arranged for a bayonet joint and calculated to resist high pressure. Of somewhat similar design is that of Becks, illustrated by Figs. 204 and 205. The accompanying figures (206 and 207) are illustrations of a description of fire-cock now in general use at railway stations, warehouses, asylums, &c. That illustrated by Fig. 207 is provided with a drawing-off cock and flange for attachment to the rising main. Figs. 208 and 209 are sections of a frost-proof screw cock by Messrs. Simpson and Co., Fig. 209 showing the main valve closed and drain valve open, and Fig. 208 the main valve open and drain valve closed. The advantage claimed for this kind of cock over others is that in opening the main valve the first action of the screw is to completely close the drain valve; while on closing, the latter is not opened till the main valve is on its seat; thus avoiding the leakage that takes place with other descriptions of cocks, in which the drain cock is not closed when the main valve is only partially open.

Fig. 205.

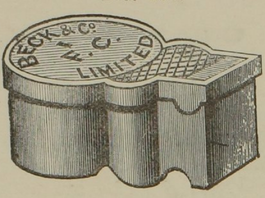


Fig. 206.

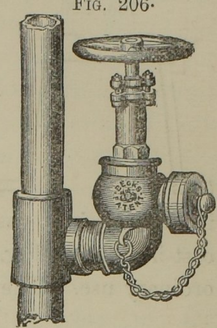


Fig. 210 represents a hydrant used in Glasgow. It is made of brass, and only to be depended on for low pressure, since, the action being like that of a common plug tap, an hydraulic shock is given, which subjects the mains to a strain by percussion that frequently ruptures them. The plug C of the hydrant is made hollow, and smaller at the top, so that the pressure of the water tends to drive it up into its seat in the outer case D; E is a cap, E′ a nut, G water way, B′ a slot which comes into action as soon as the water is shut off, B′ is then open to receive the water remaining in A which runs through, and is lost in the adjacent ground. An objection may be raised against the use of the slot B as fine sand is liable to be carried down the pipe A, in which case the plug and the seating would probably be cut and leakage ensue.

Fig. 207.

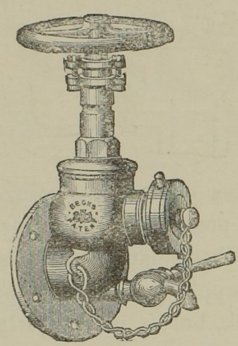


Fig. 211 represents an ordinary wooden stand-post lined with pipe, used by the London Water Companies in times of frost.

Fig. 212 represents a stand-pipe manufactured by Messrs. Beck and Co., and made to revolve, having either a single or double outlet. Figs. 213 and 214 are stand-posts of different designs, by the same makers. The former has been found serviceable for railway stations, barrack-yards, and places of that description; and the latter is one used by the East London Waterworks Company.

Fig. 208.

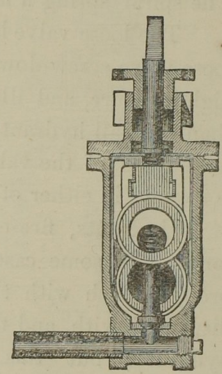
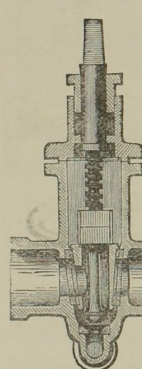


Fig. 215 is a stand-post of Beck & Co., and has been fitted up, in many instances, for the use of railway stations.

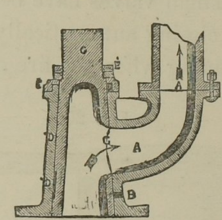
In the poorer neighbourhoods of Glasgow,* the use of stand-pipes under the constant system appears to have worked very badly for the company. Dr. Sutherland found that in the part of the city north of the Clyde, supplied by the Glasgow Waterworks, about 32,000 families were supplied from 1,800 stand-pipes with $\frac{3}{4}$-inch taps. Sixteen men were continually employed looking after them, yet it was found impossible to prevent waste.

Fig. 209.



The London companies have declared themselves willing to afford to courts and alleys a sufficient supply of water (and in many cases have done so, even where there were no proper fittings) by the means of stand-pipes, if they are sufficiently remunerated; but at present the supply of a very large area of the poorer localities is dependent on that which is stored away in vessels, having been drawn, perhaps, from a tap in the wall whilst the water was on. Mr. Bateman considers that if stand-posts were provided in these courts and alleys, there should not be less than one to every ten houses. At the Bombay Waterworks, the population are largely supplied gratuitously by self-closing public stand-pipes, which are worked by means of a counterpoise adjusted to the resistance at the various levels.

Fig. 210.



It may be objected to stand-pipes that by placing them in the streets they would be objectionable on account of the traffic, but they could be made to form the bases of lamp posts and thus be out of the way, or they might be let into the walls of houses; even at the worst, they would be no more in the way on the kerb-stones than the lamp-posts themselves.

Fig. 216 illustrates a street watering apparatus as manufactured by Messrs. Guest and Chrimes, showing a section

* Report of the Board of Health.

of sluice valve and case with 3-inch meter, elbow, shoe, and stand-post, together with the protecting case. This apparatus is used in various parts of the metropolis for filling water carts. For the purpose of watering roads, the hydrants should be placed at regular intervals.

Fig. 211.

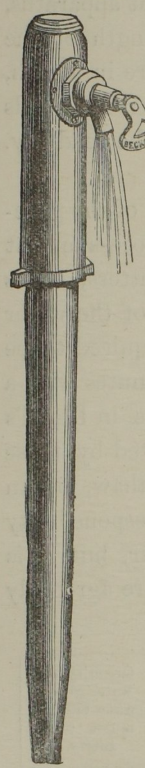
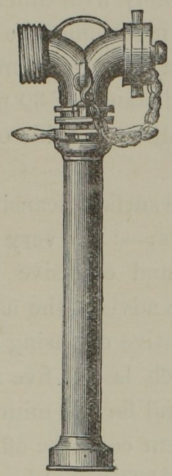


Fig. 212.



It has been estimated that 220 gallons of water are used on 1,088 square yards of macadamised road each time of watering. This is equal to 272 lineal yards four yards wide, or half the width of an average street, being at the rate of 200 gallons per thousand square yards watered, and the quantity used by each cart was thus estimated, hydrants being placed along the roads at the distance of 272 yards apart, and so no time was lost in drawing full carts over parts of the road already watered. In this way a cart holding 220 gallons will water $2\frac{1}{2}$ miles of road, twice a day, over the full width. But as stated in a previous chapter, it has been calculated from observations extending over twenty years that streets require watering on an average 120 days a year, one ton of water being sufficient for 600 square yards of ground, and the same quantity for 400 yards of granite paving. The quantity stated to be used in London is 14,000 gallons per mile of road watered twice a day.

Fig. 213.

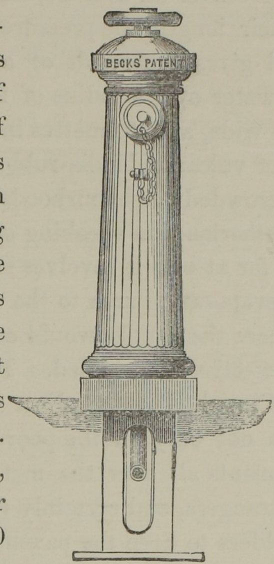
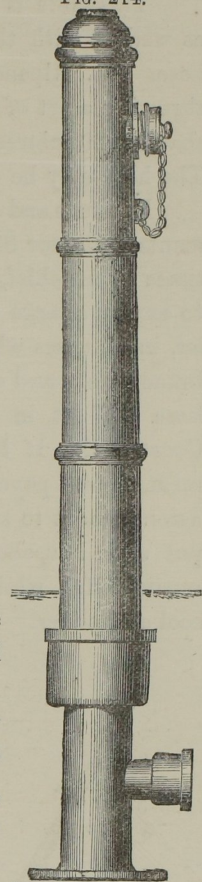


Fig. 214.



The time has not yet come when we may expect to see the open spaces in our cities ornamented with fountains having some claim to be so called, but this is no reason why every effort should not be made to improve the state of the streets themselves. Paris, very much before our capital in this respect, is provided with a system at once simple in character and effective in operation. The surfaces of the streets are cleaned and watered by means of a hose, consisting of five tubes, each about a mètre in length and supported upon a carriage having a couple of wheels, as shown by Fig. 217, which prevents the hose being destroyed by the gravel, and renders it easy to manipulate. The water is directed through a copper branch, provided with a stop-cock, the tube next the branch being only half the length of the others. The joints are made with brass flanges, the branch being removed when the

Fig. 215.

