2 Sheets—Sheet 1.

H. L. ARNOLD.

WATER MOTOR.

No. 185,011. Patented Dec. 5, 1876.

Fig. 1.

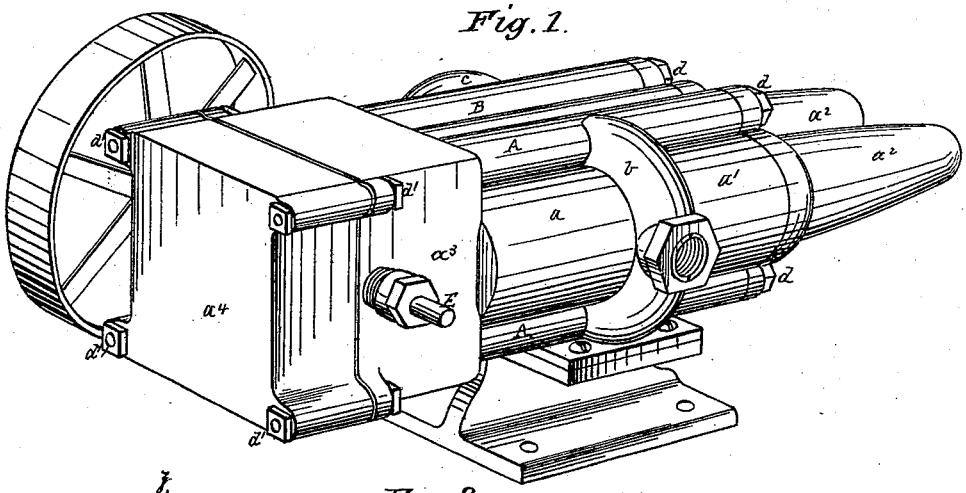


Fig. 2.

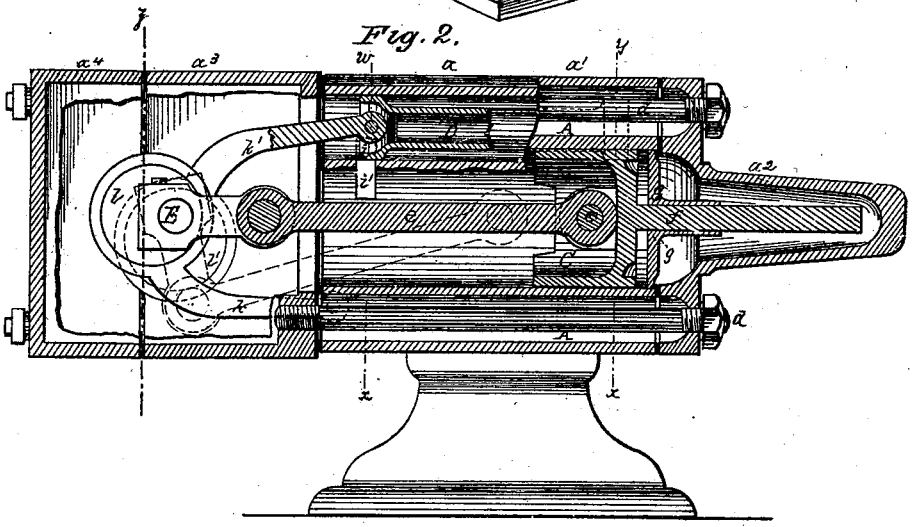
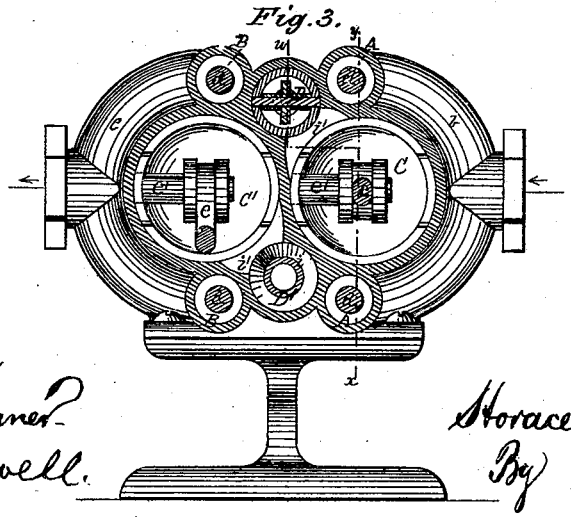


Fig. 3.



