Proceedings of the Institution of Mechanical Engineers
http://pme.sagepub.com/

Description of a Method of Supplying Water to Locomotive Tenders Whilst Running

John Ramsbottom

Proceedings of the Institution of Mechanical Engineers 1861 12: 43
DOI: 10.1243/PIME_PROC_1861_012_008_02

DESCRIPTION OF A METHOD OF SUPPLYING WATER TO LOCOMOTIVE TENDERS WHILST RUNNING.

BY MR. JOHN RAMSBOTTOM, OF CREWE.

The object of the apparatus forming the subject of the present paper is to supply Locomotive Tenders with Water without requiring the stoppage of the train for the purpose. It consists of an open trough of water, lying longitudinally between the rails at about the rail level; and a dip-pipe or scoop attached to the bottom of the tender, with its lower end curved forwards and dipping into the water of the trough, so as to scoop up the water and deliver it into the tender tank whilst running along.

The construction of the apparatus is shown in Figs. 1 and 2, Plate 10, which are longitudinal and transverse sections of the tender and water trough. Figs. 3 and 4, Plate 11, are longitudinal and transverse sections enlarged of the scoop and trough.

The water trough A of cast iron, 18 inches wide at top by 6 inches deep, Fig. 4, Plate 11, is laid upon the sleepers between the rails at such a level that when full of water the surface of the water is 2 inches above the level of the rails, as seen in Figs. 1 and 2, Plate 10. The scoop B, for raising the water from the trough, is of brass, with an orifice 10 inches wide by 2 inches high, as shown in Figs. 3 and 4; when lowered for dipping into the trough, its bottom edge is just level with the rails and immersed 2 inches in the water. The water entering the scoop B is forced up the delivery pipe C, Fig. 1, which discharges it into the tender tank, being turned over at the top so as to prevent the water from splashing over. The scoop is carried on a transverse centre bearing D, and when not in use is tilted up by the balance weight E clear of the ground, as shown dotted in Fig. 3; for dipping into the water trough it is depressed by means of the handle F from the footplate, which requires to be held by the engineman as long as the scoop has to be kept down.

The upper end of the scoop B is shaped to the form of a circular arc, Fig. 3, as is also the bottom of the delivery pipe C, so that the scoop forms a continuous prolongation to the pipe when in the position for raising water. The limit to which the scoop is depressed by the handle F is adjusted accurately by the set screws G, which act as a stop and prevent the bottom edge of the scoop being depressed below the fixed working level; the set screws also afford the means of adjusting the scoop to the same level when the brasses and tyres of the tender have become reduced by wear, causing the level of the tender itself to be lowered. The orifice of the scoop is made with its edges bevilled off sharp, to diminish the splashing, and the top edge is carried forward 2 or 3 inches and turned up with the same object.

Two other forms of scoop have been used, but they are not considered so eligible as that already described and shown in Figs. 3 and 4, Plate 11. In one of them the scoop was hinged on the bottom of the delivery pipe C along the front edge, with a set screw as before for adjusting it to the proper level in the trough when the brasses and tyres have become worn. The other form of scoop was made to slide up inside the delivery pipe with a telescope joint; and for adjusting its height the lifting lever was centered in an eccentric bush which could be turned round when necessary, so as to raise the lever and allow for the wear of the brasses and tyres.

The water trough A is cast in lengths of about 6 feet, so as to rest upon each alternate sleeper, and is fixed to the sleepers, the height being adjusted by means of the wood packing, as shown in Figs. 1 and 2, Plate 10. The ends of each length are formed with a shallow groove, in which is inserted a strip of round vulcanised india-rubber H, Fig. 3, to make a flexible and water-tight joint, the metal not being in contact; this meets all the disturbances arising from expansion, settlement of road, and vibration caused by the passage of trains. The length of trough now laid on the Chester and Holyhead Railway near Conway is 441 yards in the level, as shown in the diagram Fig. 5, Plate 12; and at each end the rails are laid at a gradient of 1 in 100 for a further length of 16 yards, the road being raised for that purpose so that the summit of the incline is 6 inches higher than the level portion: the trough is tapered off in depth to a bare plate, so that the same thickness of wood packing serves for fixing it throughout the entire length. The portion of the line where the trough is fixed is a curve of 1 mile radius, and the outer rail is canted 1 inch above the inner, the wood packing being made taper for fixing the trough horizontal; but the cant does not interfere with the efficient action of the scoop on the tender, since it amounts to only 1-6th inch on the 10 inches width of scoop. At each extremity of the water trough is an overflow pipe I, Fig. 5, limiting the height of water in the trough.

