3 Sheets—Sheet 1.

# H. L. ARNOLD.

## Piston Water-Meter.

No. 203,984. Patented May 21, 1878.

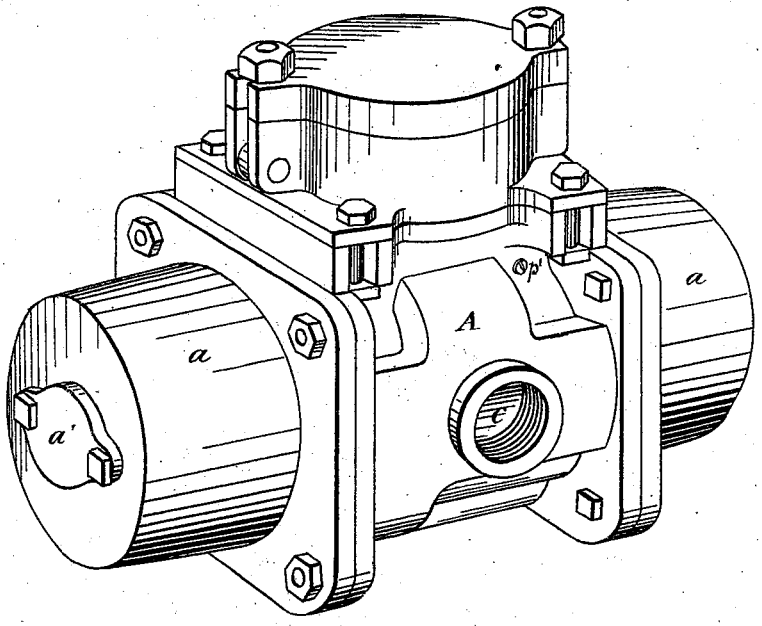
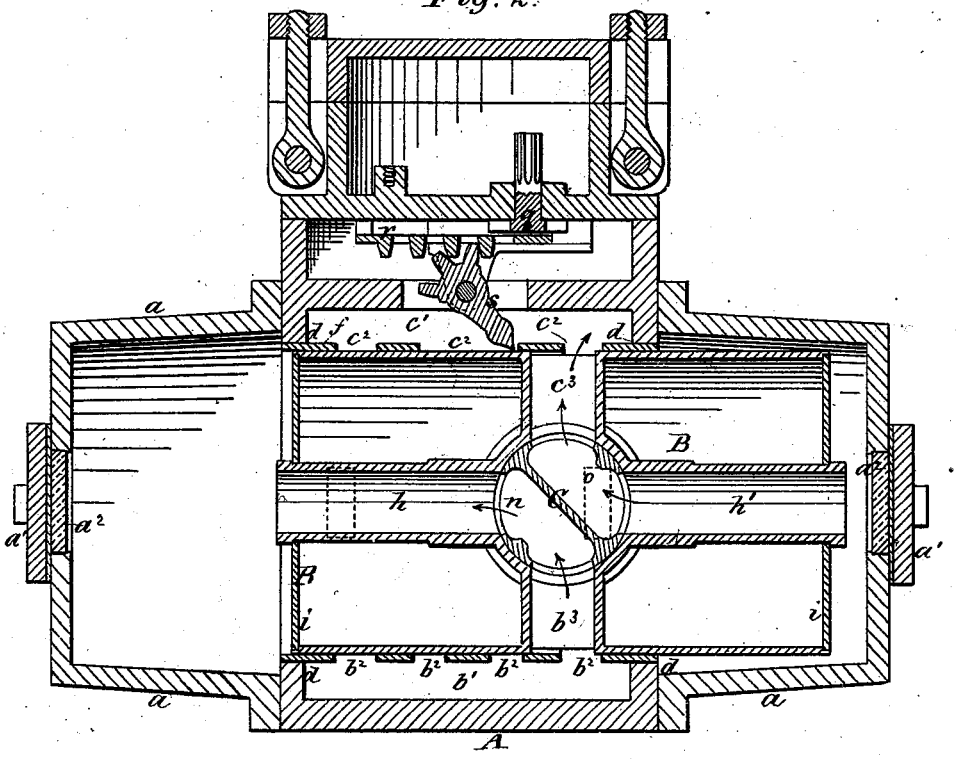



Fig. 2.