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2 Sheets—Sheet 2.

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WATER MOTOR.

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Fig. 6.

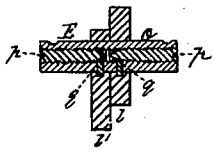


Fig. 4.

Fig. 7

Fig. 5.

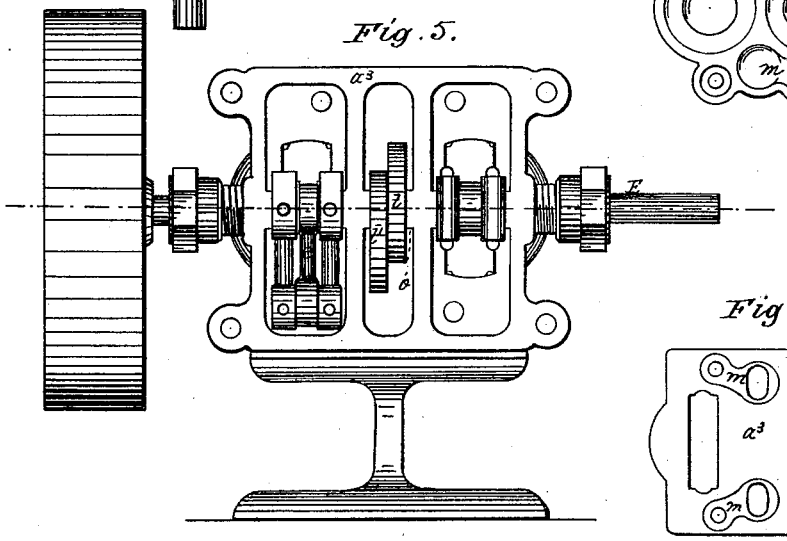
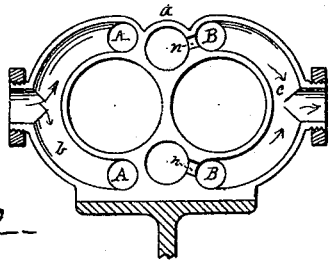


Fig 8.

Fig. 9.



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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-MOTORS.

Specification forming part of Letters Patent No. **185,011**, 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-Motors; 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-motors, and to such as embody two cylinders and pistons, which are coupled together by a crank-shaft, and slide-valves, which are actuated by eccentrics.

Such motors are well adapted for light service, and, to meet a general demand, they should be as inexpensive as possible, capable of yielding a maximum of power to the quantity of water employed, durable in all their parts, and so simple in their construction as to be easily repaired, if necessary.

Motors of this class are closely analogous to piston water-meters, and I am enabled to attain much economy in their manufacture by employing certain novel features of my own invention, which are described and claimed by me in a separate application for Letters Patent for improvements in water-meters.

One feature of my invention consists in a novel shell or casing, which incloses all the moving parts of my motor. Said shell is composed of five separate sections, which, when placed in position endwise, are secured together by longitudinal bolts. The main sections, containing the induction and eduction water-passages, the valve chambers or seats, and the piston-cylinders, are two counterparts, cast from one pattern and united by nuts, as described and claimed in my aforesaid application for patent. The rear-end section or head of the shell contains two separate cylindrical chambers for the reception of guiding-rods for the pistons. The front head is composed of two sections, each of which contains a part of three chambers. All the joints between the sections are transverse to the line of the piston-cylinders. When united, each of the piston-cylinders communicates with one of the chambers in the rear head, and also with one of the chambers of the front head, the three constituting, in fact, one chamber, which is, however, divided into two chambers by the piston. The valve-chambers communicate, in like manner, with the third or central chamber in the front head.

Another feature of my invention consists in the combination, with the cylinders, their pistons, cranks, and crank-shaft, of two crank-chambers, separated from the cylinders by a partition slotted for the pitmen, whereby no packing is required about the mechanism which connects the pistons and cranks, and also whereby the water contained in the crank-chambers is guarded against disturbance by the water passing into and from the cylinders with which said chambers communicate.

Another feature of my invention consists in the combination, with a piston-cylinder, of a piston and crank, connected by a pitman, a guiding-rod on the opposite side of the piston, and a guide-rod bearing, whereby the piston is made to operate as a cross-head for its pitman and crank.