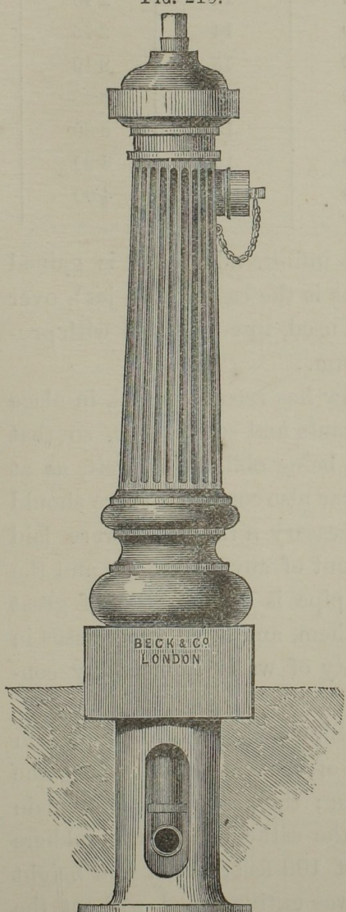
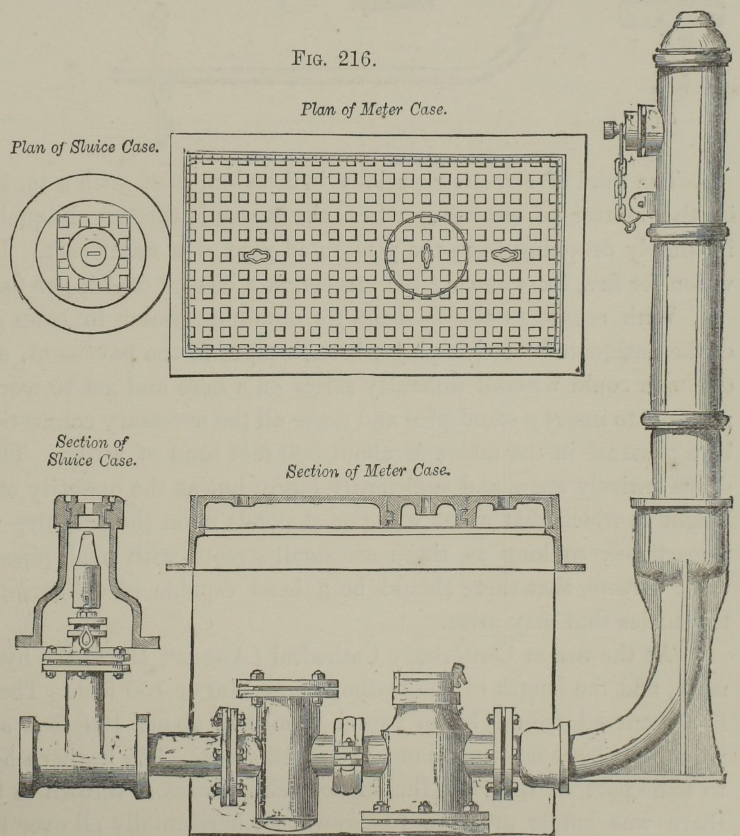


Fig. 216.



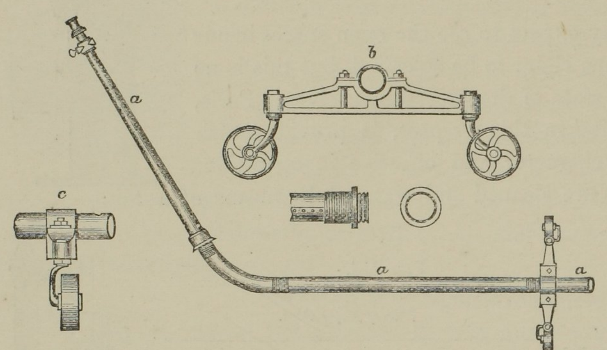
operation is ended. In Fig. 217 *a* shows the end length with the branch, and the plan of one of the carriages; *b* is the front elevation, and *c* the end view of the carriage.

The results of these tubes, as used in the Bois de Boulogne, with an apparatus having a nozzle on its branch 0·012 mètres in diameter, are given in the following table extracted from a work of M. Alpaud.

This table is given as an average, for in practice the results vary very considerably with different apparatus, as well as with their length, the pressure being of course very greatly reduced by increasing the length of the hose. M. Alpaud gives the result of an apparatus twelve mètres long, having a branch one mètre in length, throwing a jet of water over a radius of 25 mètres. The hydrants are placed at a distance of 30 mètres on roads that are 20 mètres wide, and 40 mètres in narrower streets, in which case they are all on one side of the roadway. The hose may be of vulcanized india-rubber, leather, or canvas.

In courts and crowded neighbourhoods especially, stand-pipes could be used for the surface cleansing of the pavements. Doctor Sutherland, in speaking of the sweeping only of crowded courts, says:—'The very process may at times do mischief, for at best it involves smearing the surface with unwholesome and offensive matters, so as to expose a large evaporating area to the atmosphere.' He further states:—'I have advised the use of the water jet, in all cases where the supply would admit of its application, and when the defective cleansing required to be immediately and effectively remedied. The cost of an operation of this kind, which lasted five minutes with a hose and jet, in Church Passage, New Compton Street, was three halfpence, and for ten minutes in Lloyd's Court, 3¼d. It is not only in the poorer neighbourhoods that a great improvement could be effected by these means; our pavements all over the metropolis, after a shower of rain or a frost followed by a thaw, are an astonishment to strangers, and certainly from a sanitary point of view a national disgrace. The responsibility put upon householders to keep the pavement opposite their frontage in a clean state is not only unfair, but it is unsuccessful, while a hose and a jet would effectually wash the pavement, and make the atmosphere agreeably cool and purer.

Fig. 217.



Pressure at the surface. Mètres.	Quantity of water given per second. Litres.	Extent of the jet. Mètres.	Quantity of water given when branch is not 'on.' Litres.
8	0·90	10	1·80
12	1·25	12	2·40
15	1·40	14	2·75
20	1·60	15	3·10
25	1·80	15	3·40
30	1·90	15	3·60
35	2·00	16	3·80
40	2·10	16	4·00

The mud of streets, especially in London, is of such a tenacious character that infinite advantage is gained in the matter of cleansing when the water is thrown obliquely and with force (as is the case with a jet), over its simply dropping from the perforated pipe of a water cart. In Hamburg a jet is used, in connection with provision for fire, for watering the streets, at a charge of 1d. per foot frontage per annum.

With regard to the facilities for obtaining water in cases of fire, Captain Shaw has recommended, in place of the antiquated wooden plugs, branch pipes to the pavement, and permanent hydrants and stand-posts, so that one man could without difficulty screw on a hose and get to work at a fire, without being obliged to wait, as at present, to insert a stand-pipe and make all the necessary connections. The same officer also considers there should be a pressure in the mains of about 300 feet head of water. This would not be necessary if the pipes were laid down entirely anew and sufficiently large; but as the quantity of water that comes out of any given pipe, and the height to which that water will rise, depends upon the pressure under which that pipe is placed, it is of great importance, so long as there are small streets, with small pipes running through them, and large warehouses in these streets, that there should be a head capable of delivering a sufficient quantity of water to meet any contingencies that may arise.

At the fire at Canterbury Cathedral (August, 1872) the hydrant used (one of Simpson's) was on a 5-inch main, and the length of the leathern hose 600 or 700 feet. The height to the roof of the cathedral, where the fire occurred, would be in round numbers, about 100 feet above the 5-inch main; the pressure in the main would not be more than about 170 or 180 feet. The leathern hose was carried up the cathedral by the soldiers to some part of the roof, the jet not being therefore thrown to the vertical height of 100 feet; but at that height there was ample pressure to throw a jet horizontally all over the roof. The fire was extinguished without the aid of an engine by the pressure from this 5-inch main. 'In almost all cases, Mr. Bateman says, 'where I am engineer, the fire-engine has been abandoned, and the water is obtained from the mains almost instantaneously. The fire-engines are merely used as omnibuses to carry the men and the apparatus.'

But if the pumping fire-engine is to be abandoned as the medium for extinguishing fires, the size of the distributing pipes must be such that their line of virtual declivity at the maximum discharge shall be considerably above the roof of the house supplied ; and when a branch is laid expressly for the use of fires, it is better that the hydrant should be at a sufficient distance from the house to be safely accessible.

CHAPTER XIV.

METERS, SERVICE PIPES, AND HOUSE FITTINGS.

Introduction—Water Meters: High and Low Pressure Meters; Positive and Inferential Meters; Kennedy's, Winsbarrow's, the Manchester Meter, Siemens & Adamson's, Pontifex & Wood's, Horsley's, the Eureka; Remarks on Positive *v.* Inferential Meters; Low Pressure Meters; Relative Value of High and Low Pressure Meters; Application of Meters; Deacon's Waste Water Meter; Advantage of Inspection by Meter; House Services*: Iron, Lead, and Tin-lined Lead Services; Medical Testimony on the Use of Lead Pipes; Experiments on Lead and Tin-lined Lead Pipes; Heap's Patent Joint for Lead Pipes; Moore's Pipe Protector; Common's ditto—Ferrules—Stop Cocks: Bib Cocks and Taps; Self-closing Taps; Ball Cocks—Cisterns: Iron, Lead-lined, Slate, and Earthenware—Waste Preventers: Chandler's, Dalziell's; Double Cistern and Waste Preventers for Closets: Pinn's Apparatus.

HAVING examined the methods by which water is conveyed from its source into the streets of the town or district to be supplied, and described the various apparatus by which it is so far regulated, the next thing claiming attention is—its more immediate delivery to the consumers; how it may best be conducted into their premises, and how, when there, such supervision may be exercised, that, whilst its legitimate use is encouraged, waste shall be reduced to a minimum. In considering these matters, we have again to take into account the question of constant and intermittent supply; but as this is fully investigated in a subsequent chapter (XVI.), it will be dealt with here only so far as it affects the provisions and fittings of the premises supplied. When the increasing size of a town rendered it necessary to economise the supply of water at its disposal, or when its acquisition was expensive, as it is, for instance, by pumping, the great difference in its consumption by various consumers showed the desirability of possessing an instrument that could measure separately the quantity used by each party. This led to the invention of several very ingenious meters, some of which register with an accuracy sufficient, with proper care and attention, for all practical purposes.

