No. 764,629. PATENTED JULY 12, 1904.

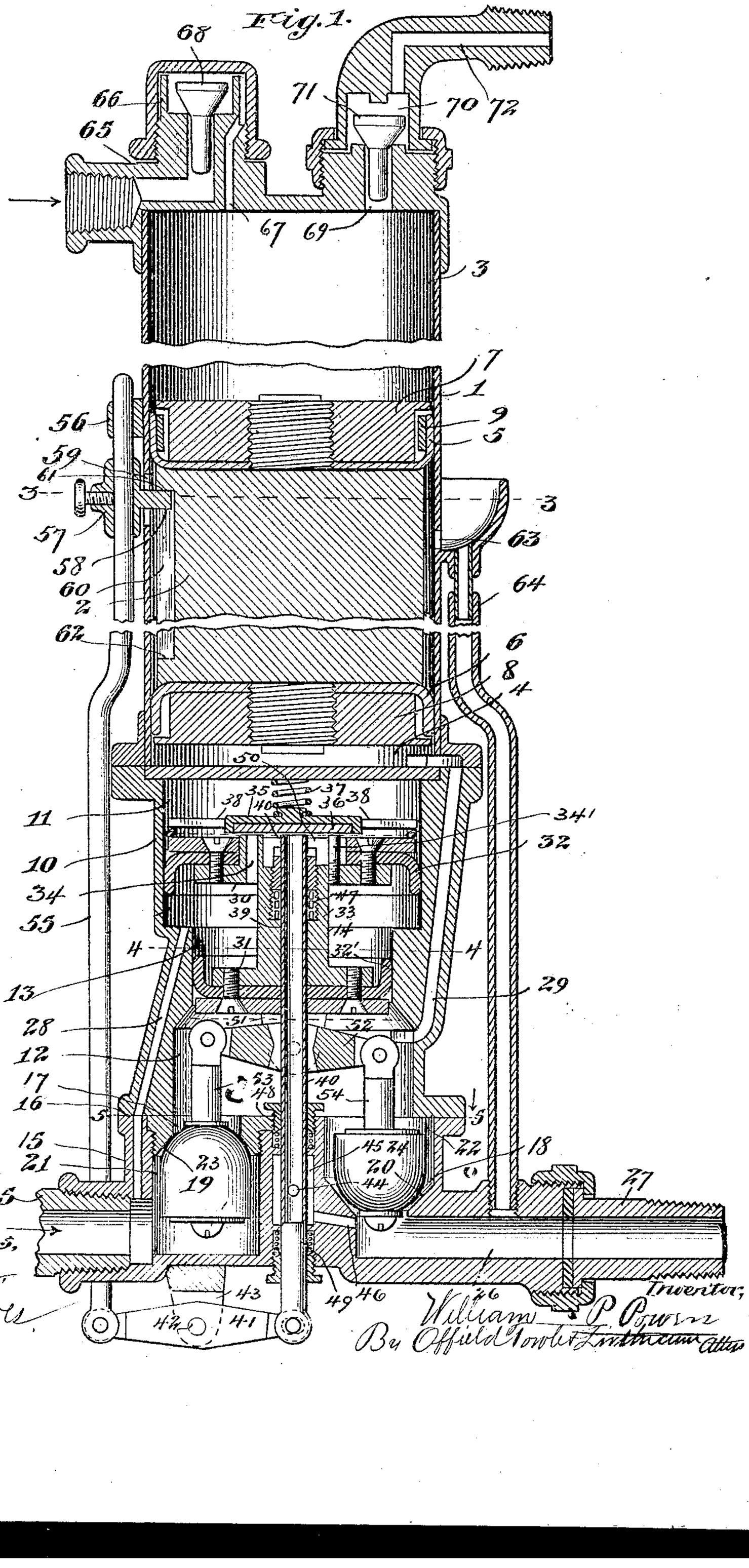
W. P. POWERS.

HYDRAULIC MOTOR.

APPLICATION FILED MAR. 15, 1902.

NO MODEL. 3 SHEETS—SHEET 1.

Fig. 1.