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## Piston Water-Meter.

No. 203,984. Patented May 21, 1878.

Fig. 3.

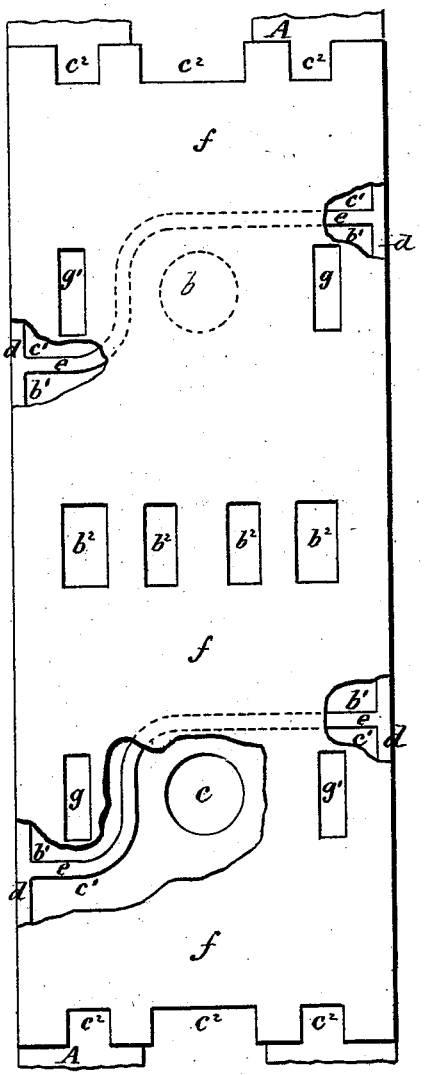



Fig. 5.

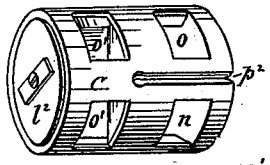



Fig. 6.

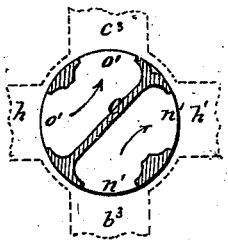



Fig. 7.

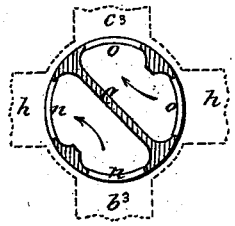



Fig. 8.

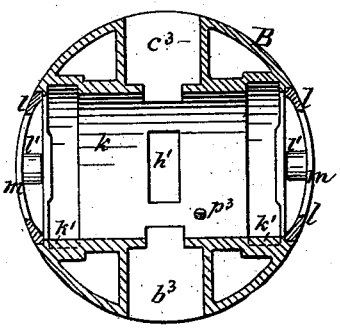
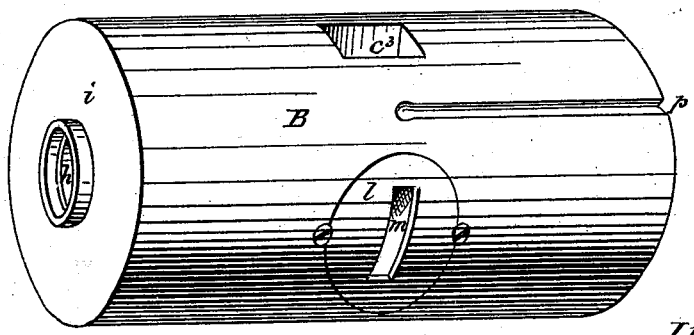



Fig. 4.

