight of rope when the whole is wound on, 23.10 tons, makes a total weight of 57.17, or 58 tons, to be sustained on the twelve rollers beneath the two plummer-blocks; and, therefore supposing each set to bear the same weight, each roller has to carry nearly 5 tons; each end of the axis of the drum being 12 inches diameter in its bearing, the brakes must sustain 29 or 30 tons.

† From an indicator diagram which was taken on one of the engines, for the purpose of ascertaining the amount of power expended on the different resistances which the engines had to overcome, it appeared, that at starting, the pressure of the steam above the atmosphere, was $3\frac{1}{2}$ lbs. per square inch, and the vacuum being $13\frac{1}{2}$ lbs., the total pressure per square inch was 17 lbs.; also, that the average pressure throughout the stroke was 14.6 lbs., but the engines did not then move at their working speed.

had been in use for a very short time it broke, and continued to do so frequently; in consequence of which a wire rope was substituted. This rope, $3\frac{1}{8}$ inches in circumference, or $1\frac{1}{4}$ inch diameter, is formed of six strands, each composed of six wires, or thirty-six wires in the rope. It is covered over with small hempen rope or tarred yarn. The breakages of this rope are much less frequent than with the hempen rope, but still they do occur occasionally.

In order to make the rope wind evenly on the drum, it is guided by two levers mounted on one centre pin, and crossing one another in the form of a pair of scissors, the levers having rollers on their inner side. These levers are worked by a man, standing on the platform below, and he guides the rope by pressing them alternately against either side as his eye directs, so as to wind the rope evenly around the drum.

The weight of the hempen rope was 8 lbs. per yard, that of the wire rope is $6\frac{1}{2}$ lbs. per yard; therefore the weight of the rope lying on the railway was in the former case $19\frac{1}{2}$ tons, and in the latter $16\frac{1}{2}$ tons. Swivels are introduced at intervals in the length of the rope, to allow it to twist and untwist itself in working. The weight of the rope is sustained by bearing sheaves, disposed at intervals along the line, in the middle of the space between the rails; some of them being laid at angles to suit the curves of the road.

The cylinder of the 12 H.P. engine is 20 inches in diameter, the piston makes a stroke of 3 feet, and 34 strokes per minute. The two air-pumps which are worked by it are 13 inches in diameter, with a stroke of $10\frac{1}{2}$ inches, and are placed one on each side of the centre of the main lever.

The air pumps of the large engine are 31 inches in diameter, with a length of stroke of 2 feet 6 inches; so that the capacity of the stroke of each pump is 13.1 cubic feet, or 26.2 cubic feet for the pumps of a pair of engines; therefore the capacity per minute, is 26.2×22 strokes = 576.4 cubic feet. In like manner, the capacity of the small pumps, per minute, is 55 cubic feet, or nearly $\frac{1}{6}$ th that of the large pumps in the same time.

The well from which cold water is obtained is 10 feet diameter inside, and is steined partly with brick and partly with iron. In this well are two sets of three-barrelled pumps, but only one set is worked at a time. The barrels are each 7 inches in diameter, the stroke is 18 inches, and they make twenty strokes per minute; so that the quantity of water raised by one set, per minute, is 150 gallons. These pumps are worked constantly throughout the day.

The marine boilers are 10 feet 3 inches wide, 10 feet 8 inches high,

and 24 feet long; the steam chests are 5 feet in diameter and 4 feet 10 inches high; each boiler has three fires within it.

The circular boilers are each 7 feet 6 inches in diameter, by 24 feet long; the two circular flues, through their whole length, are 2 feet 6 inches diameter. The steam chests are 3 feet 9 inches diameter, and 4 feet, 5 feet, and 6 feet high respectively. The average consumption of fuel is, per day, for the two marine boilers together, $7\frac{1}{2}$ tons, and for the three circular boilers together, 8 tons. In these quantities is included what is required for getting up the steam in the morning.

The time of working, corresponding to this average, is 13 hours. The weight on the safety valve is $4\frac{1}{2}$ lbs. per square inch.

The engines and machinery at Blackwall are similarly arranged, but on a smaller scale. The railway there passes by the side of the engine-house on the ground, and therefore the ropes are gathered on at the lowest part of the circumference of the drums, instead of at the highest part, as at the Minories, where the railway passes over the engine-house. The engines, constructed by Mr. Barnes, are of the marine side-lever form, of the nominal forces of 70 H.P. each, the pistons are $45\frac{1}{2}$ inches diameter, with 4 feet stroke, and their average speed is 25 strokes per minute. The large spur wheels are 17 feet diameter, to the pitch line, with 120 teeth, $5\frac{1}{2}$ inches pitch and 14 inches broad, working into mortice spur wheels on the axis of the drums, 10 feet 10 inches diameter, with 80 wood cogs. The drums are $16\frac{1}{2}$ feet diameter when empty, and 22 feet diameter outside. The small steam-engine for working the air-pumps, is 8 H.P.; it was constructed by Messrs. Miller and Ravenhill.

The paper is illustrated by two drawings, Nos. 3797 and 3798, giving the general plans and the details of construction of the machinery of the line.

Mr. FAREY said, that as the wire rope had been mentioned, its peculiarities of construction should have been described. It consisted of six strands, each of six wires, coiled round a hempen core, and the whole of the strands were also laid round one centre core of hemp. Wherever the wires were in actual contact with the core, corrosion appeared to take place, which of course augmented the rapidity of the destruction of the rope. It was, however, now merely a question of expense, as, since the adoption of the wire rope, breakage seldom occurred. Mr. Farey thought, that the old hempen rope had frequently been broken by the undue strain which was suddenly brought upon it, by its slipping on the drum. He imagined, that a