

May 19, 1959

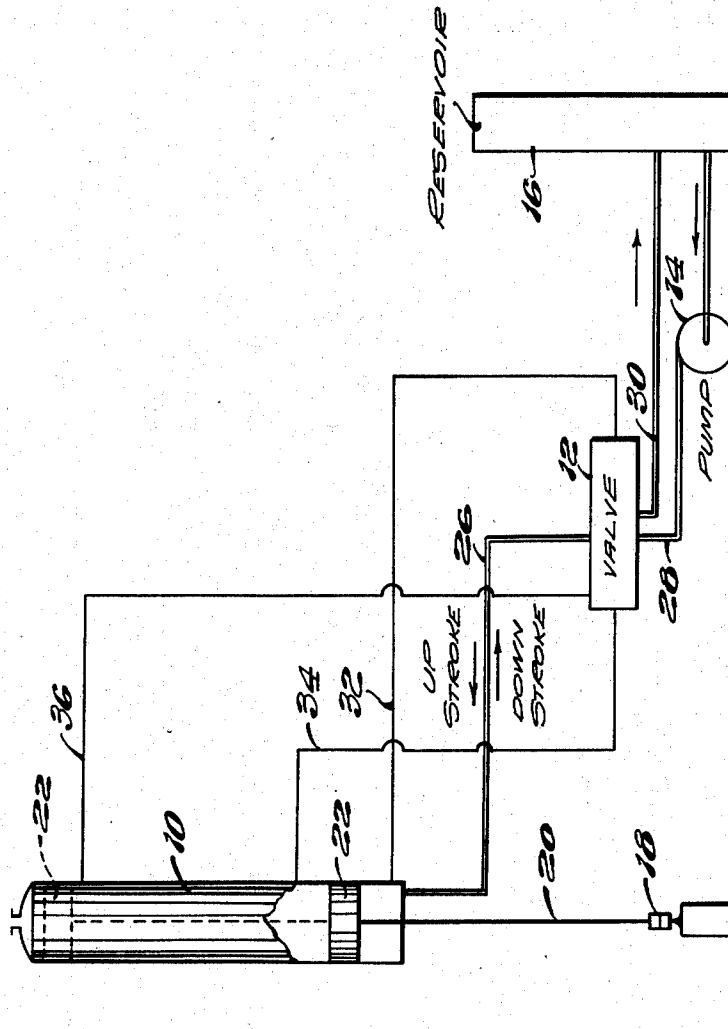
M. L. JONES

2,887,093

HYDRAULICALLY OPERATED PUMPING APPARATUS

Filed Oct. 18, 1956

6 Sheets-Sheet 1



INVENTOR,
Marvin L. Jones

BY

Herbert W Brown

May 19, 1959

M. L. JONES

2,887,093

HYDRAULICALLY OPERATED PUMPING APPARATUS

Filed Oct. 18, 1956

6 Sheets-Sheet 2