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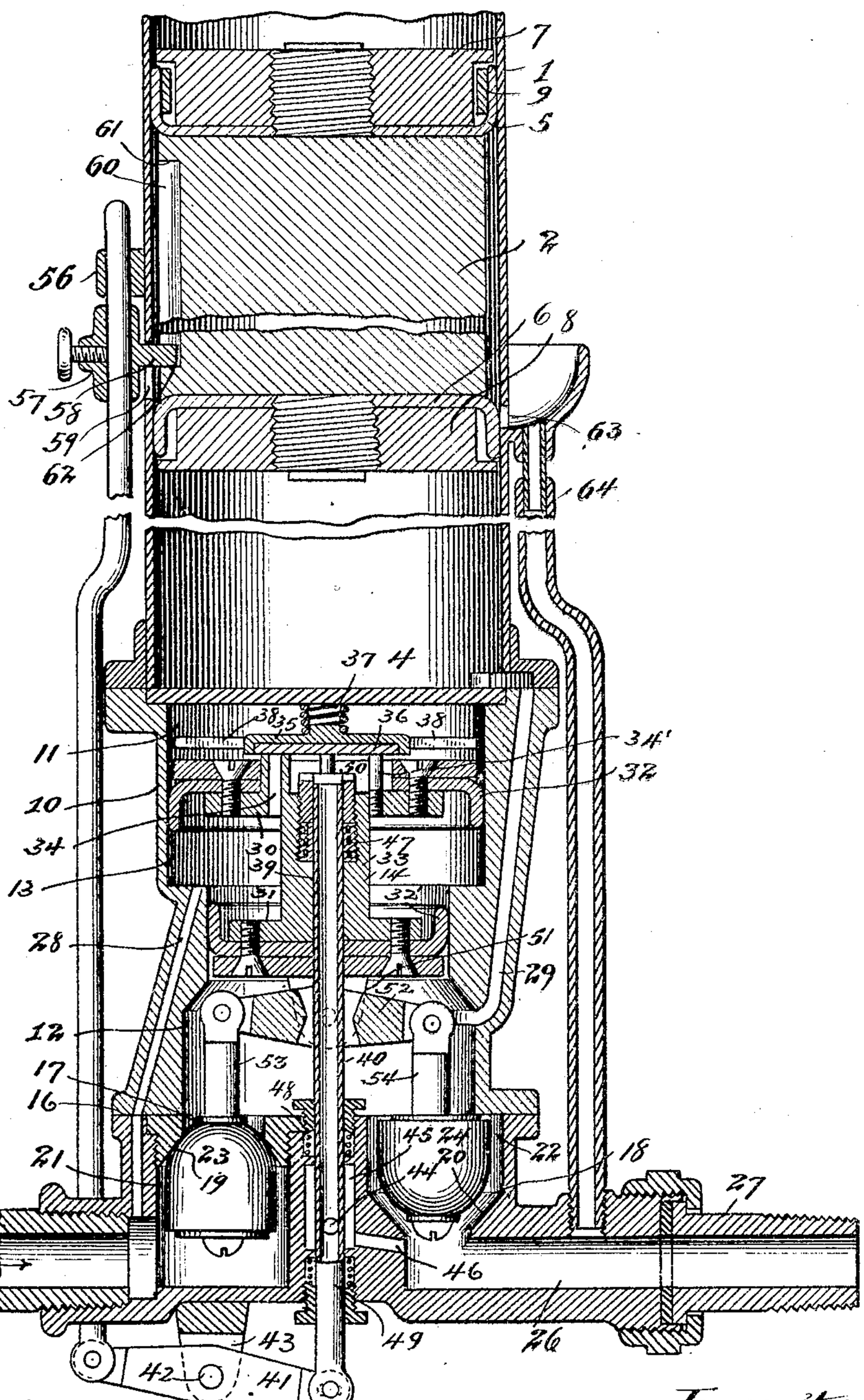
NO MODEL. 3 SHEETS—SHEET 2.

Fig. 2.



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NO MODEL. 3 SHEETS—SHEET 3.

Fig. 3.

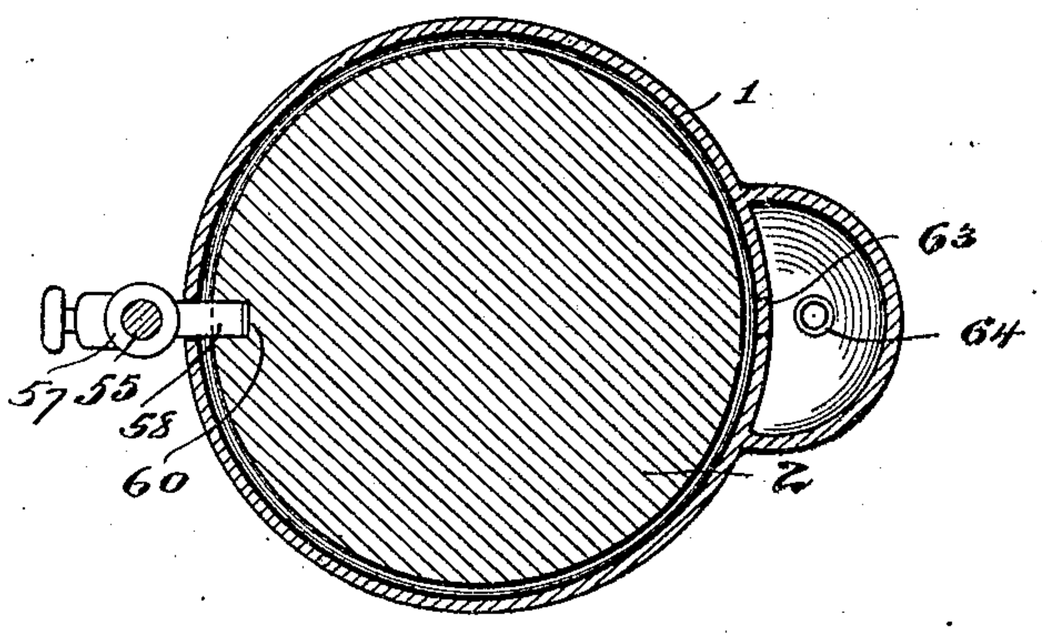


Fig. 4.