Where the water has to be raised by pumping or the natural supply is limited in amount, it is necessary to prevent the water running to waste through the overflow pipes. For this purpose the supply pipe K, Fig. 6, Plate 12, has a valve L fitted on its orifice, and delivers the water into the small cistern M, from which it flows into the trough A through the pipe N; when the trough is full up to the high water level, the water overflows from the cistern into the pocket O and thence into the bucket P on the end of the valve lever, closing the valve and cutting off the supply water. There is a small hole in the bottom of the bucket P, through which the water in the bucket constantly escapes: so that when the water level in the trough A has been lowered by the passage of an engine, the water in the cistern M no longer overflows into the bucket P, and that in the bucket escapes through the hole at the bottom, allowing the valve lever to be raised by the balance weight at the other end and open the valve for a fresh supply. By this means a large quantity of water is economised, since there is only the small quantity escaping through the hole in the bucket, instead of the water constantly running to waste through the large overflow orifices at the two extremities of the trough.

The trough contains 5 inches depth of water, and the scoop dips 2 inches into the water, leaving a clearance of 3 inches at the bottom of the trough for any deposit of ashes or stones. The trough is so constructed as to present no obstruction to be caught by any loose couplings or drag chains that may be hanging from the trains passing over it; and experiments have been tried with a bunch of hook chains and screw couplings hanging down behind the tender and dragged along the trough without any damage occurring.

As to any difficulty from ice, a thorough trial has been afforded by the late severe weather. By means of the small ice plough shown in Figs. 7, 8, and 9, Plate 12, which was run through the trough by hand each morning, the coating of ice was removed from the surface of the water, and no more was formed afterwards excepting a film so thin that it was removed by the scoop itself in passing through the trough without being felt at all. It has indeed been shown that the continuance of this action with the succession of trains in ordinary working would be sufficient in this climate to prevent the formation of any ice thicker than could be readily and safely removed by the passage of the scoop alone, even during as severe a season as the last. The present trough, which has been in use nearly three months, is supplied hitherto by a pump, which it may be here mentioned failed once through being frozen up; but a natural stream of water will shortly be connected to it, giving a regular supply by gravitation, and serving to prevent the water freezing by maintaining a constant current through the trough.

The principle of action of this apparatus consists in taking advantage of the height to which water rises in a tube, when a given velocity is imparted to it on entering the bottom of the tube: the converse operation being carried out in this case, the water being stationary and the tube moving through it at the given velocity.

The theoretical height, without allowing for friction &c., is that from which a heavy body has to fall in order to acquire the same velocity as that with which the water enters the tube. Hence, since a velocity of 32 feet per second is acquired by falling through 16 feet, a velocity of 32 feet per second or 22 miles per hour would raise the water 16 feet: and other velocities being proportionate to the square root of the height, a velocity of 30 miles per hour would raise the water 30 feet very nearly (a convenient number for reference), and 15 miles per hour would raise the water 7½ feet; half the velocity giving one quarter the height. In the present apparatus the height that the water is lifted is 7½ feet from the level in the trough to the top of the delivery pipe in the tender, which requires theoretically a velocity of 15 miles per hour; and this is confirmed by the results of experiments with the apparatus: for at a speed of 15 miles per hour the water is picked up from the trough by the scoop and raised to the top of the delivery pipe, and is maintained at that height whilst running through the trough, without being discharged into the tender.