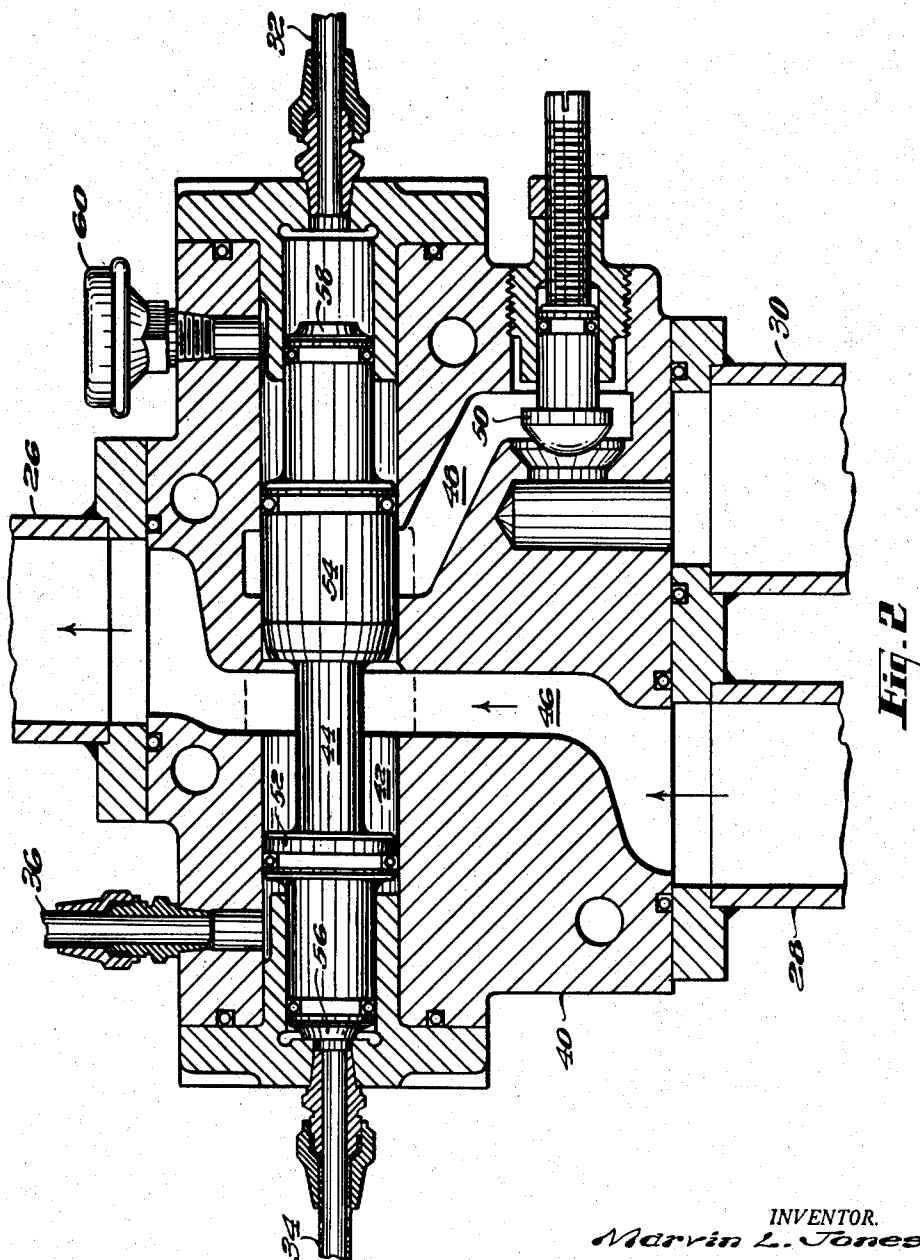


Fig. 2

INVENTOR.
Marvin L. Jones
BY
Kenneth Brown

May 19, 1959

M. L. JONES

2,887,093

HYDRAULICALLY OPERATED PUMPING APPARATUS

Filed Oct. 18, 1956

6 Sheets-Sheet 3

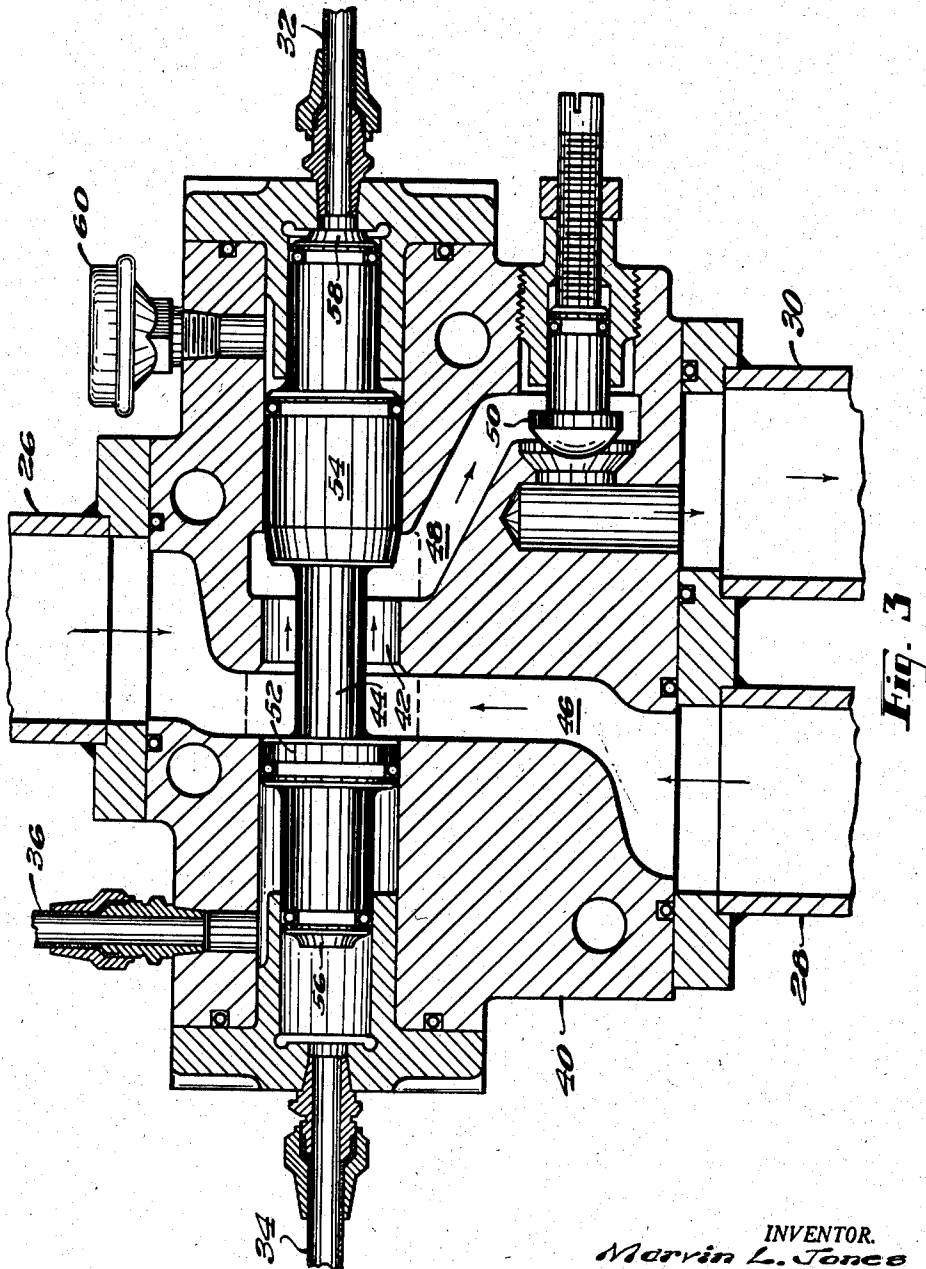


Fig. 3

INVENTOR.
Marvin L. Jones

BY

Samuel W. Brown
Atty

May 19, 1959