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3 Sheets—Sheet 3

# H. L. ARNOLD.

## Piston Water-Meter.

No. 203,984. Patented May 21, 1878.

*Fig. 9.*

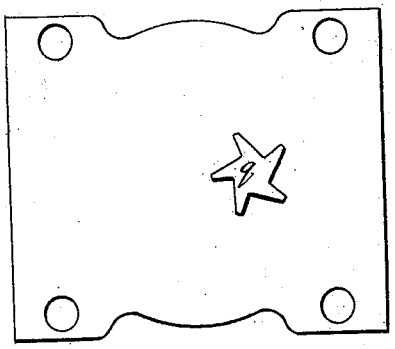



*Fig. 10.*

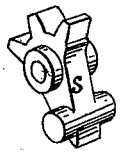



*Fig. 12.*

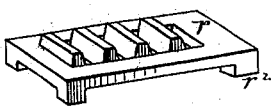



*Fig. 11.*

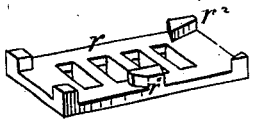
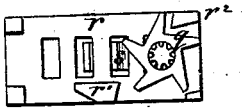



*Fig. 13.*

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# UNITED STATES PATENT OFFICE.

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

## IMPROVEMENT IN PISTON WATER-METERS.

Specification forming part of Letters Patent No. **203,984**, dated May 21, 1878; application filed February 13, 1878.

*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 Liquid-Meters; and I do hereby declare that the following specification, taken in connection with the drawings furnished, and forming a part thereof, is a true, clear, and complete description of my said improvements.

My invention relates to piston-meters, and the object thereof is to simplify their construction, with a view not only to lessen their prime cost, but to secure accurate and easy operation.

So far as my knowledge extends, piston-meters as heretofore constructed have in all cases involved more or less valve-operating mechanism of a more or less complicated character, and such mechanism is not only conducive to undue friction, but it is expensive and liable to derangement.

A piston-meter embodying the main feature of my invention contains but two moving parts, by which the admission and discharge of fluid are attained alternately into and from each end of the meter.

The main feature of my invention consists in the combination, with a meter-cylinder having suitable induction and eduction ports and passages, of a reciprocating piston having suitable water-passages; and a sliding valve, which is seated in a transverse valve-chamber within and across the piston, is provided with ports which alternately connect each end of the meter with the induction and eduction passages in the meter-cylinder by the way of the passages within the piston, and is actuated in all its movements by the pressure of liquid alternately on each of its ends or heads. With this simple combination of elements, the piston and its valve constitute the only moving parts within the meter by which the continuous discharge of water in equal measures is effected. An indicating or registering mechanism is, of course, essential in all meters, and I employ the piston as the prime mover thereof, as is common in piston-meters. By the direct pressure of the fluid on the heads of the valve it may be moved simply to and fro, if limited to such movement, as in accordance with one feature of my invention; or it may also be semi-rotated in its seat during its longitudinal movement, which rotation has heretofore been effected by the employment of a sliding rod and cam motion. When this axial movement is desired the valve-periphery is provided with an angular groove or score, which is occupied by a stationary pin in the body of the meter-piston, and thus, in accordance with my invention, the two movements of the valve are attained solely by the pressure of fluid on the heads of the valve.

It is obvious that the water-passages in the piston and the meter-cylinder will be varied in their character, in order to co-operate with valves having different movements.