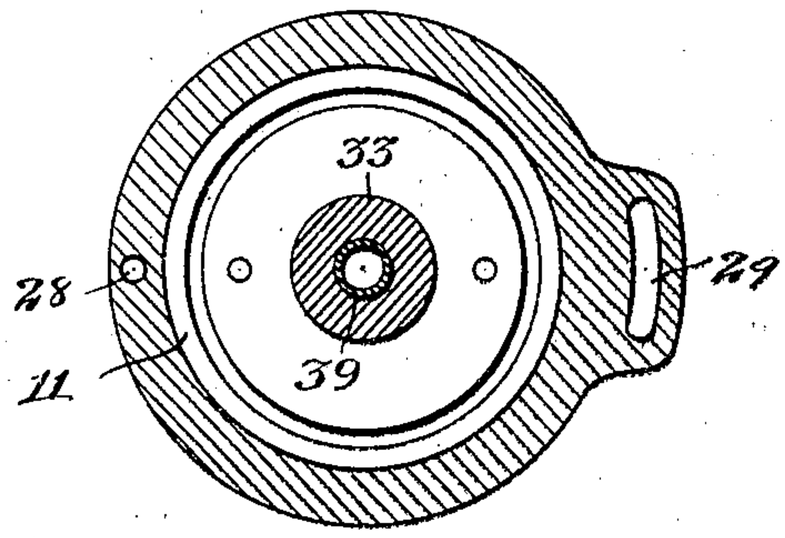
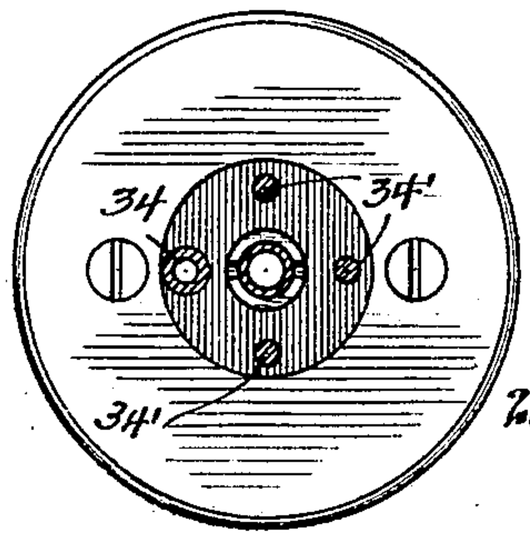


Fig. 5.

Fig. 6.



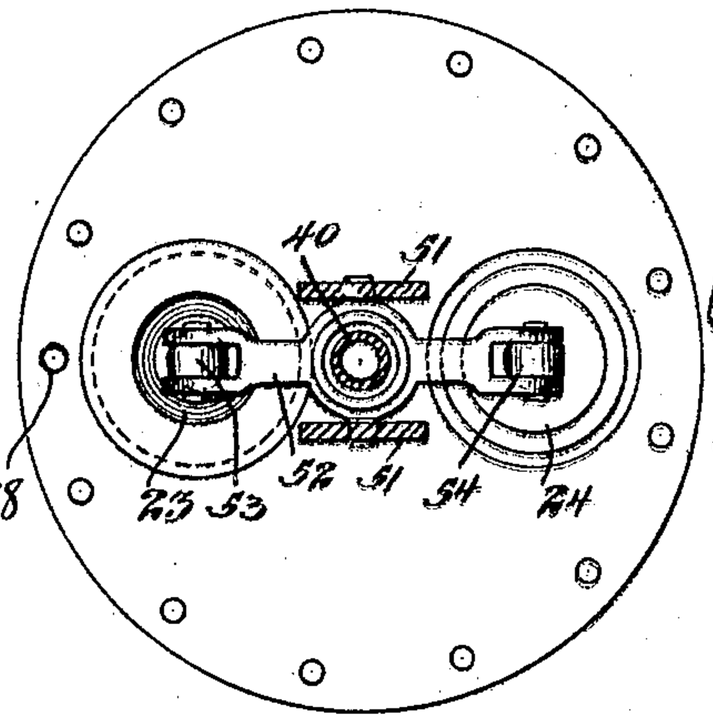
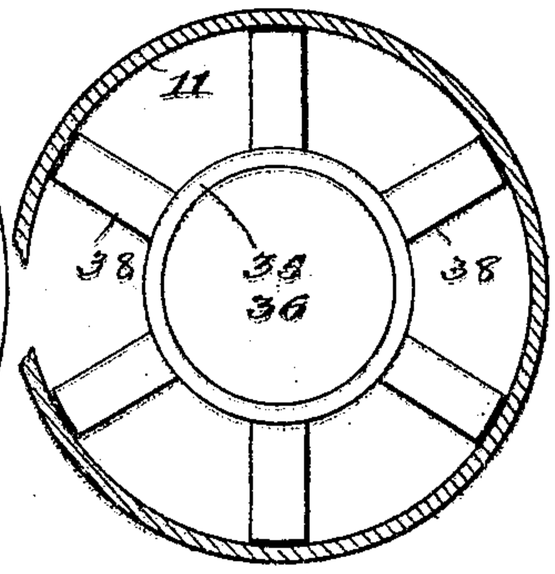