Meters are of two kinds—high-pressure and low-pressure; the former deliver the water without any material loss of the pressure existing in the mains, and the latter deliver it without pressure.

The high-pressure meters in general use are divided into two classes, according to the principle upon which they are constructed:—

1st.—Positive Meters.

2nd.—Inferential Meters.

Positive meters are those in which a measuring chamber is alternately filled and emptied, and the number of those fillings recorded, the action of their moving parts being generally something similar to that of an engine piston. They are sometimes called reciprocating meters. Of this class are Kennedy's, Winsbarrow's, the Manchester Meter, &c.

An inferential Meter does not actually measure the water passing through it, but its registering depends on the velocity of the current acting on a drum or turbine, and thus giving motion to the indicating apparatus. These are sometimes called rotary meters. Of this class are Siemens & Adamson's, Horsley's, Pontifex & Wood's, &c.

Figs. 218, 219, 220 and 221 illustrate Kennedy's Meter. It has a metallic piston, *a* Fig. 218, which is fitted with an india-rubber ring *a′*, rendering it water-tight, and nearly free from frictional resistance. At the two ends of the cylinder are the india-rubber cushions *b*, which form a water-tight joint, in the event of the piston being forced to either end of the cylinder. The piston rod, passing through the stuffing box in the cylinder cover, is attached to the rack *c*, which works a pinion on the shaft. The cock key *d*, by means of which the water is admitted to and escapes from the meter, is represented in Fig. 221 in its position during the down-stroke, and in Fig. 220 during the up-stroke. It is fixed upon the same axial line as the shaft, and is fitted with a duplex lever actuated by the weighted lever *e* carried loosely on the shaft. This weighted lever, after reversing the key, falls on the yielding face of an india-rubber covered buffer *f*, which, travelling before it, gradually brings it to rest. As the piston moves up and down, the shaft is turned in reverse directions, thus actuating the index and reversing

* See Rules and Regulations of City of Norwich Waterworks Company, Chap. XVI. p. 255.

gear. The rack is kept in gear by an anti-friction roller, carried on a stud projecting from one of the brackets which support the shaft. Fig. 219 is a side section taken through the centre shaft, cock key, and piston. The water enters at the inlet *g*, and is directed by the cock key *d* down the passage *h* to the bottom of the cylinder, forcing up the piston, which presses the water above it up through the passage *i* into the outlet passage *i'*. When the piston has moved up a little farther the bob *e*, passing its centre of gravity, will fall on the key arm, sending it down, until stopped by the buffer-box. The key will then be, as shown on Fig 220, at right angles to its former

Fig. 218.

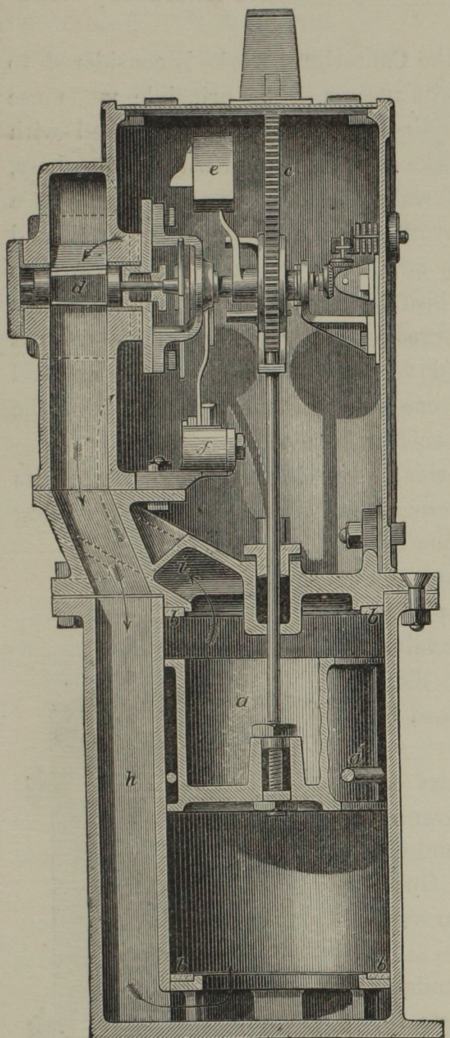


Fig. 219.

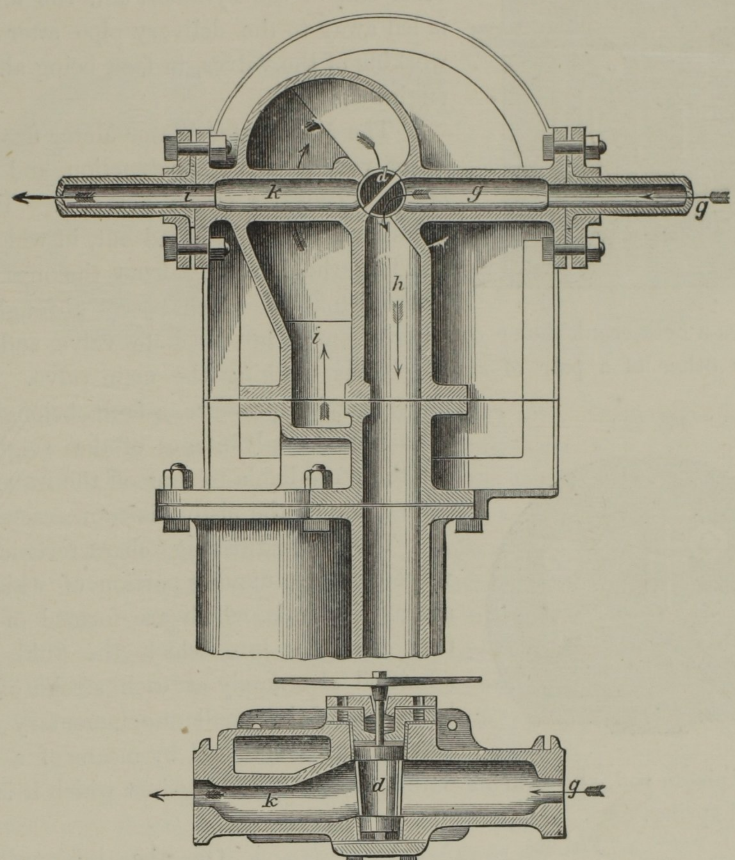


Fig. 220.

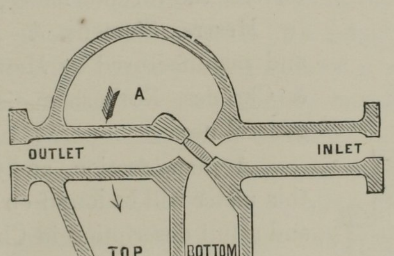
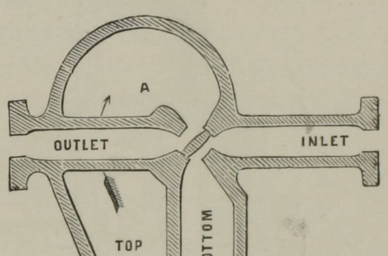


Fig. 221.

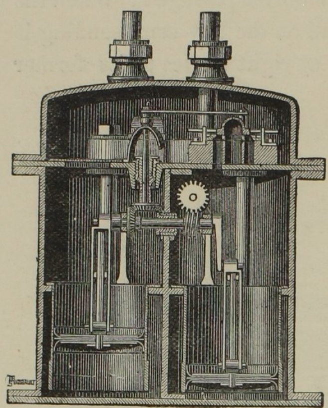


position, Fig. 221, and the water be directed from *g* down the passage *i* into the upper part of the cylinder, forcing the piston down, whilst the water admitted below during the last stroke is forced up the passage *h*, and out of the outlet *i'*. When the piston has arrived at nearly the bottom of the cylinder, the lifter will have lifted the bob *e* from the left side of the buffer-box, and raised it to the centre of gravity; from thence it will fall on the right-hand key arm, and bring the cock key to its former position, ready for another up-stroke. As the piston packing is of india-rubber, the temperature of the water should not exceed 100° Fahr. and in situations where this temperature is likely to be exceeded a brass piston of more expensive construction should be used; and if the supply be to a steam boiler care should be taken to insert a back pressure valve between the meter and the boiler. The lowest head under which the meters will deliver varies from 4 inches in the largest to 3 feet in the smallest sizes. The manufacturers state that this meter will work with a flow of 1 gallon in 10 minutes.

Figs. 222, 223, 224, illustrate a meter, the invention of Mr. Jno. Winsbarrow, and its action is identical with that of a double-cylinder engine. Fig. 222 is a sectional elevation ; Fig. 223 a plan of the valve plate and valves; and Fig. 224 the front elevation.

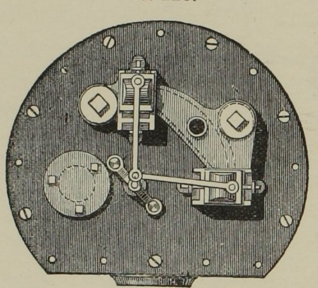
The water to be measured works two pistons connected to cranks at right angles to each other. Upon the horizontal crank-shaft is fixed a bevelled pinion gearing with another on a vertical shaft passing through a stuffing box in the partition separating the valve chamber from the two compartments containing the pistons, and by means of this shaft the valves are caused to slide to and fro on their seats. There is a valve to each cylinder, and each valve seat has three openings; the left and right-hand ones, Fig. 222, are those by which the water to be measured passes from the chamber to one or other end of the cylinder, and the middle opening is that by which the water is led away to the delivery pipe after having done its work on the piston; the working of the valves, in fact, being almost the same as that of an ordinary steam-engine valve.