The theoretical maximum quantity of water that the apparatus is capable of lifting is the cubic content of the channel scooped out of the water by the mouth of the scoop in passing through the entire length of the trough: this measures 10 inches width by 2 inches depth below the surface of the water in the trough, and 441 yards length, amounting to 1148 gallons or 5 tons of water. The maximum result in raising water with the apparatus is found to be at a speed of about 35 miles per hour, when the quantity raised amounts to as much as the above theoretical total: so that in order to allow for the percentage of loss that must unavoidably take place, it is requisite to measure the effective area of the scoop at nearly the outside of the metal, which is ¼ inch thick and feather-edged outwards, making the orifice slightly bell-mouthed and measuring at the outside 10½ inches by 2¼ inches; this gives 1356 gallons for the extreme theoretical quantity.

The result of a series of experiments at different speeds is that

(22 Jan. 1861)	at 15 miles per hour the total delivery is	0	gallons.
,,	22	1060	,,
,,	33	1080	,,
,,	41	1150	,,
(23 Nov. 1860)	50	1070	,,

Hence it appears that the variation in the quantity of water delivered is very slight at any speed above 22 miles per hour, at which nearly the full delivery is obtained; the greater velocity with which the water enters at the higher speeds being counterbalanced by the reduction in the total time of action whilst the scoop is traversing the fixed length of the trough. It also appears that at any speed above that which is sufficient to discharge the water freely from the top of the delivery pipe, all the water displaced by the scoop is practically picked up and delivered into the tender. In these experiments the water level was maintained the same in the trough each time by keeping it supplied up to the overflow orifice at each end; and the scoop was lowered to the same level each time by means of the set screws, the height of the tender itself being maintained practically the same in each case.

At higher speeds than 22 miles per hour the velocity of the water entering the scoop is much greater than is required to raise it to the height of the tender; and on taking up the water by a prolonged vertical pipe curved forwards at the bottom end, in place of the scoop, it is thrown upwards in a strong jet. By closing the top of this pipe and connecting it to a pressure gauge, it has been found that at a speed of 50 miles per hour the water exerted a pressure in the pipe of 30 lbs. per square inch, maintaining the gauge at this pressure during the passage through the trough. This pressure is equivalent to a column of water 70 feet high, and the velocity due to that height is 46 miles per hour, confirming the actual speed of 50 miles per hour. In order to diminish the velocity at which the water enters the tender tank, the delivery pipe is enlarged continuously from the bottom to the upper end, making the area for discharge 10 times that for entrance, as shown in Fig. 2, Plate 10, so that at 50 miles per hour the water is discharged into the tender at only 5 miles per hour or 7 feet per second, equivalent to falling a height of about 1 foot. The theoretical form for the taper of this pipe for giving a uniform degree of retardation to the current of water throughout its length would be a parabolic curvature hollowed inwards at the sides; but the form considered most eligible in practice is one of uniform taper, to allow more freedom of passage in the middle of its length. The form of the front or convex side of the pipe is however of little moment, as the stream of water flows up the back or concave side without pressing against the convex side, which might indeed be removed in the lower portion of the length, leaving the pipe an open curved trough, without risk of the water escaping.

In the preliminary experiments before constructing the apparatus, a trial was made of the effect of a stream of water issuing through an open trough attached to the end of a large water main, under such a pressure that a regular stream of water was maintained at a speed of 15 miles per hour. A curved pipe similar in form to the scoop and delivery pipe in the drawings and about 3 feet high was placed in the stream of water facing the current, and the water was found to be raised up the pipe and freely discharged in a stream from the top: the orifice of the pipe was 2 inches by ¼ inch at the bottom and 2 inches by 2 inches at the top, being an increase in area of 8 times. On placing a ⅜ inch pipe bent at the bottom to face the current, the water did not cease to flow over till the top was raised 7½ feet above the level of the stream.

For the purpose of measuring the speed conveniently during some of the experiments, the writer employed the simple instrument shown in Figs. 10 to 13, Plate 13, consisting of a small vertical glass cylinder R half full of oil, made to rotate rapidly on its axis by a cord passed round the trailing axle S of the engine: the depressed centre of the surface of the rotating oil indicated readily and accurately the speed of running by the graduated scale at the side of the glass cylinder.