It is important, with a view to lessening friction, not only that the number of moving parts in a meter be reduced to a minimum, but also that their movements be of the simplest order; and to that end in my meter the piston and its valve are each limited to a longitudinal movement, the valve moving within the piston in a line at right angles to axis of the piston; and my invention further consists in the combination, with a meter-cylinder having oppositely-located induction and eduction ports and passages and oppositely-located valve-ports, of a reciprocating piston provided with radial and longitudinal passages, and a sliding valve, which occupies a transverse chamber located within the piston, is moved by the pressure of liquid on its heads, is limited to a longitudinal movement in said chamber, and is provided with ports for alternately connecting each passage in the piston with the interior of the meter-cylinder and the induction and eduction ports in said cylinder. The arrangement of the induction-ports in the meter is such that water enters through a radial passage in the piston, passes through the valve, and thence, by way of a longitudinal passage in the piston, into the meter-cylinder. The eduction-ports of the meter-cylinder are located opposite the induction-ports, and water is discharged from the meter-cylinder through the longitudinal pas-

sages in the piston, through the valve, and thence, by an opposite radial passage in the piston, to the eduction-ports of the meter-cylinder. The valve-ports in the meter-cylinder are located near each end thereof, the induction-ports being diagonally opposite to each other, and exactly opposite a co-operative eduction or exhaust port. The water which operates the valve is supplied from the chamber which is common to the main induction-ports, and the exhaust valve-port communicates with the chamber which is common to the main eduction-ports. The fluid which is employed to operate the valve does not enter the measuring-space of the meter-cylinder, and is therefore in excess of the cubic capacity thereof; but as it requires a certain quantity of water to move the valve at each stroke of the piston, it involves only such calculations as will determine the exact cubic capacity of both the measuring-space of the cylinder and the water-space of the valve-chamber to the extent of the movement of the valve.

There are numerous minor features of invention, which will be hereinafter referred to in connection with the detailed description, in connection with the drawings, in which—

Figure 1 represents, in perspective, a meter embodying my invention. Fig. 2 represents the same in central longitudinal vertical section, with the piston at or near the end of its stroke. Fig. 3 represents the interior of the meter-cylinder in plane projection, with portions of the lining broken away to show the partitions in the shell. Fig. 4 represents, in perspective, the piston detached. Fig. 5 represents, in perspective, the valve detached. Figs. 6 and 7 represent, respectively, lateral sections of the valve in line with the centers of its ports, and with the radial and longitudinal passages of the piston shown in dotted lines communicating therewith. Fig. 8 is a transverse section of the piston in a line with the center of the valve-chamber. Fig. 9 represents the under side of the cap-plate of the meter detached, with the star-wheel, through which motion is imparted from the piston to the registering apparatus. Fig. 10 represents the segmental gear-lever, which engages with the piston. Fig. 11 represents the rack-bar, which is moved to and fro by the gear-lever. Fig. 12 represents the under side of the rack-bar. Fig. 13 represents, in plan, the rack-bar, gear-lever, and star-wheel, operatively connected.

A denotes the meter-cylinder. It is provided with beads $a$, which are recessed to receive the end of the piston to the full extent of its stroke. Each head is provided with a detachable finger-plate, $a^1$, which has on its inner surface a rubber or other cushion, $a^2$, for relieving the piston from shock at the termination of its stroke.

The meter-cylinder is provided, also, as usual, with oppositely-located induction and eduction coupling-connections, and, although either may be used as induction, I will, for the purposes of this specification, designate that at $b$ as the induction, and that at $c$ as the eduction.

It is a matter of consequence that the cylinder be constructed at low cost, and by one feature of my invention I am enabled to cast the main portion of the cylinder with a simple core, and secure free and capacious water-passages. From a view of Fig. 3 it will be understood that the cylinder is mainly cast in one piece, and provided with the annular web $d$ at each end, and the longitudinal webs $e$, or portions which extend from end to end, each in two lines, so as to secure between the webs passages or water-spaces of the required size and form. The casting thus formed, and its webs properly reamed or surfaced on their edges, is ready to receive the cylindrical lining or shell $f$, usually of brass or bronze, and this is united, by soft solder or otherwise, to the webs of the iron shell.