FIG. 222.



The Manchester Water Meter used at the Canterbury works is considered to be of very efficient construction, and owes its success to the principle made use of in Nasmyth's steam hammer. The cylinder, Fig. 225, is iron, lined with brass, and smoothly bored out, in which works a piston packed with cup-leathers, dividing the incoming from the measured water; attached to the piston is a brass piston rod which passes through a stuffing-box in the cylinder cover, and actuates a bell crank lever opening a small intermediate valve, and thus admitting water under pressure to one or other of a pair of small pistons working the main valve. The insufficiency of momentum, especially under varying pressure, a fault belonging to reciprocating pistons of meters that have not the advantages of the weight and velocity of the steam engine, and are therefore liable to shut off the water on one side without admitting it on the other side of the piston, is counteracted by this arrangement.

FIG. 223.



The distinguishing characteristic of this meter is the peculiarity of its valve gear, the moving portion of which is made to work by the fluid pressing against its ends, which are formed of pistons fitting chambers into which the fluid pressure is admitted alternately at each stroke of the piston, by means of the small supplementary slide valve. The index is actuated by means of a catch fixed on the piston rod, and gearing with a ratchet wheel against which it is pressed by a small spring.

FIG. 224.

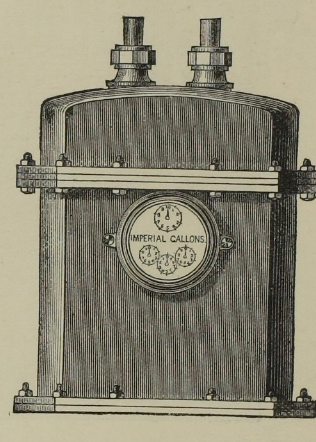
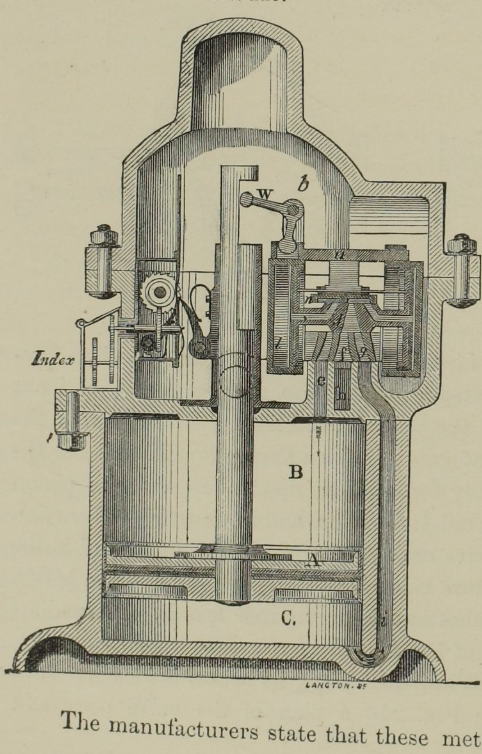


FIG. 225.



Of the inferential class of meters, the turbine meter, invented by Messrs. Siemens & Adamson, and manufactured by Messrs. Guest & Chrimes, Rotherham, is in very general use.

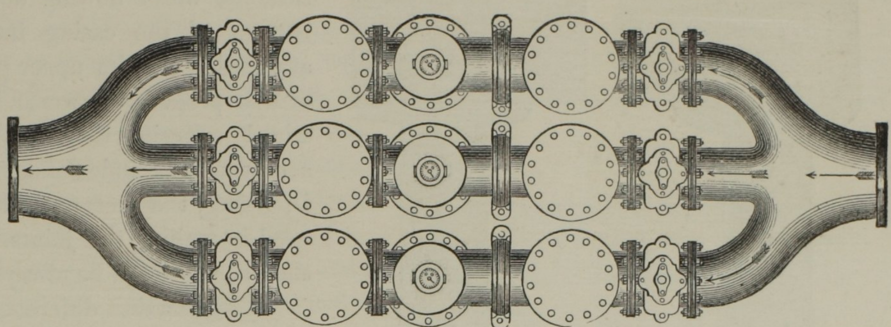
A plan, section, and details of this meter will be found on Plate 15, and a full description in Chap. XVII.

The first condition which the measuring drum has to fulfil is to make the same number of revolutions each time an equal quantity (say, for example, 100 gallons) passes through the meter irrespective of the pressure or velocity with which the water acts As the power of a jet of water by impact or reaction increases, however, in the ratio of the square of its velocity, the drum would appear to have a tendency to revolve proportionally faster when the water is acting at a greater pressure ; and consequently a larger quantity would be passing through. In order to counteract this tendency, drag stays or vanes are attached to the measuring drum, which produce a resistance increasing in the ratio of the square of the velocity, and these vanes being duly proportioned cause the drum to revolve at a velocity commensurate with the quantity of water passing through it.

The manufacturers state that these meters register with an accuracy varying less than 2 per cent. from the actual quantity passed, at all pressures, down to 2 or 3 inches head, this head representing the power required to work the turbine. This quantity, therefore, can pass through without registration; but it is generally found in practice, with proper care of the meter, to be too small to be taken notice of. The meters are said to be equal to four or five years' work without repair, and the makers guarantee to repair, renew, and pay carriage both to and from their works for an annual charge of about five per cent. on the list price of meters—a system which is stated to work well.

The annexed diagram, Fig. 226, shows an arrangement of these meters for measuring large quantities of water for a town supply or district main. A dirt box is in this case attached to each side of the meters to protect them from anything that may have passed into the pipe liable to injure the meter. The sluice valves at each end provide for the periodical examination of the meter, and cleansing the dirt box, or for repair, the water being supplied in the meantime through the other branches only.

Fig. 226.



The turbine meter of Messrs. Pontifex & Wood has been highly spoken of by Mr. Simpson as having been tried on the Chelsea Waterworks, and found reliable in its measurements. It consists (Fig. 227) of four divisions,—First, a lower compartment; second, the turbine; third, the body; and fourth, the register. The inlet *a* opens into the lowest division; the water being admitted through this flows upwards through a dished strainer, and passing through three oval and oblique holes in the centre of the bottom division, Fig. 228, strikes against the turbine disc, Fig. 227. This disc is provided with a number of recesses (Fig. 229). The pressure of the water raises the disc, and at the same time, in striking against the recesses, imparts to it a more or less rapid rotary motion according to the velocity of the water, which then flows away through the outlet (Fig. 227). The body of the meter is provided with vanes attached to the sides, to prevent the water assuming a rotary motion after passing the turbine. The register is separated from the body of the meter, and connected by a spindle to the top of the turbine.

Fig. 227.

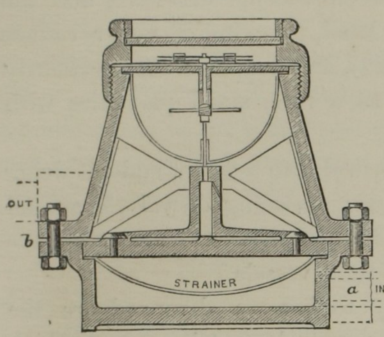


Fig. 228.

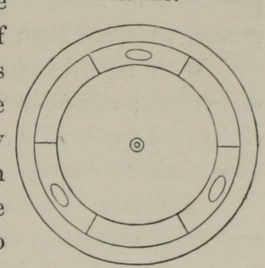


Fig. 230 illustrates a patent of Mr. Horsley's upon the principle of a rotary drum; *a* is a drum or cylinder mounted and fastened on the shaft *b*, which passes through a stuffing-box at one end of the case *c*, in which the drum revolves; *d* and *e* are inlet and outlet passages, and may be placed in any other suitable position in relation to the drum case; *f f f* are valvular flaps hinged to the periphery of the drum *a* by being slid into grooves formed thereon. These flaps fall into recesses, so that when closed they form a part of the periphery of the drum; they will necessarily fall over by their own weight, but Mr. Horsley prefers to actuate them by means of a cam or eccentric *b*, acting upon arms *g*, fastened to the flaps *f*, and forcing them outwards, as the drum revolves past the inlet passage *d*. The arms *g* pass through slots in the drum, which slots are packed with leather or suitable material placed between the drum and the circumference of the cylinder, to prevent the passage of the water in that direction. The ends of the drum *a* and the valvular flaps *f* are furnished with leather or other packing, and the longitudinal edges of the flaps may also be provided with strips of leather or other flexible material. Although the drum is shown in the cut placed nearly in contact with the top of the drum case, and in a horizontal position, this arrangement is not necessary, and the drum case may be placed either horizontally or vertically as occasion requires.

Fig. 229.

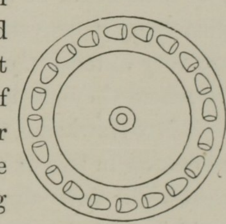


Fig. 230.