The principle of action of this plan of raising water for supplying locomotive tenders occurred to the writer several years ago, and he long felt convinced that it admitted of being made practically available for that purpose with some advantages of importance in removing difficulties that are at present experienced under certain circumstances of working the traffic. His attention was forcibly called to this on occasion of having to provide last year for the accelerated working of the Irish mail, which has now to be run through from Chester to Holyhead, a distance of 84¾ miles, without stopping, in 2 hours and 5 minutes. This necessitated an increase in the size of the tender tanks beyond the largest size previously used containing 2000 gallons; or else required the alternative of taking water half way at Conway, either by stopping the train for the purpose, or by picking up the water whilst running. A supply of 2400 gallons is found requisite for this journey in rough weather; and although 1800 to 1900 gallons only are consumed in fair weather, it is necessary to be always provided for the larger supply, on account of the very exposed position of the greater portion of the line, which causes the train to be liable to great increase of resistance from the high winds frequently encountered. An increase of the tender tanks beyond the present size of 2000 gallons would have involved an objectionable increase of weight in construction, and alteration in the standard sizes of wheels and axles &c. for tenders; and would have also caused a waste of locomotive power in dragging the extra load along the line. By this plan of picking up 1000 gallons of water at the half way point near Conway, where the water trough is fixed, the necessity for a tender larger than the previous size of 1500 gallons is avoided, effecting a reduction in load carried equivalent to another carriage of the train.

Another application contemplated for this apparatus is to the case of heavy through goods trains, such as those between Liverpool and Manchester, which are at present required to stop half way at Parkside for water only, causing an objectionable blocking of a line very much thronged with traffic, and a delay and loss of power in pulling up the heavy train.

Another advantage of this plan is the means it affords of opening up fresh sources of water supply, where a stream of good water can be obtained near the level of the rails without expense and labour of pumping it, but cannot be otherwise made available on account of not being at a station: such as the case of the Holyhead line, where at the terminus on the coast the supply of water is defective in quality and quantity, and involves heavy expense for pumping; but at about 15 miles distance along the line a plentiful natural supply of good water can be obtained at the rail level in the middle of the island of Anglesea, where however the nature of the traffic does not necessitate a stoppage.

Mr. Ramsbottom showed a working model of the apparatus to illustrate the mode of action: and observed that the plan had been matured to meet the special difficulty of working the traffic without any delay for taking in water; it had proved quite successful in practice, and thoroughly accomplished the object intended, and there was indeed less trouble in taking water with it than with an ordinary water crane. Many plans had been suggested for lowering the scoop into the trough, but none so simple and complete as that adopted of making the line with an incline at each end of the trough; the bottom of the scoop when lowered was level with the rails and quite clear of the ballast, so that it might be lowered a mile before reaching the trough; and it was then gradually dipped down into the water and lifted out again by the incline in the rails at each end, passing 3 inches clear above the ends of the trough. In practice instead of the whole quarter of a mile length of line being lowered 6 inches, only a short double incline was made at each end, rising 6 inches and then falling the same amount towards the end of the trough, the object being to enable the scoop to clear the end of the trough. The velocimeter exhibited was a simple instrument that he had contrived for some previous experiments; it showed the speed correctly by simple inspection, assisting the driver in maintaining a uniform speed in experiments, and was convenient for connexion to the engine.