The guiding-rod of the piston has its bearing extended beyond the rear end of the cylinder; and another feature of my invention consists in the combination, with a piston arranged to operate as a cross-head, and having a guiding-rod and a guide-rod bearing, of a chamber communicating with, but extended beyond, the cylinder and the guide-rod bearing, for the reception of the guiding-rod, whereby, although the bearing and the guiding-rod are sufficiently well fitted to each other to secure good operative service, no water-tight packing around said rod is requisite.

In my motor each crank occupies a separate chamber, and therefore the crank-shaft must be built up in lengths, in a manner well known. The eccentrics also occupy a separate chamber located between the crank-chambers, and are mounted upon a short length of the crank-shaft, and therefore the two eccentrics are placed in the chamber with their holes coincident, and the section of shaft is inserted from one of the crank-chambers through the dividing-wall. Economy in space being desirable, there is no space for a hub and set-screw, or for driving-keys, and therefore I have devised

a novel means for securing the eccentrics on the shaft; and one feature of my invention consists in the combination, with the eccentrics, of a section of shaft which is tubular and threaded internally throughout its length, two screws with pointed ends within the shaft, and two radial studs in the shaft, each beneath the seat of an eccentric, whereby, on turning the screws, both studs may be advanced and made to engage with the eccentrics, and thereby secure them on the shaft and admit of their ready adjustment.

Certain other minor features of my invention are hereinafter specified.

To more particularly describe my invention I will refer to the accompanying drawings, of which there are two sheets.

Figure 1, Sheet 1, represents one of my motors in perspective. Figs. 2 and 3 represent the same, respectively, in longitudinal and transverse vertical section. Fig. 2 contains sectional views both on lines *w x* and *y x*, Fig. 3, and the latter figure contains a transverse sectional view on line *w x*, Fig. 2. Fig. 4, Sheet 2, represents the same in longitudinal horizontal section on a line with the crank-shaft. Fig. 5 represents the same in end view, with the front head of the shell detached, as indicated at line *z*, Fig. 2. Fig. 6 represents, in longitudinal section, the portion of the crank-shaft which carries the valve-operating eccentrics, and exhibits the means whereby they are secured on the shaft. Fig. 7 represents the rear head of the motor in end view, and reduced in size. Fig. 8 represents, in end view, the inside section of the front head of the shell. Fig. 9 represents, in end view, one of the parts of the shell at its point of junction with its counterpart.

The shell of the motor is constructed in five sections, and, as before stated, the main body thereof is constructed in accordance with an invention described and claimed by me in another application for Letters Patent.

For the purposes of this specification it is only necessary to explain that it is composed of the two sections a and a^1, that they are counterparts cast from one pattern, and contain two piston-cylinders, two valve seats or chambers, two induction-passages, A, communicating with each other by a peripherical duct, b, and two eduction-passages, B, communicating with each other by the duct c. The rear head a^2 is of peculiar construction, and contains two separate chambers, each of which is opposite the rear end of a piston-cylinder, and extends to the rear thereof a distance equal to the length of stroke made by the piston. As these chambers are for the reception of the guiding-rod of the piston they are tubular in form, and, for convenient casting in green sand, they are tapered, as shown. The front head of the shell is also cast in two sections, a^3 and a^4. Section a^3 is square in transverse section, and divided by vertical partitions in three separate chambers, which are open at each end of the section. The two outside chambers communicate with the piston-cylinders, and contain the cranks. These crank-chambers are separated from the cylinders, as shown, by a partition, which is slotted for the pitmen. The intermediate chamber contains the eccentrics, and communicates with the valve-chambers. This section a^3 is united to the main body of the shell by four long bolts, d. Their heads engage against an interior flange of the section a^3, and they extend rearward through the center of the water-passages A and B, and through holes in the flange of the rear head-section a^2, at which point their nuts are applied, thus firmly uniting these four sections. This section a^3 is also provided at each front corner with a lateral bolt-ear. The front head-section a^4 is box-like in form, with two vertical partitions coincident with those in section a^3, which divide it into three chambers, so that when the head is in position they communicate with and constitute extension of the two crank-chambers and the eccentric chamber. Sections a^3 and a^4 are united by the bolts d' at each corner.

For closing the transverse joints of the shell any suitable packing may be employed. In some cases gum packing cut in a form to correspond with the coincident metallic surfaces is desirable. The joint between sections a and a^1 is leaded or soft-soldered, the two sections being united independently of the long bolts by means of the nuts on each side of the shell at the induction and eduction passages.