Fig. 7.



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No. 764,629. Patented July 12, 1904.

UNITED STATES PATENT OFFICE.

WILLIAM P. POWERS, OF CHICAGO, ILLINOIS.

HYDRAULIC MOTOR.

SPECIFICATION forming part of Letters Patent No. 764,629, dated July 12, 1904.

Application filed March 15, 1902. Serial No. 98,319. (No model.)

To all whom it may concern:

Be it known that I, WILLIAM P. POWERS, a resident of Chicago, in the county of Cook and State of Illinois, have invented certain new and useful Improvements in Hydraulic Motors, of which the following is a specification.

This invention relates to improvements in hydraulic pumps or motors of that general type adapted to be connected with any suitable source of water under pressure and employed for motive purposes.

Among the salient objects of the present invention are to provide a motor of the general character referred to in which the alternate power and return strokes of the main piston are controlled by means of a novel valve mechanism in which the power-stroke of the main piston operates to automatically open a discharge-port and a differential piston thereupon effects the reversal of the main valves; to provide a construction in which the initial movement of the controlling-valves in either direction operates to bring said valve mechanism more effectively under the control of the reversing forces and shifts the valves to fully-reversed position, thereby preventing the possibility of the mechanism stopping in equilibrium; to provide a construction in which the valves are moved directly into and out of engagement with their respective seats as distinguished from slide-valve mechanisms, thereby obviating the objectionable features of slide-valves; to provide a construction which depends entirely upon the motive power derived from the liquid for effecting the operation of the various valve-members, thereby dispensing with springs and their accompanying defects; to provide a construction devoid of small and delicate parts and one in which the parts are so designed that they may be economically manufactured and assembled, and in general to provide a compact, simple, and improved apparatus of the character referred to.

To the above ends the invention consists in the matters hereinafter described, and more particularly pointed out in the appended claims, and the same will be more readily understood from the following description, reference being had to the accompanying drawings, in which—

Figure 1 is a view in vertical or axial section of a motor embodying my invention. Fig. 2 is a similar section of the lower portion of the motor, showing the parts in changed position. Fig. 3 is a transverse sectional view taken on line 3 3 of Fig. 1. Fig. 4 is a transverse sectional view taken on line 4 4 of Fig. 1. Fig. 5 is a transverse sectional view taken on indirect line 5 5 of Fig. 1 and looking downwardly. Fig. 6 is a horizontal sectional view on line 6 6, and Fig. 7 is a sectional view in the plane of the under face of the cap-valve and looking upwardly.

Referring to the drawings, 1 designates as a whole a suitable cylinder, within which is mounted the main piston 2, the upper part 3 of said cylinder constituting in the present instance an air-compressing chamber and the lower portion 4 thereof the water-chamber wherein the lower end of the main piston is subjected to the motive pressure. The main piston is provided at its respective ends with cup leathers or suitable packings 5 and 6, respectively, severally secured to the ends of the main piston by means of the usual confining-blocks 7 and 8. The upper packing 5 is desirably held in bearing with the interior of the cylinder by means of a spring expansion-ring 9.

10 designates as a whole a subjacent extension-cylinder within which the valve mechanism is mounted, said extension-cylinder conveniently and as herein shown forming a base upon which the main cylinder is mounted and the two being detachably united at their meeting-points in a usual manner. The interior of the lower extension member 10 forms a chamber of irregular internal diameter, the upper and lower portions thereof, 11 and 12, being approximately of equal internal diameter, while the intermediate portion 13 is of lesser diameter or contracted throughout a substantial distance. The upper enlarged portion 11 and the communicating reduced portion 13 together constitute a differential-piston chamber, within which operates a differential piston, (designated as a whole 14,) while the lower enlargement 12 constitutes a valve-lever