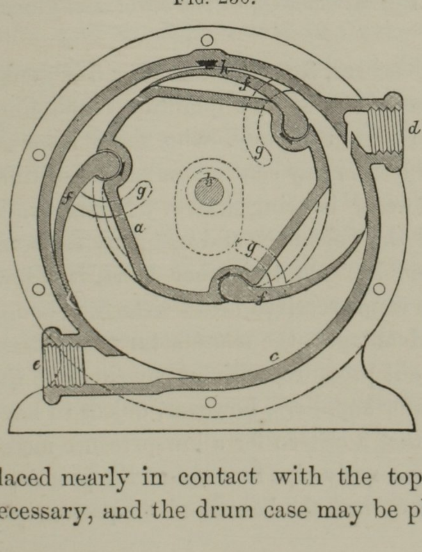


Fig. 231 is an elevation and Fig. 232 a section of a meter called the Eureka Meter, an American invention only lately introduced and patented in the United Kingdom. It is of the inferential class, and consists of a cylindrical casing, of which the upper part is greater in diameter than the lower. In this lower part is placed a propeller of hardened india-rubber, with spiral vanes so adjusted as to just clear the inside of the casing. The specific gravity of the propeller being about the same as that of water, it will move as the water moves. The inlet is placed at the side, the water flowing downwards, and escaping through the bottom of the casing into the outlet pipe which is here attached. On the upper part of the spindle forming the axis of the propeller a worm is cut which gears with the large wheel opposite the inlet pipe (*see* Fig. 232), this wheel actuating the index fingers by means of suitable clockwork. In fixing, the meter should be set "plumb," and no red lead used in making the joints. It is also necessary that the meter should, when set, be always full of water.

Fig. 231.

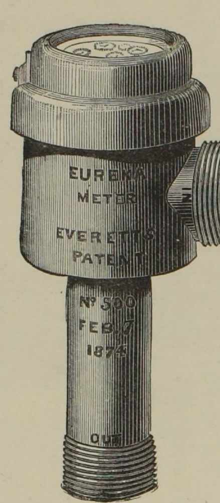
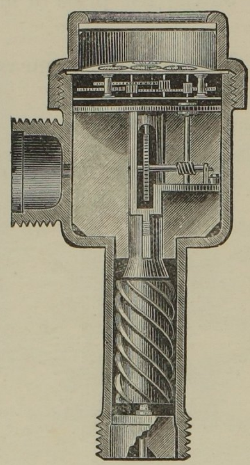


Fig. 232.



Considerable difference of opinion exists as to the relative merits of positive and inferential meters. The advocates of the latter claim simplicity of construction, cheapness, and greater freedom from friction than are possessed by positive meters; and urge that, although when new positive meters may be made to work with very little friction, yet so destructive is water under pressure, and containing silt, dirt, and sometimes acids, that the pistons, cylinders, cocks, or packing soon become defective, and the meter ceases to work with sufficient freedom or correctness. On the other hand, this kind of meter cannot register more water than actually passes through it (although it may register less), an advantage not necessarily possessed by inferential meters, and it is also claimed for it that it records, as a rule, small quantities with greater accuracy than its rival.

With regard to low-pressure meters, those made of measuring chambers formed into a drum, and revolving on centres; measuring chambers vibrating on centres; and those containing floats operating on valves, are all of limited application; they have no power to deliver water above their level, though several attempts have been made to convert them into high-pressure meters by enclosing them in air-tight vessels.

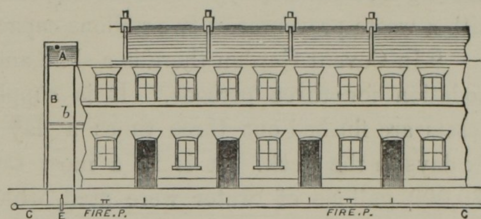
Accurate registration with the least possible loss of pressure or liability to become deranged are the requisites necessary to constitute a good meter; and though various improvements have taken place which overcome more or less the difficulty of gauging water under variable pressure, and render the meters consistent in the discharge of their duty without being liable to constant repair, still even in those most generally used a margin has to be allowed to cover discrepancies in the registration. A meter in general work, and registering within five per cent. of the actual quantity, may be considered in pretty fair working condition.

The juries of the Exhibition of 1851 who were appointed to examine the various water meters reported that none could be considered as trustworthy. It is, however, due to the various meter-makers to add that since then great improvements have been made, and those meters which have come into general application—and some are very extensively used—appear to meet the requirements of practice, to the satisfaction of the several engineers by whom they are adopted.

Mr. Hawksley, speaking of the high-pressure meter, says:—" Dyers, bleachers, &c., require, say, a 3-inch pipe to run off in two or three minutes many hundred gallons of water, and when the necessary quantity is obtained to stop the flow almost instantaneously. This causes great inconvenience to a company, who must have the main in that street, not in proportion to the quantity taken by the manufacturer in any continuous period of time, but to the rate at which it is intermittently delivered during the time the water is being drawn. Moreover, by thus suddenly shutting the taps, a great shock is brought upon the pipes of the consumer and company for some considerable area around, and where the pressure is great this is objectionable. On the other hand, if a low-pressure meter is used, it must be placed at the top of the building, and the water received into a cistern. Though this plan may appear to involve a small cost to the consumer, it has this advantage—the manufacturer can drain the water out of the cistern through a large pipe of his own, and under a light pressure, without any shock to the neighbouring pipes of the company, or the danger of bursting his own. Water suppliers, however, object to have their pipes taken on to trade premises without a meter, as it often happens that a cistern for a low-pressure meter can only be erected at some considerable distance from the point at which the supply pipe first enters the premises The consumer also often objects to the expense of cisterns, and also by the use of these the benefit of the pressure so necessary for some trades and in cases of fire is lost. These objections have caused the low-pressure meter to be disused in the vast majority of places. The advantage of regulating the flow of water drawn from the mains, and at the same time preserving the pressure, may be obtained by using high-pressure meters, combined with cisterns capable of holding a sufficient quantity of water; and as the meter could be fixed to the pipe on entering the premises, it would secure the registration of any water leaking or being abstracted from the pipe between the meter and the cistern. With this arrangement the high-pressure meter is much the superior."

A great obstacle to the introduction of constant service, especially in London, is the state of the house fittings in poorer localities, for as a rule those fittings that have escaped depredations are unfit for a constant supply, and in many instances the property is not considered worth the expense incurred in altering them. A method whereby much of this difficulty could be avoided was suggested some time since by Mr. Quick. Where, say, a row of houses of this class existed, he proposed to place at the top of the house nearest to the company's leading main, the cistern A, Fig. 233, supplied by the pipe B, from the branch main C C, a stop cock being placed at E, and the service pipe *b* taken from the cistern into the branch main again, but on the other side of the stop cock E. This cistern would be therefore acting as a safety valve to all the service pipes and fittings of that particular row of houses, and, by keeping the house pipes constantly charged, thus enabling the residents to draw water at any time from any of the floors in the row. Under arrangements of this kind, the use of meters might become more general, for it is especially in property of this description, in poor and crowded districts, that from a deficiency or absence of proper fittings enormous waste takes place, although if a charge is made in accordance with the quantity delivered it is said to provide an excuse for persons to limit themselves in the necessary use of water, and is alleged to be a consequent check upon cleanliness, it being a well-known fact that the consumption of water in small houses does not increase in proportion to the number of their inhabitants ; but in cases of this kind, by the use of a house meter, the simple fittings required would be more likely to be efficiently maintained, and, being indoors, would doubtless lead to the more healthy application of water. Upon this plan, to any given number of houses, a tank could be constructed of sufficient capacity to supply every house or flat, as the case may be, with a certain number of gallons per day. Such a tank, being under the control of the company, could be kept clean and in good condition, and would secure them against improvident waste.

FIG. 233.



The New Metropolis Water Act (1872) requires that an owner who pays the rate for a block of houses shall have a sufficiently large " communication pipe " attached to admit the requisite supply.

The New River, the East London, and other Metropolitan Companies, have frequently offered a constant supply to poorer-class houses, on the condition that a waste preventer be used, and a number of the well-known double valve waste preventing cisterns have in some instances been supplied by Messrs. Guest & Chrimes, of Rotherham.

In speaking upon this subject, Mr. Morris, the engineer to the Kent Water Company, states that many thousands of their consumers are supplied at a rate of 7*s*. or 8*s*. per house ; and he does not doubt a meter is a great teacher of economy; but, he adds, it would be practically impossible to put it into small houses. The cost and wear of the meter would, in these small supplies, amount, in fact, to more than the whole water-rent of the house. There is no mechanical or engineering obstacle to the supply of small cottages by meter, it being simply a question of expense. In the case of groups of houses, where one meter will supply several dwellings, then the meter system may be adopted without increasing the charge for water, as the cost of maintaining the meter being spread over several houses will make the charge per house as little or less than it would be under the poundage system.

Meters for the supply of better-class houses, where water-closets, baths, and fountains are supplied, have been in use for many years in most of the towns of England where constant high-pressure supply prevails, and they have more recently been adopted for the same supplies by some of the Metropolitan Companies. For such purposes they are said to be answering well at many places. For houses of this description under the intermittent system, the use of a domestic meter has been suggested, upon the principle adopted for registering the time of a uniform discharge by the ordinary swan-neck crane, either simply or in connection with other means of regulating the discharge of water. This uniform discharge implies the necessity of a uniform head of pressure, which the ordinary water cistern to every house would supply. The amouut discharged is registered by a small piece of clockwork, the action of turning on the water giving motion to the clock, and *vice versâ*.

The following quantities are usually considered sufficient for domestic purposes :—

A bath each time of use	75 gallons.
A horse per day	$16\frac{1}{2}$,,
A two-wheeled private carriage per day	9 ,,
A four do. do.	17 ,,

Each individual	. . . .	4 to 8 gallons.
A water-closet every time of use	. . . .	1 "
One yard superficial of garden ground	. . . .	0·33 "
One yard do. of roadway, every time of watering	. . . . .	0·22 "

In the case of manufacturers and other large consumers of water the use of meters may be said to be almost absolutely necessary and universal, and should be so fixed as to give the Company the control of all the pipes outside the premises leaving the interior service in the hands of the consumers.

