2 Sheets—Sheet 1.

H. L. ARNOLD.

WATER METER.

No. 185,010. Patented Dec. 5, 1876.

Fig. 1.

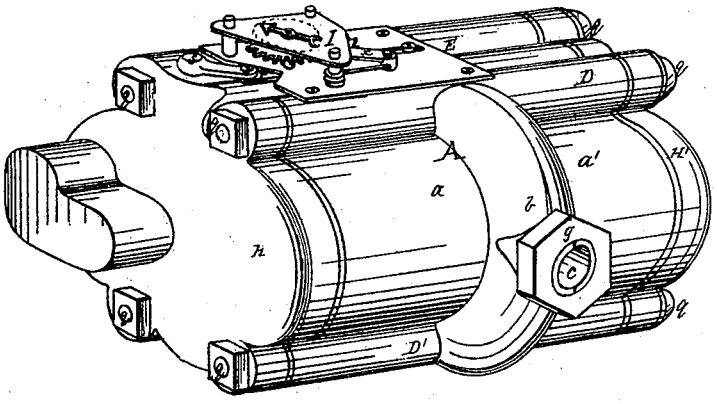


Fig. 2.

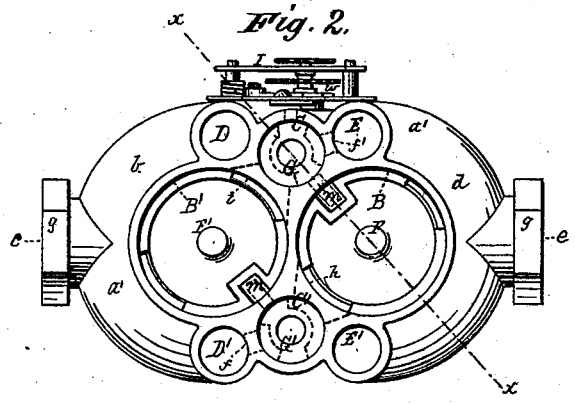


Fig. 3.

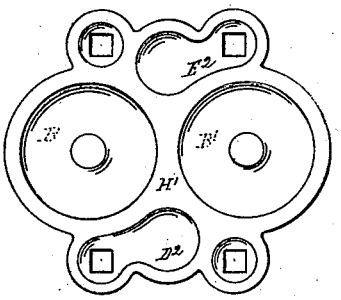


Fig. 4.

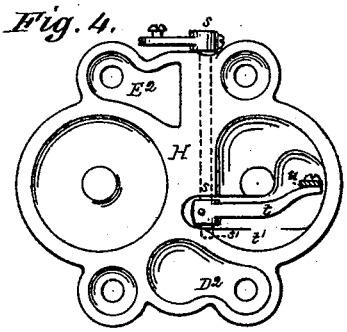


Fig. 5.

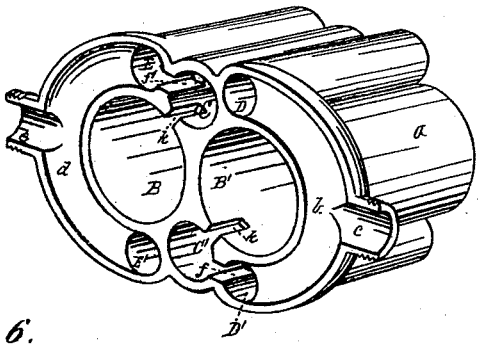
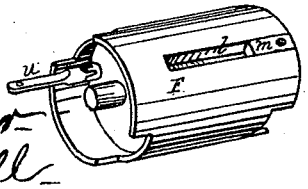


Fig. 6.



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2 Sheets—Sheet 2.

H. L. ARNOLD.

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Fig. 7.