Mr. C. **Markham** had had an opportunity of examining the working of the apparatus described in the paper, and could confirm the statements that had been made as to its efficiency. On running an engine through the trough at a speed of about 45 miles per hour, it was ascertained by measurement that more than 1100 gallons of water had been delivered into the tender; and in another experiment the speed of the engine was got up gradually from a state of rest to about 16 miles per hour, at which speed the water began to flow over into the tender freely. He had examined the trough and found it in perfect order, the joints being tight without any leakage. This mode of supplying tenders with water would be of great advantage for long runs, especially where a great speed was required, as it avoided the delay of stopping for water; it would also prove of considerable advantage in the working of through goods trains, by preventing the loss of power in pulling up a heavy train for water only. He doubted however whether there were many railways in this country that would admit of the plan being generally adopted, because it was necessary at each place to have a level of a quarter of a mile long for laying down the water trough, which could not always be obtained. Where there was a good natural supply of water, the plan appeared a valuable auxiliary means of supplying the tender with water; but he thought it should be regarded as auxiliary, for the engine might be stopped before reaching the trough, at too short a distance to allow of getting up the necessary speed for raising the water, causing detention unless the troughs were numerous along the line.

Mr. Ramsbottom remarked that for picking up water at very low speeds he had proposed placing a flap valve at the bottom of the tender, opening inwards, instead of carrying the delivery pipe up to the top of the tender and turning it over; by this means some height would be saved. At as low a speed however as 22 miles per hour the water was supplied in full quantity to the height of 7½ feet.

Mr. J. E. Clift enquired what amount of power was expended in raising the water into the tender whilst running.

Mr. Ramsbottom said the power expended would be little more than the weight of the water lifted to the height through which it was raised, with some addition for friction in the scoop and delivery pipe; there was indeed in this plan a saving of power due to the water having to be raised only to the height of the tender, instead of into a high tank for supplying the water cranes.

The Secretary confirmed the statements given in the paper as to the results of working, having been present at the experiments and witnessed the action of the apparatus in work; and the water trough was found to be in complete order after exposure to the long severe frost.

The Chairman thought the results of the trials were highly satisfactory and showed the success with which the plan had been carried out. He proposed a vote of thanks to Mr. Ramsbottom for his paper, which was passed.

The Meeting then terminated; and in the evening a number of the Members dined together in celebration of the Fourteenth Anniversary of the Institution.

LOCOMOTIVE WATER SUPPLY.

Plate 10

Fig. 1. *Longitudinal Section of Tender and Water Trough.*

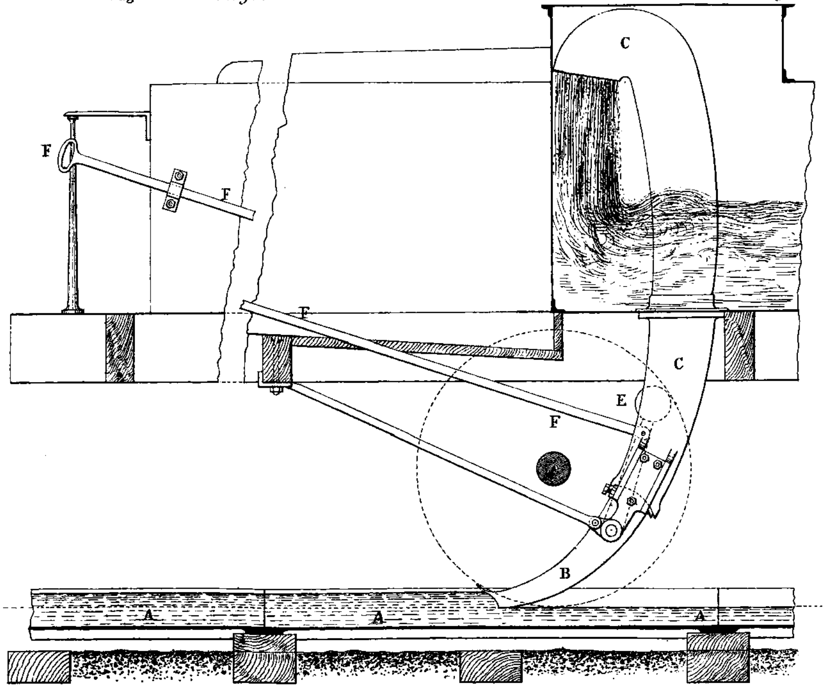
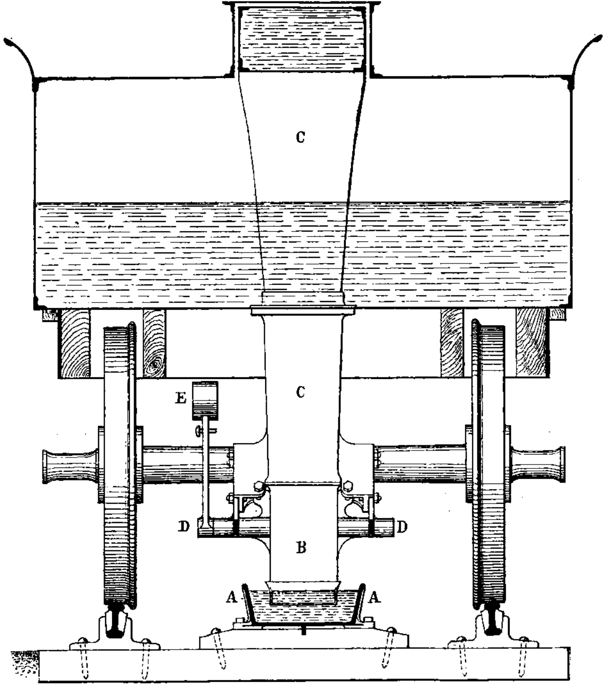