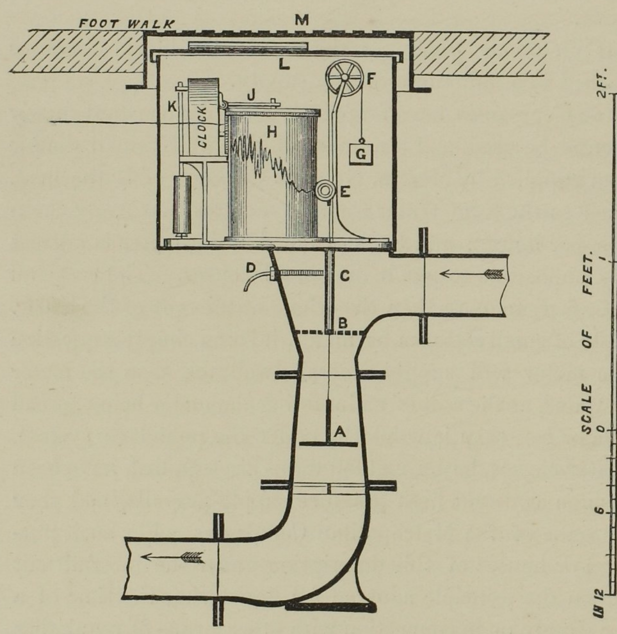
Where meters are used to command the several districts into which a town supply may be divided, it is of course easier to detect the immediate locality of waste, for it is usually pretty well known to the engineer of a company what should be the average amount supplied to each district.

For urinals and fountains approximate measurement is sometimes considered sufficient, though there should be some check upon the extravagant waste of water so frequently existing at these places. The New Metropolis Water Bill provides against waste in urinals, and requires a waste preventer, constructed so as to be capable of discharging not more than one gallon per flush, and that the water-closet cistern or service-box shall be provided with a waste preventer of two gallons capacity per flush.

"In Covent Garden there is a slate and brick urinal with accommodation for eight, and water closet accommodation for three persons. It is supplied by a one-inch meter, with connection for a hose and jet. The closets are flushed out three times a day always, and the urinals twice in winter, and three times in summer, six days in the week. It is in a most satisfactory state of cleanliness. During a period of twelve months, 180,000 gallons of water were used, which at 6*d.* per 1,000 amounts to £4 10*s.* 0*d.*, or about 8*s.* 2*d.* per closet and urinal."

"At St. Clement's Church, in the Strand, there is an iron urinal, by Macfarlane, for eight persons. This has urinal conveniences only, and is supplied, as in the former case, through a meter. Being in one of the busiest thoroughfares of the metropolis it is much used. During twelve months 91,000 gallons of water were used, being at the rate of about 5*s.* for each stall. At St. Mary's Church, Strand, there is another of these urinals, for six persons, but of the square instead of the circular shape. The cost of the water supply, in this case, has only amounted to 2*s.* 6*d.* per annum per stall." This urinal has less exposed surface in proportion to the accommodation than the circular one at St. Clement's, it is also probably less used, and these circumstances account for the difference in the water consumed.

Fig. 234.



When a meter is used for detecting waste in any district it is fixed to the supply main at or near the point where it enters the district, and the number and probable requirements of the people to be supplied are ascertained. The meter is then read at intervals, and the time between the readings noted. The quantity passed between any two of the readings is thus known, and from the data then collected it may be easily calculated if an undue amount of waste is taking place.

A meter for this purpose, called a waste water meter,* has recently been invented and patented by Mr. G. F. Deacon, C.E., the Borough and Water Engineer of Liverpool, and tried at that town with considerable success. It is of the inferential class, and differs from ordinary meters in this—that it registers on a sheet of paper the variations in the flow of water at different hours of the day, and also the time at which those variations take place. These papers may be preserved for future reference and comparison.

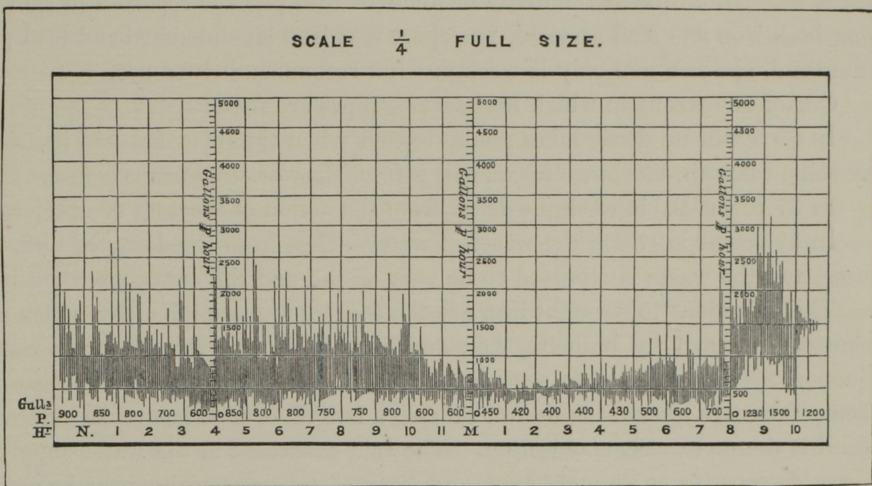
The meter consists of a vertical, hollow, truncated, brass-lined cone, Fig. 234, having within it a horizontal disc A of the same diameter as the upper and smaller end of the cone. From the upper surface of this disc projects a rigid stalk suspended from a fine German silver wire, which passes through a hole in the hollow boss C to a chamber above, where it is connected with a guided cross-head at E, carrying a pencil or tracer, and suspended from a band passing over a pulley F, supporting on the other side of the pulley a weight G, which always tends to draw the disc up to the top of the cone.

* For full description, *see* Transactions of Inst. C. E., Vol. XLII.

If, now, the instrument be fixed on the line of a water main, and all the outlets closed, the weight G will have raised the disc to the top of the cone, or zero point, and on a tap being opened beyond the outlet of the meter, water will seek to pass through, and, pressing upon the disc, drive it down to a larger part of the cone. The descent of the disc will cease when, by reason of the increased area of annular space between the disc and the cone, the pressure on its upper surface is relieved and the excess of that pressure over the pressure on the lower surface is exactly balanced by the excess of the weight G above the weight of the disc weighed in water, and the cross head weighed in air. This point at which the disc stops will be constant so long as the rate of flow is constant, and that rate of flow having been once ascertained by direct measurement will be measured in future by the tracer standing at the same point.

The vertical motions of the tracer are recorded on a paper wrapped round the drum H, driven by clockwork K. A copy of one of the diagrams is given in Fig. 235. The difficulties attending the use of small stuffing-boxes are removed by using a simple brass bush with a hole in it fitting the wire closely, and the small quantity of water which passes between the wire and the sides of the hole rises in the hollow boss C, and passes away by the drain pipe D. B is a brass diaphragm with perforations for equalising the flow of water, and L is the hinged and padlocked cover of the clock chamber, having a watertight india-rubber joint. M is a second cover carried by a frame in the footway. The drum with its paper is easily lifted from the footstep after the hinged bearing J has been raised.

Fig. 235.



The clock chamber is perfectly free from any dampness arising from the water in the mains, but in order to ensure firmness of the paper diagrams it is desirable in damp weather to place within the chamber a small saucer containing sulphide of calcium, which absorbs any moisture after the lid is closed. Although not absolutely necessary, it is nevertheless most desirable for the efficient carrying out of the system, as well as for the proper control of the supply to each block of premises in case of accident, that there should be stop cocks on the communication pipes between the service main and each house, or groups of houses, under the control of the inspector without entering the premises.

Between the hours of 12 midnight and 5 A.M. is the best time for working the system, as between those hours the consumption is most regular. The Inspector begins by closing the stop cock to a block of buildings, and noting the time at which this is done. On examining the diagram there will either be no change, at that time, in the steady night line, broken only by an occasional draught, or it will show by a vertical movement of the pencil, and a continuation of the steady line at a lower level, that only a reduction in the continuous flow has taken place, and therefore the premises supplied by the pipe in question should be visited by an inspector on the following day. By closing all the stop cocks it may be ascertained whether the mains are in a sound or a leaking condition.

The system of inspection by meter possesses several advantages over the old method of house-to-house visitation. The annoyance caused to the householders by personal visits is avoided, and leakage is detected which, occurring in inaccessible or unseen situations, would otherwise be allowed to exist. The state of the mains also may at any time be tested, and the error be avoided of taking up mains that are really sound, but are supposed from their age or from other reasons to be faulty, and of allowing others to exist when they may be leaking to a great extent, but may not be suspected of so doing. Two examples will illustrate some of the advantages of the meter system of inspection. "From the meter and stop-cock investigations a large leak was found to exist, but for some time its precise position baffled discovery. It was at last discovered to originate in a lead pipe, one end of which was connected with the main, whilst the other was pouring its contents into an old sewer man-hole. It had probably been cut off during some alterations, and carelessly left in the position in question. In another case a large leak was traced, and found to arise from a hole, an inch in diameter, in the bottom of a three-inch service main. This hole was immediately over the crown of an old sewer, from which it had washed out a brick, and directly into which it was pouring its contents. Both these cases must have been in existence many years."

House services, or, as they are termed in certain Acts of Parliament, "communication pipes," are the small pipes by which the water is conveyed from the street main into and about the premises of the consumer. They are made generally of wrought iron, lead, and lead alloyed or lined inside with tin.