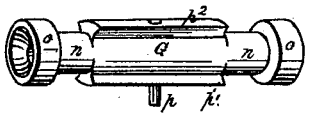
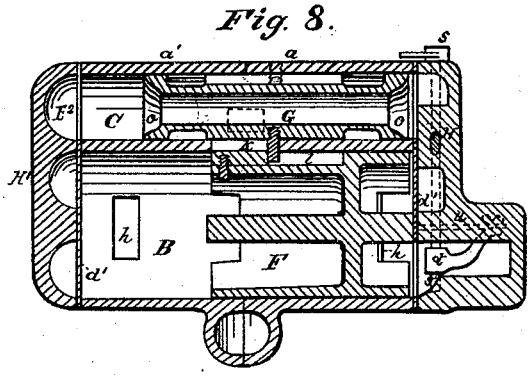


Fig. 8.



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UNITED STATES PATENT OFFICE.

HORACE L. ARNOLD, OF GRAND RAPIDS, MICHIGAN, ASSIGNOR OF ONE-HALF HIS RIGHT TO WM. H. POWERS, OF SAME PLACE.

IMPROVEMENT IN WATER-METERS.

Specification forming part of Letters Patent No. **185,010**, dated December 5, 1876; application filed October 2, 1876.

To all whom it may concern:

Be it known that I, HORACE L. ARNOLD, of Grand Rapids, in the county of Kent and State of Michigan, have invented certain new and useful Improvements in Water-Meters; and I do hereby declare that the following specification, taken in connection with the drawings furnished and forming a part of the same, is a clear, true, and complete description thereof.

My said improvements relate to piston-meters, and particularly to that class in which two or more measuring-pistons are employed, with two or more valves, and are so arranged and connected that each of the pistons actuates a valve for controlling another piston. An early instance of meters of this class is the one described in the Letters Patent issued to H. R. Worthington, July 24, 1855, No. 13,320.

Prior to my invention such meters have been so constructed as to render them comparatively difficult to manufacture, and too expensive to enable them to enter into general use.

The prime object of most of the novel features herein described is the economic production of meters of the class referred to, meantime increasing their accuracy for measuring, their ease in operation, and their general durability.

Inasmuch as no balance wheels or springs are employed, and as the pistons are wholly disconnected from each other, it is necessary that the live water should be delivered to the pistons in such a manner that one piston will follow the other in all its movements. This delivery of water is, by Worthington, effected by means of diagonally-crossed water-passages, and although, as suggested in the specification of his Letters Patent before referred to, it may be possible to dispense with the diagonal ports and his slide-valves, by substituting therefor a system of levers, it is obvious that the less operative mechanism an accurately-measuring fluid-meter contains the greater its practical value.

In my meter the live water is delivered to the valves in a manner substantially as in the Worthington meter, but I have devised an entirely different system of water-passages, and it is owing to this novel system of passages that I am enabled to attain an important saving in the first cost of the apparatus. Instead of diagonal water-passages, which, in casting, require dry-sand cores, mine are all straight, parallel with each other and with the piston-cylinders, and therefore the entire shell can be cast with green-sand cores; and one portion of my invention consists in a shell for a piston-meter having water-passages, valve-chambers, and piston-chambers, which are straight and parallel with each other. By reason of this peculiarity of construction I am enabled to cast my shell in counterparts from a single pattern one-half the length of the shell, and provide for a central peripherical induction and eduction passage communicating, respectively, with two of the straight water-passages before referred to; and another feature of my invention consists in a piston-meter shell, having piston-cylinders, valve-chambers, and water-passages parallel with each other, cast in counterparts and connected by a transverse joint.

Aside from the economic advantages accruing from casting such a shell, it will be seen that all the valve chambers and cylinders may be simultaneously bored out and finished by a suitable special tool, or that, being simply straight work, they may be cheaply finished by ordinary tools; also, that the water-passages may be readily smoothed out to secure an easy flow of fluid with a minimum of friction; also, that the lateral valve-ports connecting the piston-cylinders with the valve-chambers near their ends may be cheaply cut and finished by means of milling-tools; also, that internal ports and valve-slots, located midway in the water-passages and valve-chambers, may readily be cut into the central portion of the valve-chambers by milling-tools, before the two counterparts are united.