Fig. 2. *Transverse Section.*



(Proceedings Inst. M. E. 1861. Page 43) Scale 1/30th. Ins 12 6 0 1 2 3 4 5 6 7 8 9 10 Feet.

LOCOMOTIVE WATER SUPPLY.

Plate 11.

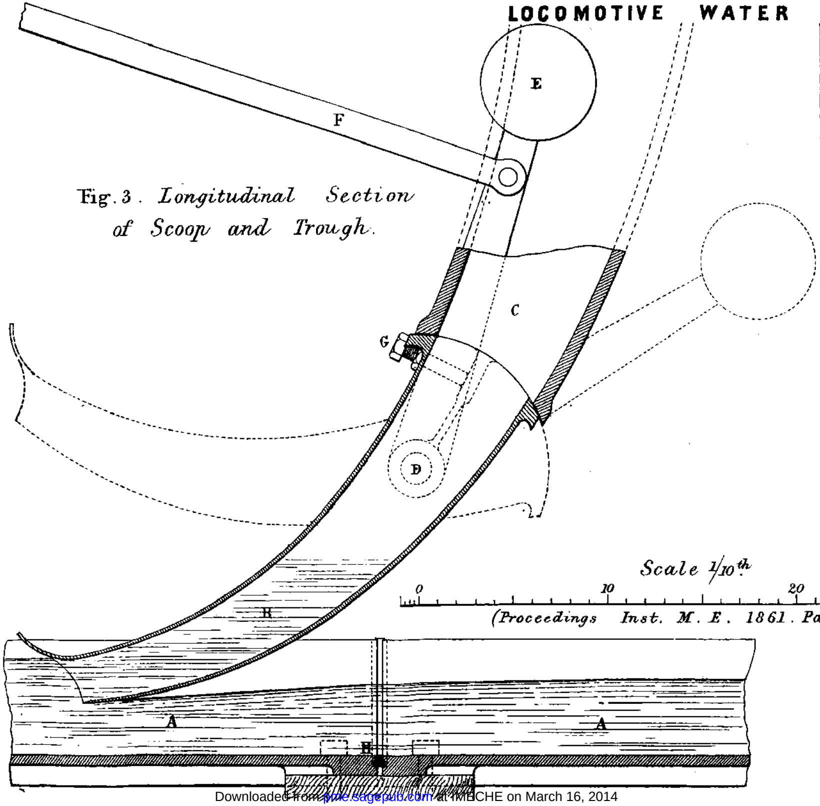


Fig. 3. *Longitudinal Section of Scoop and Trough.*

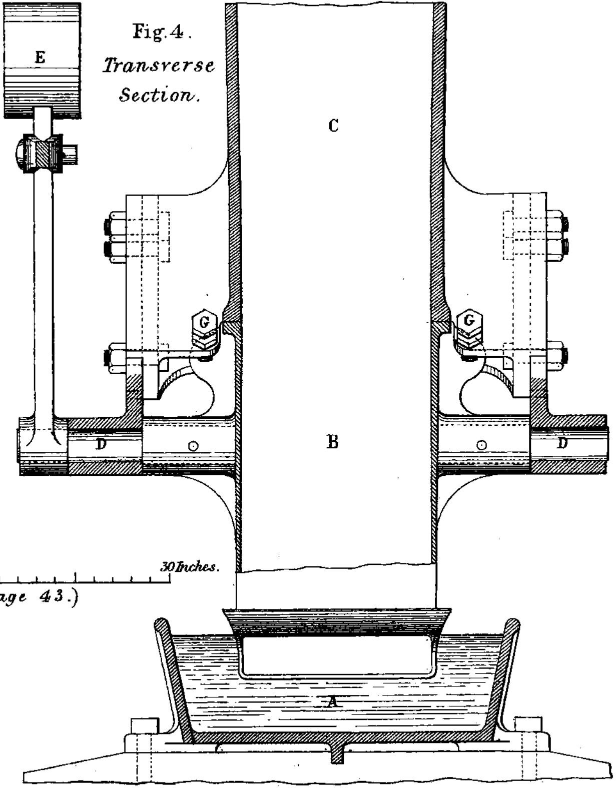


Fig. 4. *Transverse Section.*

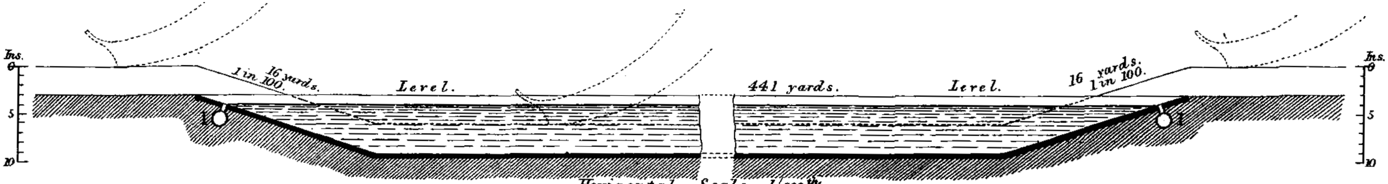
Scale 1/10th.

(Proceedings Inst. M. E. 1861. Page 43.)