Much interest has of late been manifested as to the kind of material that should be used for these pipes, especially when intended for domestic supply.

Out of 148 towns in England, Scotland, and Wales, returning answers to enquiries, the following information respecting the use of wrought-iron service pipes was obtained:—

In	87	towns	they decay, or are not used on that account.
,,	25	,,	doubtful, or had no experience.
,,	11	,,	do not decay, or it has not been observed.
,,	25	,,	recommended.
And	18	,,	returned no answer to this question.

The number of towns included in the schedule in which iron service pipes are either partially or entirely used is 68. In 43 towns the decay of wrought-iron pipes is reported to lead to the waste of water. In 35 towns using both iron and lead services, 25 report that iron is condemned and lead preferred. In seven towns the result is doubtful, and in three only is wrought iron recommended for use.

Out of 130 towns in which lead service pipes are used:—

In 89 towns no decay takes place, except when the pipes are laid in ashes, marl, clay, lime, rubbish, some clay soils, coal ash, mortar, cinders, salt refuse, slag, or sulphurous refuse.

In 37 towns liable to slight decay from the action of the soil, or other causes.

In 39 towns in which the waste of water arises from the decay of lead, 31 show that decay is due to special causes, and the waste is reported to be very slight, and the occasions when it occurs very rare.

The objections to wrought iron are the constructional difficulties which attend its use, for which reasons it is frequently rejected by builders, &c.; and its liability to oxidation from contact with the water. The former objection may be avoided to some extent by the judicious use of double-screwed joints inserted at convenient places; these are afterwards useful, in case a length of pipe has to be removed for alterations or repairs. The second is the more serious objection. The acid contained in the water supply of some towns, and also the earth, is very destructive to wrought iron, and pipes of this material cannot be coated by the process used for the protection of mains of cast iron, as the varnish that is absorbed by the crystalline nature of the latter metal scales off when applied to the fibrous surface of the former.

Galvanizing iron, it appears, does not preserve it from corrosive influence, for at Wolverhampton and other places, and also, according to the testimony of M. Rouse, who has written on the subject of its use in the French Navy, this process renders it brittle under pressure, and liable to the action of frost. In the experiments made by Mr. B. Latham* (see Table, page 212), the loss of weight sustained by pipes of this description is greater than in any other case. This gentleman speaks of having taken up pipes at Croydon which were reduced to the thickness of a sheet of paper by the destructive agency of water. The following extract from his report may account for the excessive decay of iron which appears to have taken place. "Unfortunately," he says, "it now happens in the Croydon district that if there be any defect in the services or fittings, impure water or impure air is drawn into the mains when the water under pressure ceases. The air which takes the place of the water when the mains are drained is now taken from localities in which the purity of the supply is questionable. As an example, take a district of 3,000 houses, the water-closets of which are fitted with screw-down valves. In the event of any of these valves being left open (of which there can often be no doubt), when the supply of water is cut off air from the water-closets rushes into the mains, and on the water being again turned on, it becomes aërated from this very objectionable source."

It may be stated that the rapidity of corrosion of iron pipes is sometimes due to the quality of the iron as well as that of the water, as some kinds of iron are more predisposed to chemical action than others.

With regard to the effect of lead pipes upon water a large amount of medical and scientific evidence has been produced.

Professor Brand, London, says: "Farnham and Watford waters (soft) have a very considerable action on lead; to such an extent, I should think, as to be very dangerous; much more so than either the Thames or Lea waters."

Alfred S. Taylor, Guy's Hospital, says, "The West Middlesex water (hard) is not likely to acquire any noxious impregnations from lead. When the saline substances which it contains, and which give to it its moderate degree of hardness, are removed by distillation, the water acquires a well-marked impregnation from lead by a few minutes' contact with it. It is evident, therefore, that this saline matter confers on the water the property of resisting this chemical action with lead."

* Report on the Water Supply of Croydon, 1871.

Dr. Thomas Clark, Professor of Chemistry, Aberdeen University, says : "It is well known that distilled water acts very readily upon lead. With respect to lead pipes, I should say the less lead is used the better in all cases."

Mr. Joseph Quick, of the Southwark Water Company, states that "the Manor Estate at Clapham Common was supplied through lead pipes with water from a spring well in the centre of the Common. The inhabitants were attacked with severe illness, which seems ascribable to the length of lead pipe through which the water passed. Upon analysis lead was detected in the water, and the lead pipes were taken up and removed."

Dr. Angus Smith, M.D., Manchester, acknowledged that "with soft water, lead was very dangerous, and considers that, in some cases, it may be equally so with hard."

"I am inclined to think," says Mr. Henry Ward, Lecturer on Chemistry, Guy's Hospital, "that the action on lead depends greatly on the aëration of the water. In rainy weather, when the Dee water is coloured, and contains little air, the quantity of lead deposited in any case appears to be less than when the water is clear and well aërated."

In the report of Messrs. Graham, Miller, and Hoffman, they state: "They are disposed to conclude that the danger from lead in town supplies has been over-rated, and that with a supply from the Water Companies not less frequent than daily, no danger is to be apprehended from the use of the present distributing apparatus, with any supply of moderately soft water which the Metropolis is likely to obtain."

"So uncertain," says Dr. Lander Lindsay, "is the action of water on lead, so impossible is it to predicate the nature or extent of that action, under the varying mechanical and chemical conditions of water supply of houses and towns, so difficult is it to prevent possible danger, so numerous and excellent are the substitutes that may be provided for lead in the construction of cisterns and pipes, that it is desirable henceforth to abolish the use of lead as a material for the conveyance or storage of water."

"Out of sixteen samples of Welsh water collected for the Commission on Water Supply by Mr. Pole, nine were found to act more or less on bright lead, and five to have no action; while on tarnished lead two had considerable action, and fourteen had no action."

"An enquiry of the most extensive kind, held in 1854–5 by the Town Council of Glasgow, in connection with the Loch Katrine supply, proved—*inter alia*—the Loch Katrine and other equally pure or soft waters (containing under 2 or $2\frac{1}{4}$ grains per gallon of solid matter), with a hardness of 0·6 or 0·8, Clarke's scale, exerted, under given circumstances, no deleterious action on lead."

There are two ways in which water may act on lead—1st, it may corrode the metal and form a white deposit; 2nd, it may dissolve the metal, in which case it would not be visibly apparent, and proper tests would have to be applied to discover its presence. The proportion of lead required to produce serious ill effects is small; in a case where Mr. Herepath analysed the water, it was found to be less than one-ninth of a grain per gallon.

From the preceding testimony it appears that with certain kinds of water, and under certain conditions, lead pipes may be tolerably safe; whilst under other circumstances, and with other waters, they may prove highly dangerous. It also appears that the uninterrupted flow of water through a lead pipe to immediate use may not affect it injuriously; while, on the other hand, should it remain long in the pipes without change, or be passed through pipes that have been some time empty, it may become sufficiently tainted to be dangerous.

There are cases, it is said, in which waters, by being passed through certain materials, may be rendered innoxious, and incapable of acting upon lead. Mr. Bateman claims this property for the chalk and sandstone conduits of the Loch Katrine Waterworks. He says "that the water passing through the old red sandstone or limestone loses its power of acting upon lead; the water dissolves a small quantity of salt and carbonate of lime; these substances protect the surface of the metal from further chemical action." (See also Chap. II.)

In the dilemma arising from what was considered the failure of both iron and lead, pipes of bitumenized paper and gutta-percha have been tried, but failed under pressure. They also imparted a disagreeable odour and taste to the water, and were liable to be affected by change of temperature.

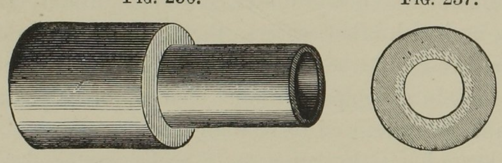
The following Table contains the results of experiments made by Mr. B. Latham for the purpose of testing the durability of various kinds of pipes. Soil was taken from a district in Croydon known to have an effect upon pipes, and placed in an earthenware jar. Two short lengths of pipe were buried in it, the action taking place in the soil through a long period being artificially produced by distilled water containing a small percentage of nitric acid. The duration of the experiment was 40 days.

Description	Weight of Specimen before Treatment	Weight of Specimen after Treatment	Loss in Grains	Duration of Experiment
	Grains	Grains		Days
Block-Tin Pipe	944	944	Nil	40
Do.	1,412	1,412	Nil	40
Lead Pipe	4,125	4,125	Nil	40
Do.	7,036	7,036	Nil	40
Enamelled Iron Pipe	2,469	2,469	Nil	40
Enamelled Iron Pipe (Imperial Tube Company, Birmingham)	3,305	3,305	Nil	40
Tin-lined Lead Pipe	2,913	2,913	Nil	40
Do.	3,778	3,777	1	40
Composition Pipe	1,662	1,661	1	40
Do.	2,438	2,437½	½	40
Lavcnant Enamelled Iron Pipe . . .	2,096	2,094	2	40
Do. do. . . .	3,092	3,091	1	40
Galvanised Iron Pipe	2,035	2,029	6	40
Do.	3,428	3,420	8	40
Plain Iron Pipe	2,336	2,331	5	40
Do.	3,261	3,257	4	40

Several attempts have been made with tinned lead to produce a thoroughly innoxious pipe for house service. One process of coating is accomplished by drawing the pipe through a bath of molten tin; another by passing the pipe as it is formed through molten tin, held round the pipe above the die for the exterior coating, and supplying it, for the interior, from a perforated cup in the top or core of the mandril. Another method is that of electro-plating the pipe with tin. The ordinary processes fail in that they generally cover the pipe with such a thin wash of tin that it is rapidly worn off by the friction of the water, thus reducing the pipe to the same condition as one of common lead.