While all the chambers and passages within the shell of my meter are circular, straight, and parallel with each other, I secure the same delivery to and discharge from the piston-cylinders as in Worthington's meter, by connecting two of the water-passages with their respective valve-chambers by means of

recesses in the rear faces of the heads of the meter; and another feature of my invention consists in the combination, with parallel piston-cylinders, valve-chambers, and water-passages, of heads, which are recessed for connecting both ends of two of the water-passages with the valve-chambers, with which they respectively co-operate.

In the Worthington meter the slide-valves are actuated by contact therewith of flanges or arms on the piston-rod, located between two separate piston-heads, which operate as one piston, and all meters of this class involve the same mode of operation. When, however, two separate pistons in one cylinder are employed, the necessary intermediate space between the two necessitates a longer shell than a single piston would require in a meter having the same measuring capacity. Moreover, the longer the piston is the less the necessity for a close fit to the cylinder, because the water has a greater packing-area. Therefore I employ a piston with a single head, and a peripherical shell, which extends in both directions therefrom.

Instead of a central space, as in Worthington's, I employ a longitudinally-slotted recess, centrally located in the periphery of the piston, having a length nearly equal to the extent of the movement which the piston makes in either direction before actuating the valve which controls its fellow piston. Said valve is in an adjacent chamber, which communicates with the cylinder containing the piston which actuates this valve by way of a slot parallel and coincident with the slotted recess in the the piston, and having such length as to but little more than permit the valve to receive its correct travel by means of a stud or pin, which is fixed in the valve, and projects through said slot into the recess of the piston, so that in its movements to and fro the piston will move without moving the valve until the end of the recess strikes the stud, after which both move together to the end of the stroke. The recess in the piston is guarded against the passage of water thereto from either side of the piston by the packing-surface of the piston, which wholly surrounds it; and another feature of my invention consists in a meter-piston having in its periphery a centrally-located longitudinal recess or slot for operating a slide-valve.

It being important that this recess should be guarded to the fullest possible extent, and although by the central slotted recess in the piston I guard it from water *via* the piston-cylinder, I go still farther, for preventing undue leakage by way of the valve-chamber. This I accomplish by providing on the portion of the valve which overrides the slot in which the valve-stud is located a packing-surface, which extends beyond the sides of the recess, and has a length of more than the length of the slot, plus the travel of the valve, so that, wherever the valve may be, there is ample lap of this packing-surface beyond the sides and ends of the pin-slot, to secure a practically water-tight joint; and another feature of my invention consists in the combination, with a piston-cylinder, and a valve-chamber communicating with the cylinder by a pin-slot, of a slide-valve, provided with a valve-surface, which invariably covers the pin slot.

As a flat slide-valve is unbalanced, and necessitates in its construction machine-work, which is not readily executed in a boring-lathe, I employ cylindrical piston-valves; and in order that these valves may be moved freely I employ those which are tubular and have open ends; and although such valves are not new, *per se*, one portion of my invention consists in the combination, with the pistons in a piston-meter, of double piston-valves, tubular in form, open at both ends, and having an independent water-space between the pistons, whereby the water-way area leading to or from the port is largely increased, and whereby the valves in their movement are freed from end pressure, which could not be the case if they had to move against a column or body of water. The power for moving these valves is derived from the pistons, which, in each instance, engage with the end of a pin which projects radially from the middle of the valve, through a slot in the valve chamber, into a longitudinal recess in the periphery of the piston. The alternate pressure of the piston upon opposite sides of the pin, at its end, is conducive to a tilting strain on the valve, which, unless provided for, would rapidly wear the pistons or heads of the valve and the sides of the valve-chamber.

By one feature of my invention I obviate this tendency, by providing the stem of the valve with a central bearing-surface opposite the valve-surface around the pin before referred to. This bearing-surface is turned off to the radius of the valve, and, being opposite the pin, and of considerable area, it operates as a heaving face for preventing any undue tilting strain on the valve. Between these two surfaces, on each side of the valve, is a longitudinal space, and between the inner ends of each piston of the valve and these surfaces is an annular recess, all of which, when the valve is in its chamber, affords ample space for a water-passage between the pistons of the valve.