It will be seen that when thus constructed the cylinder has two large chambers, that at $b^1$ being the induction and that at $c^1$ being the eduction chamber. The bronze or brass shell $f$ is provided with two series of ports—the induction ports or passages at $b^2$, and eduction ports or passages at $c^2$—respectively arranged in rows at opposite sides of the cylinder. The shell has also two diagonally-opposite valve-ports, $g$, which communicate with the induction-chamber $b^1$, and two diagonally-opposite valve-ports, $g'$, which communicate with the eduction-chamber $c^1$, so that each induction valve-port $g$ is opposite an exhaust valve-port, $g'$. This mode of constructing a meter-cylinder with annular and longitudinal webs, and an interior separate shell or lining, provided with suitable ports, constitutes one portion of my invention, and I thereby am enabled to produce a cylinder by the simplest methods of casting, and secure perfectly free and open water passages and chambers and ports of any required number, size, or form. Although several ports are shown for induction and eduction, it is to be understood that each series operate as one long port or passage, that they are separated only to secure a good bearing for the piston and ample strength for the brass lining, and that during the movement of the piston, as hereinafter described, more than one of these ports will be always uncovered to the piston-passages.

The piston B is peculiarly constructed, and embodies several minor features of invention. It is hollow, and has central tubular water-passages $h$ and $h'$, each of which alternately serves for induction to and eduction from its respective end of the meter. The piston has a central transverse cylindrical chamber, and these water-passages $h$ and $h'$ extend through the walls of this chamber and to the ends of the piston, in which are heads $i$, each tightly soldered to the tube or pipe containing the water-passage, and to the piston, so as to afford an air-tight chamber within the piston,

which, being filled with air, serves to secure desirable buoyancy and lessen the friction of the piston in contact with the cylinder. The piston has also two radial passages, one of which—that at $b^3$—serves always as an induction-passage, and that at $c^3$, oppositely located, serves as an eduction-passage. These passages in the piston all terminate in the central cylindrical chamber before referred to, and which is the transverse valve-chamber $k$, to which all of the several water-passages in the piston extend. Near each end of the valve-chamber is an annular recess, $k'$, which serves as a mud-pocket. The valve-chamber at each end is provided with a head, $l$, which has an outer surface conforming with the periphery of the piston, and on the inner surface it has two bosses, $l^1$, with which a rubber cushion on the valve (to be hereinafter described) engages to prevent shock. Each valve-chamber head $l$ has a rectangular port, $m$, for admitting water from the valve-ports $g$ to the valve-chamber, and discharging the same into the exhaust valve-ports $g'$, before described. The heads $l$ are secured in position by countersunk screws.

The valve C is cylindrical, and fitted to move longitudinally in the valve-chamber $k$. It is provided with two pairs of diagonal passages. The pair $n$ and $n'$ communicate, through the lower periphery of the valve, with the radial induction-passage $b^3$ in the piston, and thence with the induction-ports $b^2$ in the meter-cylinder, and, according to the longitudinal position of the valve, water is inducted either into the central piston-passage $h$ or the passage $h'$, as the case may be, to the spaces adjacent to the ends of the piston. The other pair of passages, $o$ and $o'$, communicate, through the upper periphery of the valve and the radial piston-passage $c^3$, with the eduction-ports $c^2$ in the meter-cylinder, and also with the central piston-passages $h$ and $h'$, and thereby afford a passage of the water from either end of the cylinder, according to the longitudinal position of the valve.

At each end of the valve, and attached thereto, is a cushion, $l^2$, which engages with the bosses $l^1$ on the valve-chamber heads $l$, as before described.

The piston B is limited to a longitudinal movement by means of a longitudinal groove, $p$, and a screw, $p^1$, which projects through the cylinder, with its inner end occupying said groove.

When the valve C is limited to a longitudinal movement (which is preferable) the valve is also provided, like the piston, with a longitudinal groove, $p^2$, and a screw, $p^3$. If, as in some prior meters, it is desired that the valve shall also partially rotate, the groove, instead of being straight, will be diagonal or helical; but it will, of course, be understood that when the valve has this compound movement the several water-passages will be modified to conform thereto, as in prior meters, in which the valve is semi-rotated by the intervention of mechanical appliances.