chamber, within which are mounted certain parts of the valve mechanism. In the preferred construction shown herein the lower part of the extension 10 is made in the form of a separate casting (designated as a whole 15) and united with the main extension 10, as indicated by the dividing-line 16, in a usual manner, and within or through the member 15 are formed the main valve-ports 17 and 18, respectively, which admit and discharge the liquid to and from the motor. The parts 17 and 18 are made in the form of oppositely-facing beveled and annular valve-seats 19 and 20, respectively, communicating with subsidiary valve-chambers 21 and 22, respectively, within which are located the main valves 23 and 24. Said valves are direct-seating—*i. e.*, they move toward and from their seats in direct lines. The inlet-chamber 21 is placed in communication with a source of liquid-supply under pressure through a pipe 25 and communicates through the port 17 with the lower part of the chamber 12, while the valve-chamber 22 is in communication with the chamber 12 and communicates through the port 18 with an outlet-passage 26, connected with a discharge-pipe 27.

28 designates a passage or duct affording communication between the differential-piston chamber and the supply side of the motor at a point outside of the inlet-valve 23, said passage in the present instance communicating with the chamber 21 and being formed to extend through the walls of the members 10 and 15, thereby placing the said differential-piston chamber in open communication with the liquid under pressure at all times.

29 designates a water-passage forming communication between the chamber 12 and the lower or inlet end of the main cylinder, this passage being also conveniently and as shown in the present instance formed to extend through the walls of the member 10.

The differential piston 14 comprises two members (designated as a whole 30 and 31, respectively) made of suitable diameter to substantially occupy the respective portions of the chamber within which they fit and severally provided with suitable cup leathers or packings, as 32 and 32′, the two members of the piston being united by a central body or stem 33 of such length as to provide a substantial intervening space between said members. Through the upper and larger piston member 30 is formed a port 34, desirably and as shown herein in the form of a round bore arranged eccentric to the central body or stem of the piston and affording communication between the upper part of the chamber 11 and the space between the piston members. Within the upper part of the chamber 11 is mounted a plate-like valve member or cap 35, provided with a suitable packing-facing 36 and arranged to control the valve-port 34, said valve member 35 being normally held in spring-pressed engagement with its seat by means of a coiled expansion-spring 37, interposed between the upper end wall of the chamber 11 and the upper side of the valve member. In order to maintain said valve member centered, it is provided with a plurality of radial arms 38, extending to or near the side walls of the cylinder, and in order to support the valve horizontally and above the end of the differential piston studs 34′ are provided, the ends of which are in the plane of the valve-seat of port 34.

Through the differential piston is arranged to extend an axial passage 39, within which is arranged to reciprocate a hollow valve-actuating rod 40, which extends downwardly through the lower end member 15 and is there connected with a change-motion lever 41, pivotally supported, as indicated at 42, upon a suitable bracket or lug 43. The upper end of the hollow actuating-rod is adapted to abut against the face of the valve member 35, and it forms a communicating passage between the upper part of the chamber 11 and the outlet-passage 26, being to this end provided at a point where it extends through the lower member 15 with one or more outlet-ports 44, communicating with a surrounding chamber 45, which in turn communicates through a passage 46 with said discharge-passage 26. It will be understood that the lower end of the hollow rod below the ports 44 is closed, as indicated in the drawings, and in order to prevent the liquid from flowing past the outside of the actuating-rod at the various points where it reciprocates through the several supporting members it is provided with packing-glands 47, 48, and 49. The upper end of the differential-piston stem is centrally recessed at its upper end at the point where the actuating-rod 40 emerges therethrough to form an inlet-chamber 50, which permits the entrance of the liquid to said hollow actuating-rod and likewise contributes to the proper closing action of the valve member 35 by lessening the seat area upon which the latter acts.

The lower end of the differential piston is provided with a pair of depending ears or lugs 51, between which is pivotally supported a valve-connecting lever 52, the latter being provided at its center with a suitable opening, as indicated in detail, Fig. 5, to accommodate the passage therethrough of the actuating-rod 40 and said opening being of sufficient size to permit the oscillation of said lever without interfering with said actuating-rod. With the respective ends of the lever 52 are connected the main valves 23 and 24 by means of suitable stems or links 53 and 54, and inasmuch as said main valves are oppositely disposed with relation to each other it will be obvious that as the differential piston rises the inlet-valve will first be drawn up into engagement with its seat and a further upward movement of the piston will operate to

positively lift the outlet-valve away from its seat. Vice versa, when the piston descends the exhaust-valve will first be lowered into bearing with its seat, whereupon it will become the fulcrum or point of resistance, and the further descent of the piston will operate to positively force the inlet-valve open.