For operating a registering apparatus it is essential that there be some kind of connecting mechanism between the interior moving parts of the meter and said exterior apparatus, and also that said connecting mechanism be operated with such joints as will prevent leakage.

It is obvious that packing, ordinarily considered, is conducive to friction, and that undue friction in water-meters should be avoided as far as is practicable.

One feature of my invention consists in the combination, with the piston of a water-meter, of a register-operating shaft mounted within a recessed head of the meter upon a step, and

provided with an arm or lever above the step within the meter for connection with the piston, and an arm outside the meter for connection with the registering apparatus. The recess in the head affords a space within which the lower arm can vibrate when moved by the piston. The shaft has a long bearing which requires no special packing, and it can be therefore comparatively loosely fitted and free from undue friction. Its lower end being mounted in a step, and the interior lever being mounted upon the shaft between the step and the long bearing, secures an easy movement and obviates liability of the irregular wear of the shaft and its bearing, which would be otherwise incident to the weight of the arm and the parts connected thereto, and to the one-sided strain thereon through the operation of the piston and the actuating of the registering apparatus.

To more particularly describe my invention, I refer to the drawings, in which—

Figure 1, Sheet 1, represents one of my meters in perspective. Fig. 2 represents the meter in end view with its rear head detached. Figs. 3 and 4 represent, respectively, the inner faces of the two heads of the meter detached. Fig. 5 represents, in perspective, one-half of the shell of the meter, the same being a counterpart of the other half thereof. Fig. 6 represents, in perspective, one of the pistons detached. Fig. 7, Sheet 2, represents, in perspective, one of the valves detached. Fig. 8 represents the meter in longitudinal section on the diagonal line *x*, Fig. 2.

The shell of the meter is shown at A. It is composed of two counterparts, *a* and *a'*, the point of connection between the two being midway between the two ends of the shell. One of these parts is shown in Fig. 5. B and B' denote the two measuring-cylinders, and C C' the two valve-chambers, which contain valves for controlling the induction and eduction of water to and from said cylinders. D and D^1 denote two induction water-passages connected with each other by a peripherical duct, *b*, in the shell, which has an entrance at *c* for connection with any water-supply pipe. E and E^1 denote two eduction water-passages, which are connected with each other by the peripherical duct *d*, and have an exit or discharge aperture at *e* for connection with a cock or other discharging device.

It will be seen that the measuring-cylinders, the valve-chambers, and the four water-passages are straight, circular, and parallel with each other; also, that the peripherical water-passages *b* and *d* are at right angles thereto, and are formed by the duplicate annular recesses in the two counterparts.

Each part of the shell is only one-half the length of the complete shell, and by reason of this short length, and the fact that the four circular water-passages, two valve-chambers, and two measuring-cylinders are parallel with each other, and the peripherical ducts being formed by the uniting of the two counterparts, I am enabled to cast each half of the shell solidly with green-sand cores.

At central points therein, one of the induction and one of the eduction passages communicate with a valve-chamber by a lateral duct, as at *f* and *f'*, Fig. 5. This duct is formed by cutting away the metal with a milling-tool, at the point shown, in two of the counterparts, so that when they are put together a port is formed having twice the length of the cut made by the milling-tool. A longitudinal central slot is also cut in like manner, as at *k*, so that the two valve-chambers open into different cylinders as a means of operative communication between the valve and piston, as will hereafter be described.

Two counterparts, having been properly faced off, are placed end for end in close contact with each other. The two halves of the inlet and outlet ducts *c* and *e* are threaded externally to receive the nuts *g*, which bind the two halves securely together. Interior threads are also provided for connection with a supply and a discharge pipe. The joint between the two halves is rendered water-tight by soft solder or other suitable means. When thus united the shell is treated as if a solid piece of casting. The water-passages, if not sufficiently smooth, may be readily drilled, bored, or reamed, and the valve-chambers and measuring-cylinders may be bored, as usual in such operations.