Among the valuable features thus far described there is one which constitutes one portion of my invention—to wit, the combination, with the piston and its valve, of valve-chamber heads, having ports of a lesser area than the area of the valve-heads, whereby the valve may be made of such diameter as to secure easy movement, and yet not be subjected to pressure or be liable to move until the piston has nearly completed its stroke. The piston-head, being of large area and having but a short distance to travel after uncovering the valve-ports, completes its movement without difficulty.

For comprehending the operation of my meter, it will be assumed that the piston has nearly reached the end of its stroke and has placed in coincidence the ports $m$ in the valve-chamber heads, respectively, with an induction valve-port, $g$, (see Figs. 2 and 3) and the opposite eduction-valve port, $g'$, at which moment the valve will be nearest the induction-valve $g$. As soon as the water-pressure is received by the valve it moves toward the eduction-port $g'$, which receives the water within the chamber at the opposite end of the valve, and this movement occupies but little time. The valve thus moved opens communication between the filled end of the meter *via* a central water-passage and the radial passage $c^3$ in the piston to the eduction-passages $c^2$ in the meter-cylinder, and simultaneously said valve opens communication between the end of the meter to be filled *via* the radial piston-passage $b^3$ and the central passage, after which the piston, by pressure on its head, is carried toward the opposite end of the meter until, as before, the valve-ports $g$ and $g'$ at that end are in coincidence with the ports $m$ in the valve-chamber, when the valve is again moved with the same result, and so on as long as water is drawn through the meter.

While suitable registering or indicating mechanism may be operatively connected, as heretofore, in various ways with the moving piston, I have devised a novel means of operatively connecting the piston with a rotating shaft, from which the register may be operated.

The cap-plate of the meter is provided with a shaft carrying on its inner end an escapement-wheel, $q$, which occupies a space between two parallel slide-bearings, which support a sliding rack-bar, $r$, provided on its rear side with lugs $r^1$ and $r^2$, and certain posts which maintain the rack-bar at a distance from the surface of the cap-plate greater than the thickness of the escapement-wheel. The lug $r^1$, when the rack-bar is moved in one direction, engages with one of the teeth of the escapement-wheel and turns it one-tenth of a revolution; and when the bar is moved in the op-

posite direction, the lug $r^2$ engages with another tooth on the opposite side of the wheel and imparts to it a similar movement.

The rack-bar is reciprocated to and fro by means of a toothed or segmental lever, *s*, which engages with the rack-bar, and has its working end extended downward into the meter sufficiently to occupy one of the radial water-passages in the piston, which, when moved in one direction, imparts a longitudinal movement to the rack-bar in the opposite direction, thus intermittingly rotating the escapement-wheel.

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

1. In a liquid-meter, the combination, with a cylinder having suitable induction and eduction-ports and passages, of a reciprocating piston containing interior water-passages, and a sliding valve which occupies a chamber within and is carried by the piston, and which controls the interior passages of the piston, and is actuated in all its movements by the pressure of liquid on its heads, substantially as described.

2. In a liquid-meter, the combination, with a cylinder having suitable induction and eduction ports and passages, of a reciprocating piston provided with interior passages, and a valve which occupies a transverse chamber within the piston is carried by it for controlling its interior passages, is moved by the pressure of liquid on its heads, and is limited to a longitudinal movement within its chamber, substantially as described.

3. A piston-meter cylinder composed of a cast-metal shell, having an annular web at each end and longitudinal webs or portions connecting said annular webs, in combination with an interior lining provided with ports, substantially as described.

4. The combination, with a meter-piston, of a sliding valve occupying a transverse chamber in the piston, and heads at each end of the chamber, which are provided with ports of a lesser area than the area of the valve-heads, substantially as and for the purposes specified.

5. The combination, with the piston, of the segmental geared lever, the rack-bar, escapement-wheel, and its shaft, substantially as described.

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