The actuating-rod 40 is operated through connections with the main piston 2, said connections comprising in the present instance a connecting-rod 55, connected at its lower end with one end of the lever 41 and extending thence up to and through a suitable guide 56, conveniently mounted upon the main cylinder. At a point laterally opposite and between the limits of throw of the main piston the actuating-rod is provided with a tappet-block 57, which is provided with an extension-finger 58, extending through a slot or opening 59 in the main cylinder and entering a longitudinally-extending slot 60, formed in the body of the main piston. The ends 61 and 62 of the slot 60 form tappet-shoulders, which alternately engage the finger 58 of the tappet-block in the forward and return movements of the piston, and thereby impart a limited movement to the actuating-rod 55 and through its connection with the change-motion lever 41 a corresponding reciprocation to the hollow valve-rod 40. The tappet-block 57 is adjustably mounted upon its actuating-rod, so that the throw imparted to the latter may be adjusted.

Inasmuch as there is usually a slight leakage of the liquid past the lower cup leather or packing of the main piston, a drain-aperture 63 is desirably provided in the main cylinder at a point between the limits of throw of the respective ends of the piston, which drain-aperture communicates with a drain-pipe 64.

In the present instance, as hereinbefore mentioned, the motor is shown as adapted for compressing air. The upper end of the main cylinder is accordingly provided with a suitable air-inlet 65, communicating with a valve-chamber 66, which in turn communicates with the interior of the cylinder through a passage 67, the backflow of air from the cylinder being prevented by means of a gravity check-valve 68. Likewise an outlet-passage 69 is provided for the compressed air which communicates with a second check-valve chamber 70, wherein is located a second gravity check-valve 71, the valve-chamber 70 being arranged to communicate with a suitable discharge-pipe 72.

The operation of the apparatus constructed and arranged as herein set forth may be described as follows: It will be understood that the main piston 2 is of sufficient weight to insure its prompt return by gravity, and assuming that the piston, as shown in Fig. 1, is descending and has engaged the tappet-block in its downward movement and shifted the hollow valve-rod 40 upwardly, thereby lifting the valve member 35 slightly away from the port 34, the pressure will be nearly equalized on both sides of said larger member, and inasmuch at the main exhaust-valve is at this time open, and therefore there is no pressure upon the lower end of the differential piston, the pressure acting on the inside of said piston will cause the latter to descend. The descent of the differential piston results in promptly further opening the port 34 and also lowers the main exhaust-valve into closed position and immediately thereafter forces the main inlet-valve open against the water-pressure, the descent of the differential piston being arrested by the valve 24 engaging its seat and valve 23 engaging the bottom wall of its chamber. As soon as the main inlet-valve has thus been forced open the liquid flows in through the lower chamber 12 and thence through the passage 29 to the inlet end of the main cylinder, thereby driving the piston in the latter upwardly and compressing the air which has been drawn in during the descent of the piston and expelling it. As the main piston approaches its upper limit of movement its shoulder 62 engages the lower side of the tappet-block and raises the actuating-rod 55, thereby lowering the hollow valve-rod 40. The valve-member 35, however, follows the valve-rod under the action of its spring 37 until said valve member engages the seat upon the upper end of the differential piston, whereupon it is arrested, and the further movement of the hollow valve-rod carries it out of engagement with said valve member 35, and thus permits the liquid which has occupied the space above the differential piston to escape through the valve-rod. As soon as the liquid above the differential piston begins to escape the differential pressure acting upon the two member of different area of the piston forces the piston upwardly, thereby carrying the main inlet-valve into closed position and immediately thereafter opening the exhaust-valve, whereupon the inflow of liquid being shut off and the exhaust opened the main piston descends by its own gravity, thus completing the cycle of operations.

It will be understood that when the reversal begins, which results in opening the exhaust and permitting the main piston to descend, a slight withdrawal or downward movement of the hollow valve-rod is immediately followed by a movement in the opposite or upward direction of the differential piston, thereby fully opening the exhaust from the space above the differential piston, so that in this case, as in the case of the first-described reversal, there is no possibility of the parts reaching a position in which the forces are in equilibrium. On the contrary, in the case of the reversal in either

direction as soon as the reversal begins the reversing forces are caused to act more effectively.

It will be seen from the foregoing description that a motor embodying my invention is not only completely positive in its operation, but that the valve mechanism thereof is so constructed throughout as to dispense with the use of slide-valves. This is a feature of great importance, since it entirely obviates the difficulties experienced with valves of the slide type—such as the cutting out of the packing where the valve member reciprocates across the ports, the wearing of the seats into irregular and non-fitting shapes, the rapid loss of efficiency as the valve becomes worn and reduced in size, and other well-known defects.

That feature of construction by which the main valves are operated by the differential piston in such manner that during the initiation of the reversal one of the main valves only is moved is obviously a feature of great importance, since it practically halves the power required to start the shifting of the valves. Obviously as soon as the reversal has been fairly inaugurated the full pressure is available to reverse the valves, and this full pressure will be effective before the second one of the main valves begins to move. It is to be noted that the main supply and exhaust valves do not move simultaneously, but, on the contrary, have a consecutive-order movement.

While I have herein shown and described a preferred and practical embodiment of the invention, yet the details thereof may be modified without departing from the invention, and I do not therefore limit myself to these details except to the extent that they are made the subject of specific claims.