By using a special tool, carrying four boring-spindles, the valve-chambers and cylinders may be simultaneously finished, and to such a tool four additional spindles may be attached for simultaneously boring out the water-passages, should it be necessary to perform that operation.

Each valve-chamber communicates at each end with its respective measuring-cylinder by lateral ports, as shown at *h* and *i*. (See Figs. 2 and 8.) These ports are cut by means of a milling-tool, of a diameter sufficiently small to enter the measuring-cylinder, and they have, therefore, a large area of opening in the cylinder, and a smaller area in the valve-chambers—that is to say, these ports have straight sides, but are longitudinally enlarged within the cylinder. I am, therefore, not only enabled to economically make these ports, but they are smoothly finished, and have the most favorable form for affording a free passage of fluid.

Although the peripherical water-passages, communicating on each side with two of the straight passages, as shown, constitute the best means, as I believe, for induction and eduction, it is yet possible to attain a portion of the substantial benefits of my invention, so far as economy is concerned, by employing the straight and parallel water-passages, valve-chambers, and piston-cylinders, without the peripherical ducts; as, for instance, by substituting for said ducts short sections of pipe with T-joints and elbows, and these may be entered either at the middle of the straight

passages, which would be preferable, or at their ends, through the heads of the meter, as will be clearly obvious to persons skilled in the art.

The heads H and H′ are also readily cast in green sand. Each, however, requires a pattern for casting, but these two patterns and the single pattern for one-half of the shell constitute all that are requisite for casting the entire body of the meter. Each head has two recesses in its inner face. Those at D^2 constitute connecting-ducts, whereby the valve-chamber C′ is connected at each end with the ends of the eduction water-passage E^1, and the recesses E^2 in like manner connect valve-chamber C with induction water-passage D. The head H has also a recess, *t′*, hereafter fully described.

The valves being hollow, it of course follows that a single recess in each head will connect the proper water-passage with its valve-chamber, and be sufficient to secure operative results; but it is obviously preferable to employ the two recesses, because thereby the columns of water are shortened, and an equally direct induction of water to and eduction from both ends of the valve-chambers is afforded, which would not be the case if a single recess were employed.

It will be seen by the parallel arrangement of the several chambers in the shell that I am enabled to economize in metal, which is an important point, as none but first-class steam metal should be used in apparatus of this character if first-class results are desired.

The heads, when in position, are firmly secured to each other and to the shell by the four bolts *q*, each of which occupies the center of an induction or eduction water-passage, which are proportioned to receive them, and also afford ample water-way. The two halves of the shell, although well secured to each other by the nuts *g*, are also further secured by the bolts *q*, which clamp the shell between the two heads.

F and F′ denote the measuring-pistons. They are alike in form and dimensions. In order to secure an extensive packing-surface without requiring such a close fit as to result in undue friction, and without unduly diminishing the measuring capacity of the cylinders, I construct my pistons with a single web or head, surrounded by a light cylindrical shell, which has a length considerably greater than the distance which the piston travels. Each is provided with a piston-stem, which projects at each end slightly beyond the cylindrical portion, in order that on the completion of each movement of the piston the stem may abut against the inner face of the head, or against the packing covering said face, as at *d′*. Each piston is also provided with a longitudinal slot in its shell, as at *l*. In order to obviate undue weight in the piston, only one side thereof (adjacent to the slot) has an increased thickness, which is greater than the depth of the slot. This slot may be provided for in casting, or cut with a slotting-tool entering from the open end. As this slot constitutes a portion of the means by which each piston is connected with the valve which controls its fellow piston, and, as both ends of said slot are operative surfaces, it is desirable that the location of these ends should be accurately determined—that is, the slot shall be of a certain predetermined length. The solid end of the slot is finished by milling-tools, correctly adjusted to secure its proper location. The opposite end surface is provided by the block *m*. The sides of the slot are slightly tapered, and the sides of the block *m* correspond thereto, so that it cannot advance beyond the proper point. A screw, as shown, secures it in position. After the slot has been cut, and the block *m* inserted and secured, the exterior of the piston is turned off, and properly finished.