Fig. 236 is a side view, and Fig. 237 a section of Haines's patent lead-encased block-tin pipe manufactured by Messrs. Walker, Campbell, & Co., of Liverpool. It consists of an interior pipe of pure block-tin encased in a coat of lead of considerably greater thickness, and the two pipes are so combined as not to be separated by bending or contortion. In consequence of the greater tensile strength of tin as compared with lead, this kind of pipe may be made very much lighter for the same bursting pressure than an ordinary lead pipe of the same internal diameter.

Fig. 236. Fig. 237.



The following are the results of experiments on the bursting pressure of ordinary lead pipes, and that of the patent lead-encased block-tin pipes:—

ORDINARY LEAD PIPES			LEAD-ENCASED BLOCK-TIN PIPES		
Diameter of Pipe	Weight per Yard	Average Bursting Pressure of Three trials	Diameter of Pipe	Weight per Yard	Average Bursting Pressure of Three trials
Inches	lbs.	lbs. on Sq. Inch	Inches	lbs. ozs.	lbs. on Sq. Inch
1	12	1,158	1	6 12	1,187
1	10	1,023	1	5 10½	1,037
¾	10	1,364	¾	5 1	1,627
¾	9	1,231	¾	4 2	1,597
½	7	1,772	½	3 3	2,499
½	6	1,645	½	2 12¼	2,401

Results of Mr. Kirkaldy's Tests of the Comparative Extension under Bursting Pressure of Haines' Patent Pipe and Common Lead Pipe.

HAINES' LEAD-ENCASED TIN PIPES							ORDINARY LEAD PIPES						
Calibre of Pipe	Weight per Yard	Average Thickness of Pipe	External Circumference	Circumferential Extension at Bursting Pressure			Calibre of Pipe	Weight per Yard	Average Thickness of Pipe	External Circumference	Circumferential Extension at Bursting Pressure		
Inches	lbs.	Inches	Inches	Inches		per cent.	Inches	lbs.	Inches	Inches	Inches		per cent.
½	3·034	·119	2·30	·36, ·32, ·39	·36	15·6	½	5·695	·183	2·75	·17, ·25, ·15	·19	7·0
¾	4·955	·137	3·20	·53, ·48, ·42	·48	15·0	¾	8·218	·190	3·60	·54, ·47, ·31	·44	12·2
1	6·328	·133	4·06	·51, ·42, ·31	·41	10·1	1	11·312	·205	4·45	·30, ·27, ·23	·27	6·1
1½	6·547	·114	4·70	·65, ·53, ·68	·62	13·2	1¼	12·375	·186	5·15	·74, ·66, ·53	·64	12·4
				Average per cent.		13·5					Average per cent.		9·4

Table showing Cohesive Strength deduced from the Results of Tests made by J. M. Gale, Esq.

COMMON LEAD PIPES					LEAD-ENCASED TIN PIPES				
Calibre of Pipe	Thickness of Metal	Weight per Yard	Average Bursting Pressure (of Three trials) per Square Inch	Cohesive Strength	Calibre of Pipe	Thickness of Metal	Weight per Yard	Average Bursting Pressure (of Three trials) per Square Inch	Cohesive Strength
Inches	Inches	lbs.	lbs.	lbs.	Inches	Inches	lbs. ozs.	lbs.	lbs.
1	·260	12	1,158	2,226	1	·130	6 12	1,187	4,565
¾	·260	10	1,363	1,965	¾	·140	4 2	1,627	4,358
½	·200	7	1,772	2,214	½	·120	3 3	2,499	5,206
				3)6,405					3)14,129
Average Cohesive Strength . .				2,135	Average Cohesive Strength . .				4,709

Results of Experiments made at the Workshops of the Liverpool Waterworks, May 5, 1870.

COMMON LEAD PIPES					LEAD-ENCASED TIN PIPES				
Calibre of Pipe	Thickness of Metal	Weight per Yard	Average Bursting Pressure (of Three trials) per Square Inch	Cohesive Strength	Calibre of Pipe	Thickness of Metal	Weight per Yard	Average Bursting Pressure (of Three trials) per Square Inch	Cohesive Strength
Inches	Inches	lbs.	lbs.	lbs.	Inches	Inches	lbs.	lbs.	lbs.
½	·220	7	2,470	2,806	½	·110	2¾	2,678	6,086
¾	·240	11	1,941	3,328	¾	·110	4¼	2,117	7,217
1	·220	12	1,050	2,386	1	·120	5½	1,474	6,141
				3)8,520					3)19,444
Average Cohesive Strength . .				2,840	Average Cohesive Strength . .				6,481

Experiments have been made on the lead-encased block-tin pipes by bending and distortion, and it has been found that the homogeneous character of the combination was still maintained. Professor Muspratt tested them by bending a portion of one into the shape shown in Fig. 238, leaving a distance of about 3 inches between the two limbs. It was then filled with several mineral acids in succession, and to increase their action immersed in a hot bath. The solutions were analysed, and the metal in residuum found to be pure tin, proving that no rupture between the tin lining and lead case could have taken place by the distortion of the pipe. "I have subjected," says the same authority, "other portions of the same pipe to chemical tests, having for their aim the determination of the fact whether or not it was affected by service waters, or fermented and weak acid liquors. The conditions under which these experiments were conducted, especially in relation to the nature and strength of the liquids employed, and the time allowed for their action, were such as to test the behaviour of the pipe to almost extreme degrees. I have found that neutral natural waters have no action upon the pipe, and that fermented liquors containing generally appreciable traces of acid substances do not act upon it. Unfortunately this pipe cannot be soldered so simply as one of lead, on account of the melting point of tin being considerably lower than that of lead. To prevent the tin lining melting during the process, and the possibility of any impediment to the true union of the pipes, a tube a few inches in length, and of the same diameter as the bore of the pipe, is placed at the junction, and the solder may be shaped the same as in a lead joint, or the joint made in the form of a cone. The manufacturer recommends the use of cadmium, which renders the solder fusible at a much lower temperature, thus preventing any disturbance to the tin lining of the pipe. Bismuth would probably answer the same purpose, and at a much lower cost."

Fig. 238.

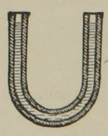
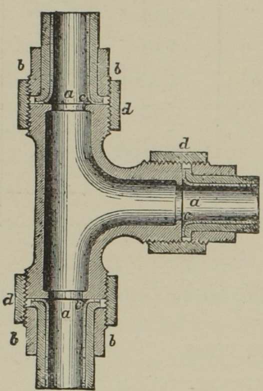


Fig 239



Figs. 239 and 240 illustrate a joint (Messrs. Heap & Co.'s patent) by the use of which the application of heat is avoided. The ends of the pipe *a a*, are passed through the nuts *b b*, the end of each pipe being then slightly expanded by driving the plug (Fig. 241) into it. The flanges at *c* are then formed by means of a flat-faced hammer; the collar *d* is then passed over them, and tightened up with a spanner. This pipe may also be joined with flanges.

Much annoyance is often caused by the bursting of service pipes in cold weather. The water in freezing expands, and brings a strain upon the pipes that ultimately bursts them; and when a thaw sets in, leakage takes place through the fracture. Various expedients have been tried to avoid this. One device is, to keep a small jet of gas burning during the frost, in contact with the service pipe at the point where it enters the house, the pipe being protected by a thin sheet of copper gauze.

Fig. 240.

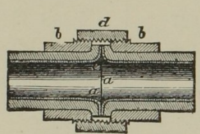


Fig. 241.

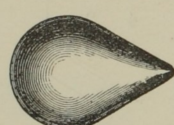
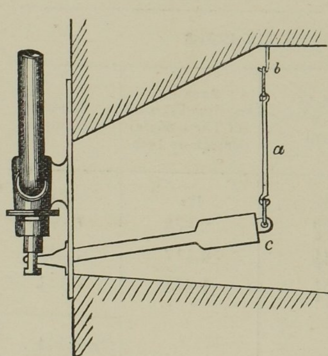


Fig. 242 illustrates an invention known as "Moore's Pipe Protector," the object of which is to cut off the connection between the service and the main when a frost sets in. One end of a weighted lever is fastened at *c* to the lower end of a glass tube *a* which is attached to the brickwork of the wall at *b*; the other end of the lever acts upon a valve placed on the service pipe. The tube is nearly filled with water, leaving only a small space for air. On the water freezing it bursts the tube, thus liberating the lever, which falls and closes the valve.

Fig. 242.



Common's Automatic Apparatus for protection of pipes from frost depends for its action on the freezing and expansion of a small quantity of water contained in a properly formed hermetically sealed thin copper vessel. In one arrangement the vessel is in connection with a weighted lever acting on a three-way cock. When the frost is sufficiently severe, the water in the vessel expands, and causes the lever to fall, thus shutting off the water from the main, and at the same time allowing the dead water from the pipes in the house to escape. To obtain water the lever must be raised. If a thaw has set in, the lever on being released will remain open, but if the frost continues it will fall again, and cut off the water as before. The water can also be cut off independently of the copper vessel, the apparatus thus taking the place of an ordinary stop cock.

By another arrangement the vessel opens a small valve, and allows a very small stream of water to escape, keeping up sufficient motion to prevent the pipes bursting.