LOCOMOTIVE WATER SUPPLY.

Plate 12.

Fig. 5. *Diagram of Laying of Water Trough.*



Horizontal Scale 1/600th.

Ice Plough.

Fig. 7. *Side Elevation.*

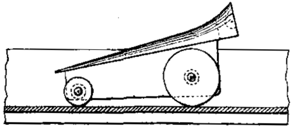


Fig. 8. *Back Elevation.*

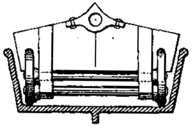


Fig. 9. *Plan.*

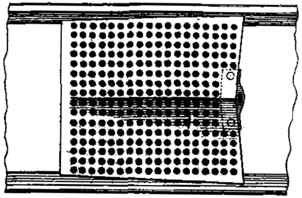
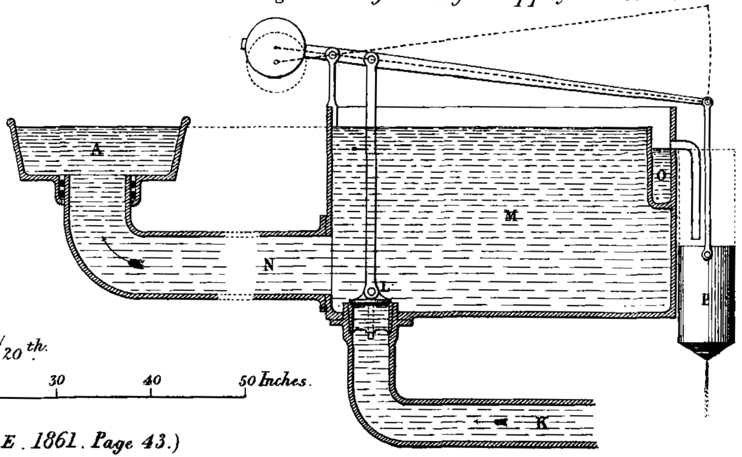


Fig. 6. *Regulating Supply Cistern.*



Scale 1/20th.