At each end of the piston its shell is recessed adjacent to the ports which communicate with the valve-chambers, as shown in Fig. 6. In order to obviate the necessity of machining these recesses I cast the pistons with two recesses at each end, opposite each other, so that any one piston may be used in either of the measuring-cylinders, and yet have one of its recesses at each end in proper position with relation to each valve-chamber port. G and G′ denote the two sliding cylindrical valves, which occupy the valve-chambers C and C′, respectively. They are precisely alike; and one of them is shown detached and in perspective in Fig. 7. They are preferably cast in one piece, and have a tubular stem, *n*, and a piston at each end, as at *o*. Each valve has a pin, as at *p*, which projects therefrom radially at a point midway of the length of the valve. This pin, in each instance, projects through the adjacent slot *k*, which extends from each valve-chamber into one of the measuring-cylinders, and loosely occupies the slot *l* in the piston which actuates the valve. In order to guard this slot against the passage of water from the valve-chamber the valve is provided at one side with the packing-surface p^1, in the center of which the pin *p* is located. This packing-surface has a greater width than that of the slot, and is longer than the slot plus the distance which the valve is moved in operation, so that at whatever point the valve may be the slot will be well guarded by the packing-surface. Each valve has a bearing-face, as at p^2, opposite the valve-surface p^1, turned off to accurately fit the valve-chamber. This bearing being opposite the pin *p* and the valve-surface p^1, and both surfaces being turned to the radius of the valve, the bearing-surface operates as a bearing-face in resisting the tendency to a tilting action of the valve, due to the contact of the meter-piston with the valve-pin; and it therefore greatly relieves the valve pistons and chambers from the liability to wear which would exist if the heaving-face were not employed. After the valve-chambers have been bored and the valves finished, the latter, with-

out the pins, are inserted in the chambers, after which the pins, having threads thereon, are inserted by entering them through the slots *k*. This having been accomplished, the blocks *m* are removed from the pistons, which are then inserted in their respective measuring-cylinders, the open end of the slot admitting the pin to enter, and the piston to occupy its proper position, after which the blocks *m* are placed in the slots and secured by their screws. The slots *l* in the piston have a length equal to the stroke of the pistons minus the travel of the valves, plus the diameter of the pin *p*. The valve G, which guards the ports of measuring-cylinder B′, is actuated by the piston F in cylinder B, and valve G′, which controls the ports of cylinder B, is actuated by the piston F′ in cylinder B′.

I will now describe the operation of the meter without reference to any registering apparatus, as all of the operative mechanism has already been described in detail. Although I have, for the purposes of description, used the terms "induction water-passages," and "eduction water-passages," it is to be understood that my meter will operate equally well regardless of the direction in which the water may be entered thereto or discharged therefrom. It is to be remembered that the two heads of the meter close at their ends two diagonally-opposite water-passages, those at D^1 and E, the former being described as an induction-passage, and the latter as an eduction; also, that these two passages communicate centrally (see Fig. 5) with the valve-chambers respectively adjacent thereto at the annular space which surrounds the stem of the valve, between its heads or pistons *o*. It is also to be remembered that two of the water-passages are connected with the valve-chambers by means of the recesses in the meter-heads—that is to say, the induction-passage D is connected by recesses E^2 with valve-chamber C, and the eduction-passage E^1 is connected with valve-chamber C′ by recesses D^2. From this it will be seen that live water is conducted into cylinder B from passage D^1 into valve-chamber C′ between the heads of valve G′, and thence alternately into the cylinder whenever the valve approaches either end of the meter. On the other hand, live water is in like manner conducted into cylinder B^1 from passage D, *via* the head recesses E^2 through valve-chamber C, when either of the heads of valve G have receded from either end of the meter sufficiently to uncover a valve-port. The eduction of water from the cylinders is made through the same ports. Water from cylinder B′ passes through its ports into the annular space in valve-chamber C surrounding valve G; thence by the central duct into the eduction-passage E; thence from the meter. Water from cylinder B passes through its ports into valve-chamber C′, thence by the head recesses D^2 to passage E^1, and thence from the meter. By having the valves tubular they increase the water-way area, and are balanced and move freely, not having to overcome or move a body of water, as would be the case if they were solid. When the parts are put together, as described, each piston makes a certain movement, dependent on the relative lengths of the piston-stroke and the valve-travel, before the slot in the piston engages with the valve-pin, after which the piston and valve move together for the remainder of the stroke. One piston continually follows the other, having at no time a simultaneous movement under ordinary deliveries, and when one has completed its stroke in either direction it rests until the second piston in approaching actuates the valve which admits and discharges water requisite for the return movement of the first piston, and so on as long as water is allowed to enter and leave the meter. It will be seen that the columns of water within the meter are all very short, and therefore such water-hammer as is ordinarily due to the operation of slide-valves in connection with comparatively long columns of inelastic fluid is so far reduced as to render my meter practically noiseless in operation, even at a speed of about two hundred and sixteen two-inch strokes per minute of each two and one-fourth-inch piston, and to this end the extreme accuracy attained by milling the ports also largely contributes.