I claim as my invention—

1. In a fluid-motor, the combination of a main cylinder and piston therein, a contiguous cylinder and differential piston therein, main inlet and exhaust valves controlling the flow to and from the said main cylinder, oppositely-disposed valve-seats and operative connections between said differential piston and said main valves, said valve-seats, valves and connections being constructed and arranged to impart a separate and consecutive-order movement to said valves, and means for varying the pressure on one side of said differential piston, said means being operable from the main piston, for the purpose set forth.

2. In a hydraulic motor, the combination of a main cylinder and piston therein, a contiguous cylinder and differential piston therein, direct-seating main inlet and outlet valves having oppositely-disposed valve-seats and controlling the flow to and from said main cylinder, operative connections between said differential piston and said valves, said valve-seats, valves and connections being constructed and arranged to impart a consecutive-order movement to said valves, whereby the seating of one main valve initiates the opening movement of the other, valve mechanism controlling the pressure and exhaust above the differential piston, said mechanism located at that end of the differential-piston cylinder having the larger area, and operative connections between said valve mechanism and the main piston.

3. In a hydraulic motor, the combination of a main cylinder and piston therein, a contiguous cylinder and differential piston therein, main inlet and exhaust valves controlling the flow to and from the main cylinder, provisions cooperating with said differential piston and said main valves, constructed and arranged to impart a separate and consecutive-order movement to the valves, an inlet-passage affording open communication between the interior of the differential cylinder and the pressure side of the motor, an exhaust-passage communicating with that end of the differential cylinder within which the piston is subject to the larger area of pressure, an exhaust-valve mechanism controlling said latter passage, operative connections between said valve mechanism and the main-cylinder piston, said operative connections comprising a shiftable actuating member and tappet connection between said actuating member and said main piston, and a valve-controlled passage leading from the space between the differential pistons to that end of the differential cylinder outside the piston of larger area.

4. In a hydraulic motor, the combination of a main cylinder and piston therein, a differential cylinder contiguous thereto and a differential piston therein, having separated heads of different area, an inlet-passage leading from the pressure side to the main cylinder, the end of said differential-piston cylinder containing the piston-head of smaller area being in open communication with a part of the main inlet-passage, a second inlet-passage affording constant communication between the differential-piston cylinder and the pressure side of the motor, and arranged to communicate with the space of said cylinder between the heads of the differential piston, a valve-controlled port leading from the space between said heads through the larger one to the contiguous end of the cylinder, main inlet and exhaust valves controlling the flow of liquid to and from the main cylinder, operative connections between said differential piston and said main valves, said main inlet-valve being arranged to control the inlet-passage at a point outside of or between the source of pressure and that part of the main inlet-passage with which said differential-piston cylinder is in open communication, an exhaust-passage communicating with that end of the differential cylinder within which the piston-head of larger area is arranged, a valve mechanism controlling said

latter exhaust-passage, and operative connections between said valve mechanism and the main piston, substantially as described.

5. In a hydraulic motor, the combination with the main cylinder and piston and main valves controlling the inlet and exhaust, of a differential cylinder and differential piston therein, and operative connections between said main valves and differential piston, said differential piston comprising piston-heads of different areas and axially separated from each other so as to provide an intervening space, an inlet-passage communicating with said differential cylinder at a point between the piston-heads therein, a port extending through the piston-head of larger area and affording communication between the parts of the cylinder at opposite sides of the said head of larger area, an exhaust-port communicating with that end of the cylinder containing the head of larger area, valve mechanism controlling said exhaust-port and said port leading through the piston-head, and operative connections between said valve mechanism and said main piston.

6. In a hydraulic motor, the combination with the main cylinder and piston and main valves controlling the inlet and exhaust, of a differential cylinder and differential piston therein, and operative connections between said main valves and differential piston, said differential piston comprising piston-heads of different areas, and axially separated from each other so as to provide an intervening space, an inlet-passage communicating with said differential cylinder at a point between the piston-heads therein, a port extending through the piston-head of larger area and affording communication between the parts of the cylinder at opposite sides of the said head of larger area, a passage formed to extend through the body of the differential piston, a valve member arranged to control said passage extending through the piston-head, a hollow actuating member working through the passage of the piston and arranged to lift said valve member away from its seat positively, and itself connected with the main exhaust and terminating in a seat that engages said valve member, said valve member being arranged to control both said hollow actuating member and the port extending through said piston-head of larger area and being mounted to follow the movements of the differential piston, and operative connections between the main piston and said actuating member.