While the shell could, of course, be made in a greater number of sections, it cannot be done without the sacrifice of practical economy. The joint between sections a and a^1 is essential for cheap and convenient casting and finishing, and that between a^1 and a^2, and also between a and a^3, are both essential, because of the radical difference in the form of the sections (to be considered in connection with casting) and the necessity of access to the internal portions of the main body of the shell. The joint between a^3 and a^4 is essential for the location, insertion, and adjustment of the crank-shaft. The motor is mounted upon a suitable standard or block, as shown, whereby it may be secured to a proper foundation.

The pistons C and C′ are so constructed that they serve as their own cross-heads. They have an extensive longitudinal bearing with their cylinders, and are directly connected to their pitmen e by means of ears on the front of the piston-head, and a transverse pin, e', which is entered through a hole in the barrel of the piston. Each has a guiding-rod, as at f, projecting from the opposite side of the head. This rod has a good longitudinal bearing or seat in the cylindrical hub g, which is sustained by arms and a ring secured in position at the rear end of the cylinder by being confined between the shoulder of an annular recess in the cylinder and the inner face of the rear head.

It will be seen that this hub or seat must

be accurately concentric with the cylinder; and although it may be fitted thereto by various expensive methods, the simple annular recess in the end of the cylinder, and the firm abutment of the rear head thereon, fully meet all requirements, and this construction constitutes a minor feature of my invention.

Each of the piston-cylinders, therefore, communicates with one of the guiding-rod chambers, and also with one of the crank-chambers, the three, as a whole, constituting one chamber, which is divided into two chambers by the head of the piston. For this reason all of the moving parts contained therein are surrounded by water, and no packing is required around the crank-connections with the piston, or around its guiding-rod.

D and D′ denote the two slide-valves. They are tubular in form, and have a head or piston at each end, as at *i*, which alternately pass the ports *i′* at each end of the piston-cylinders. The annular space between the heads of the valve when in its chamber constitutes a water-way which may be employed for eduction or induction; but this space at each valve is described herein as an eduction-passage. These valves are connected with the crank-shaft E by means of the eccentrics *l l′* and curved eccentric rods *k k′*, and arranged with relation to the piston-cranks much the same as slide-valves are in double-cylinder steam-engines, with the exception that there is, of course, no lap or lead with these valves, because of the radical difference between water under pressure and steam. The eccentric rods are connected with the valves by means of a transverse pin, which is located at one end of the valve, and does not materially obstruct the water-way.

The valves being tubular, but little power is requisite for their operation. The live water is supplied to each end of the valve-chambers from the water-passages A by means of the recesses *m* in each head of the shell. Each recess *m* in the rear head connects directly an induction-passage, A, with the adjacent valve-chamber; but the recesses in the front head connect both with the central chamber, which contains the eccentrics, and with the valve-chambers; in other words, the eccentric chamber contains live water, from which both valves are supplied, the live water in both valves entering the ports *i′* to the piston-cylinders over the ends of the valves. The exhaust water leaves the piston-cylinders by the same ports *i′*, but enters the valve-chambers between the heads of the valves, and passes thence, by way of the central ports *n*, Fig. 9, into the eduction-passages B, and thence from the motor.

The crank-shaft E is preferably built up of short lengths, united by complex cranks in a manner well known. This mode of construction enables me to provide solid bearings in the walls and partitions of the front head. The two outer ends of the crank-shaft are provided with long bearings cast with the head, and with glands or stuffing-boxes, which constitute the only packing required in my motor, except that which is requisite for securing tight joints between the sections composing the shell. The piston, being long and operated by water, requires no special packing, although annular recesses therein may be profitably employed, in a manner well known.

In mounting the eccentrics on the central section *o* of the crank-shaft, it will be seen that this section of the shaft must be inserted from one or the other of the crank-chambers, the eccentrics meantime being held with their holes coincident with each other. The limited space and the short length of shaft precludes the employment of hubs and set-screws for the eccentrics, or keys and slots in the shaft, so I have devised a novel means for securing the eccentrics on the shaft and permitting their ready adjustment. The section *o* of the main shaft is shown in Fig. 6. It is tubular, threaded internally throughout its length, and contains two screws, *p*, entered from opposite ends of the section. These screws have pointed tips, which engage their tapering surfaces against the inner ends of radial pins *q* in the shaft, and force these latter outward into holes therein, or in frictional contact with the eccentrics at their seats, and thereby secure them in position on the shaft.