The registering apparatus, considered as a whole, is shown at I. Its prime mover or ratchet is shown at *w*, and a pawl-bar at *v*, and detent at *x*. Certain novel features in the registering apparatus will constitute the subject of a separate application for Letters Patent.

The shaft *s* is connected at its lower end with one of the pistons by an arm, *t*, which occupies the recess *t′* in the head and the link at *u*. The shaft *s* is housed in a long bearing formed in the head, and this obviates the necessity of special packing. It is mounted at its base in a step at *s′*, and the arm *t* is mounted on the shaft above the step, and below the lower end of the long bearing, and this prevents any undue lateral strain on the shaft, and the unequal wear of it and its bearing, which would be otherwise incident to the sidewise strain thereon, and due to the weight of the levers mounted on the shaft and the work performed by them.

Having thus described my invention, I claim as new and desire to secure by Letters Patent—

1. A piston-meter shell, provided with water-passages, valve-chambers, and measuring or piston cylinders, which are cast in the shell, are straight and parallel with each other, and extend from one end of the shell to the other, substantially as described.

2. A piston-meter shell composed of two counterparts united at their ends, and having peripherical water-passages, and water-pas-

sages, valve-chambers, and piston-cylinders which are straight and parallel with each other, substantially as described.

3. In a piston-meter, the combination with the piston-cylinders, their respective valve-chambers, and the water-passages, of heads, having recesses on their inner faces, which connect the water-passages with the valve-chambers, substantially as described.

4. A water-meter piston, having in its periphery a centrally-located longitudinal slot or recess for receiving the pin of a slide-valve, operated by the piston, substantially as described.

5. In a piston-meter, the combination, with a valve-chamber and piston-cylinder, connected by means of a slot, of a slide-valve in the valve-chamber, provided with a pin which enters the piston-cylinder, and a valve-surface which surrounds the pin and invariably covers the slot, substantially as described.

6. The combination, with the measuring-pistons, the piston-cylinders having ports at each end, the valve-chambers communicating with the cylinder, and the water-passages communicating with the valve-chambers, of the tubular slide-valves, each controlled by one of the main or measuring pistons, and provided with a head at each end, and an intermediate recess between the heads, substantially as described, whereby fluid is admitted to or discharged from the measuring-cylinders through a valve-chamber and a water-passage over the heads of the valve, as well as between its heads and the valves relieved from end pressure, as set forth.

7. A cylindrical slide-valve for water-meters, provided with two heads, an intermediate recess for a water-way, a radial pin surrounded by a valve-surface, and a heaving or bearing face opposite the pin, substantially as described.

8. In a piston water-meter, a shaft for connecting the piston with the registering apparatus, which is mounted on a step and provided with an internal arm for connection with the piston, in combination with a head for the meter which contains the bearing and the step for the shaft and a recess for the internal arm, substantially as described.

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