10 5 0 10 20 30 40 50 *Inches.*

(Proceedings Inst. M. E. 1861. Page 43.)

LOCOMOTIVE WATER SUPPLY.

Plate 13.

Velocimeter.

Fig. 10. *Front View.*

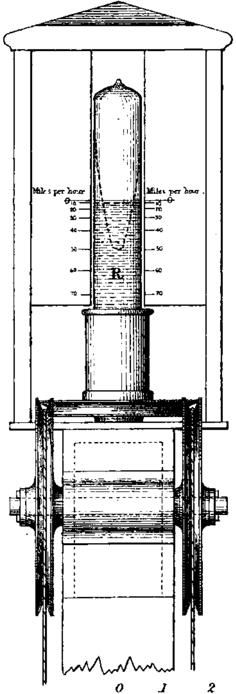
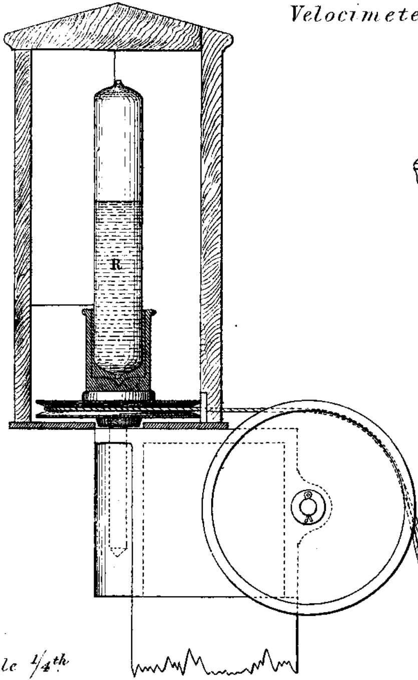


Fig. 11. *Side View.*



Scale 1/4th

0 1 2 3 4 5 6 7 8 9 10 *Inches.*

Fig. 12. *Mode of fixing on engine.*

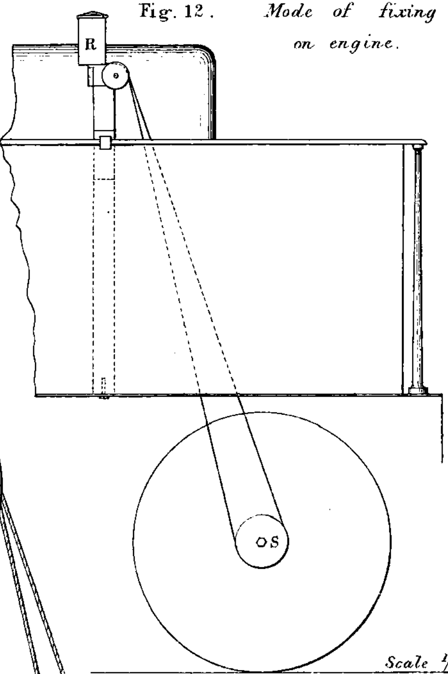
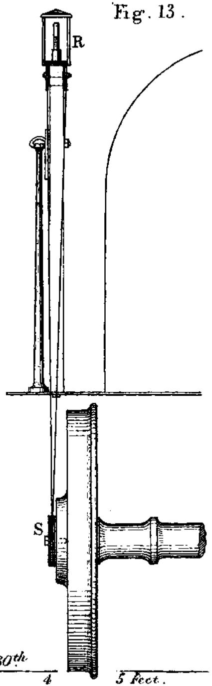


Fig. 13.



Scale 1/30th

Ins. 12 6 0 1 2 3 4 5 *Feet.*

(Proceedings Inst. M.E. 1861. Page 43.)