7. In a hydraulic motor, the combination with the main cylinder and piston and main valves controlling the inlet and exhaust, of a differential cylinder and differential piston therein, and operative connections between said main valves and differential piston, said differential piston comprising piston-heads of different areas, and axially separated from each other so as to provide an intervening space, an inlet-passage communicating with said differential cylinder at a point between the piston-heads therein, a port extending through the piston-head of larger area and affording communication between the parts of the cylinder at opposite sides of the said head of larger area, a passage formed to extend through the body of the differential piston, a hollow actuating-rod communicating with the main exhaust and working through said passage and adapted to engage a movable valve member, a valve member arranged to control said passage through the rod and the port extending through said piston-head of larger area, said valve member being mounted to follow the movements of the differential piston, and operative connections between the main piston and said actuating member.

8. In a hydraulic motor, or pump, in combination a differential piston mechanism comprising a differential piston having axially-separated piston-heads of different area, a suitably-shaped cylinder within which said piston operates, an inlet-passage communicating with said cylinder at a point between the separated piston-heads, a port extending through the piston-head of larger area and affording communication between the space between the piston-heads and that outside of the piston, a spring-pressed valve arranged to control said passage extending through the piston, an exhaust-passage communicating with the larger end of the differential cylinder through said differential piston, and likewise controlled by said valve member, and means for positively lifting said valve member away from its seat to open the passage extending through the piston-head.

9. In a hydraulic motor, or pump, a valve-controlling differential piston mechanism comprising a differential piston having axially-separated piston-heads of different area, a suitably-shaped cylinder within which said piston operates, an inlet-passage communicating with said cylinder at a point between the separated piston-heads, a port extending through the piston-head of larger area and affording communication between the space between the piston-heads and that outside of the piston, a spring-pressed valve arranged to control said passage extending through the piston, an exhaust-passage communicating with the larger end of the differential cylinder through said differential piston, and likewise controlled by said valve member, and means for positively lifting said valve member away from its seat to open the passage extending through the piston-head, said means comprising a hollow valve-actuating rod which itself constitutes the exhaust-passage controlled by said valve member.

10. A differential-piston-valve-controlling mechanism comprising a differential piston

having axially-separated piston-heads of different area, a suitable cylinder within which said piston operates, a hollow valve-actuating rod mounted to reciprocate through the body of said piston, an inlet-passage communicating with the space between the piston-head, a passage extending through the piston-head of larger area and affording communication between the larger end of the cylinder and the space between the piston-heads, a plate-like valve member held in spring-pressed engagement with the piston-head of larger area and arranged to control the passage through said piston-head and the passage through the hollow valve-actuating rod, and means for shifting said hollow valve-actuating rod longitudinally in both directions whereby it is withdrawn from engagement with the valve controlling its inlet during one movement, and is caused to lift the valve to open the passage through the piston-head in its opposite movement.

11. In a fluid-motor, the combination with a cylinder and piston therein, of inlet and exhaust ports controlling the flow to and from said cylinder, said ports being arranged to form oppositely-disposed valve-seats, direct-seating valves arranged to control said ports, each provided with an actuating-stem, a connecting-lever fulcrumed between its ends and operatively connecting said valve-stems, and a reciprocatory member controlled by the movement of the said piston, upon which said connecting-lever is fulcrumed, whereby one of said valves is closed and the other opened during the reciprocation of the reciprocatory member in each direction, the closing valve being first fully closed and thereafter becoming the point of resistance to effect the opening of the other to said fulcrumed lever, as and for the purpose set forth.

12. In a differential piston, having axially-separated piston-heads, a passage extending through one of said heads, a valve member arranged to control said passage, and mounted to have a following movement with the piston, and means for forcing said valve from its seat, and holding it during the withdrawal of the piston, whereby the movement of the piston inaugurated by the opening of said valve contributes to the further opening of the passage controlled thereby.

13. In a fluid-motor, the combination of a main cylinder and piston therein, a contiguous cylinder and differential piston therein, main inlet and exhaust valves controlling the flow to and from the main cylinder, a subsidiary valve controlling the movement of the differential piston, mechanical connections between said main piston and said subsidiary valve for actuating the latter, and mechanical provisions coöperating with said differential piston and said main valves constructed and arranged to impart a consecutive-order movement to the latter.

14. In a fluid-motor, the combination of a main cylinder and piston therein, a contiguous cylinder and differential piston therein, main inlet and exhaust valves controlling the flow to and from the main cylinder, a subsidiary valve controlling the movement of the differential piston, mechanical connections between said main piston and said subsidiary valve for actuating the latter, and mechanical provisions coöperating with said differential piston and said main valves constructed and arranged to impart a consecutive-order movement to the latter, in which movement, alternately and reversely, each valve is closed before the opening movement of the other begins.

15. In a fluid-motor, the combination of a main cylinder and piston therein, a contiguous cylinder and differential piston therein, main inlet and exhaust valves controlling the flow to and from the main cylinder, a subsidiary valve controlling the movement of the differential piston, mechanical connections between said main piston and said subsidiary valve, and mechanical provisions coöperating with said differential piston and said main valves constructed and arranged to operate both main valves to impart a consecutive-order movement thereto during each movement of the differential piston in each direction.

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