The mode of building up such cranks is too well known to require special description.

One end of the crank-shaft may be provided with a belt-pulley, or other gearing for communicating power. The other end of the shaft, under some circumstances, can carry a balance-wheel, or a register showing amount of water used.

The cranks are set with relation to each other in such a manner as to secure the easy passage of centers. The eccentrics are set as in ordinary slide-valves, due consideration being given, however, to the fact that one valve is above, and the other below, the crank-shaft.

The operation of my motor will be readily understood. Water being turned on, it will enter the cylinders at whatever ports are open thereto, and move the pistons; the opposite ports being also open, it will exhaust through the valve-chambers between the heads until the position of the valves is so far changed as to reverse the movements of the piston, and so on as long as water is supplied.

The drawings represent a motor composed, in part, of a shell which has the requisite proportions for a meter; but it will be readily obvious that the water-ways outside of the cylinders should, for maximum results, be in largely-increased proportions, and approximate in sectional area much more closely to the area of the pistons than is shown. With the proportions exhibited, however, a truly valuable light motor may be attained.

It will be seen that the live water contained in the crank-chambers and guiding-rod chambers results in no disadvantage. The matter of "clearance" does not enter here, as in

steam-engineering, as no discharge of water from one side of the piston can possibly occur, save that which is due to the entrance of water on the opposite side. The guide-rod bearing and the crank-bearings are immersed in water, and this, if as pure as is usually available, serves as a lubricant. The water in the crank-chambers is caused to revolve with the crank, and to that extent operates as a balance-wheel.

The crank-chambers are separated from the cylinders by partitions, which are slotted sufficiently for the pitmen, and, therefore, the water contained within the chambers is practically guarded against the influence of currents due to the induction and eduction of water to and from the cylinders with which they communicate.

It will be seen that all castings are simple and inexpensive; that the valve-chambers and piston-cylinders may be simultaneously finished by a special tool; that the water-tight joints are all straight lines, except the glands of the crank-shaft, which are of the simplest character. The main body of the motor will, preferably, be of fine steam-metal; but the rear head and the front head may be of cast-iron, and so, also, may the section which contains the crank-shaft, if suitable bushings be provided.

Although I have specially designated certain water-passages as "induction" and "eduction," it is to be understood that they are susceptible of operating either way.

For convenience of access to the working parts, it will be seen that by detaching the front head the cranks are exposed, and that without detaching that head the nuts on bolts *d* may be removed, which will release the rear head, and admit of the withdrawal simultaneously of all the bolts, the two valves, and the pistons without disconnecting them from the front head and crank-shaft.

If desirable, a registering apparatus may be readily applied and geared to the crank-shaft, and then the motor will serve as its own meter for measuring the water used by it in operation.

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

1. An inclosing cast-metal shell for a piston water-motor, having the portion containing the cylinders, valve-chambers, and water-passages constructed in two sections, which are counterparts, a rear head, and a front head, constructed in two sections, containing separate chambers for cranks and eccentrics, substantially as described.

2. The combination, with the two cylinders, their pistons, pitmen, cranks, and crank-shaft, of the two crank-chambers, separated from the cylinders by partitions slotted for the pitmen, substantially as described, whereby packing of the mechanism which connects the pistons with their cranks is obviated, and the water contained within the crank-chambers guarded against disturbance by the water passing through the cylinder, as set forth.

3. The combination, with a piston-cylinder, a tubular piston fitted to the cylinder, and a crank connected with the piston by means of a pitman, of a guiding-rod and a bearing therefor, substantially as described, whereby the piston is guided, and operates as a cross-head, as set forth.

4. The combination, with a piston-cylinder, a tubular piston fitted to the cylinder, connected with a crank by a pitman, a piston-guiding rod, and its bearing, of a rear head to the cylinder, which has a chamber communicating with the cylinder for receiving the guiding-rod, substantially as described, whereby packing of said rod is obviated, as set forth.

5. The combination, in the crank-shaft of a water-motor, of the threaded tubular section of shaft, the eccentrics mounted on said section, the interior longitudinal screws, and the radial pins, substantially as described.

6. The combination, with the piston of a water-meter, its pitman, and guiding-rod, of the cylindrical hub *g*, fitted to an annular recess in the end of the cylinder, and secured in position by the rear head, substantially as described.

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