M. L. JONES

2,887,093

HYDRAULICALLY OPERATED PUMPING APPARATUS

Filed Oct. 18, 1956

6 Sheets-Sheet 4

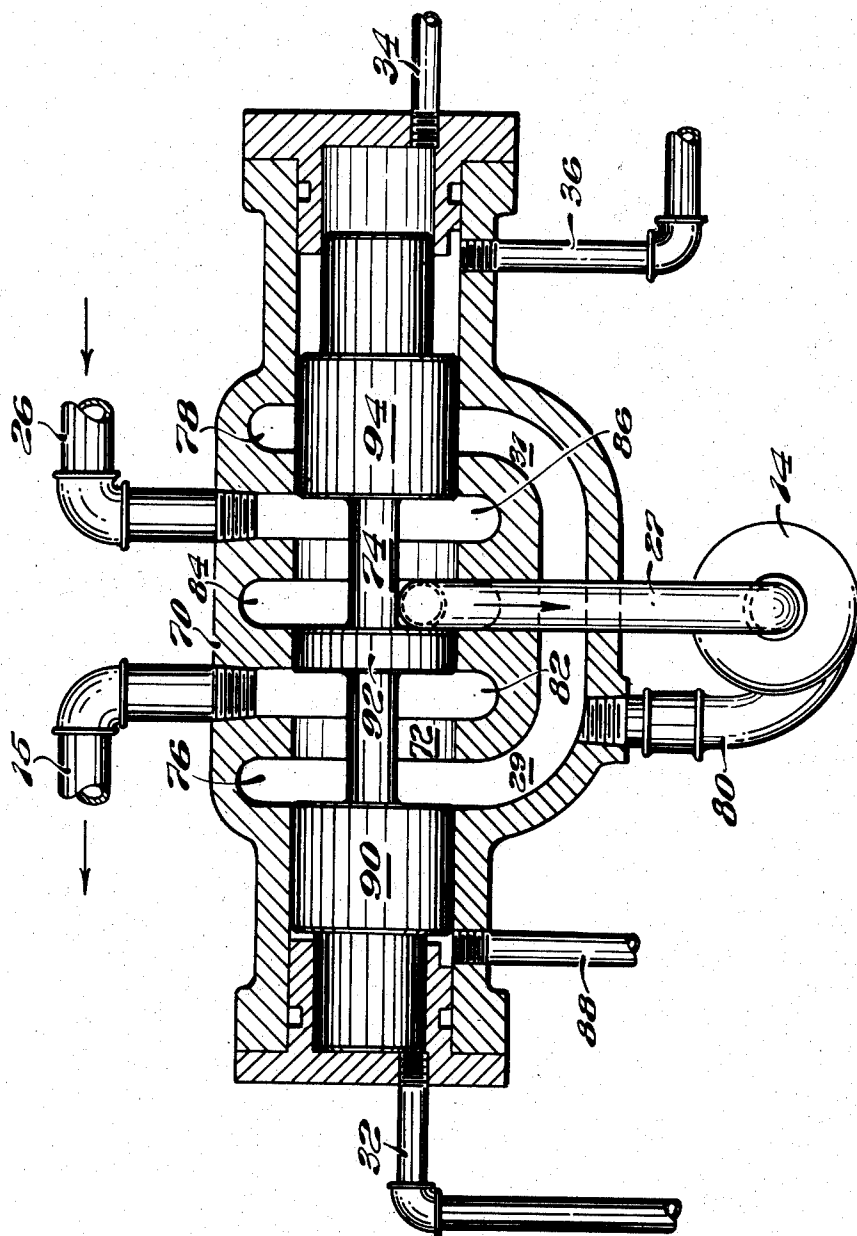


Fig. 4

INVENTOR.

MARVIN L. JONES

BY

James H. Brown
Att'y

May 19, 1959

M. L. JONES

2,887,093

HYDRAULICALLY OPERATED PUMPING APPARATUS

Filed Oct. 18, 1956

6 Sheets-Sheet 5

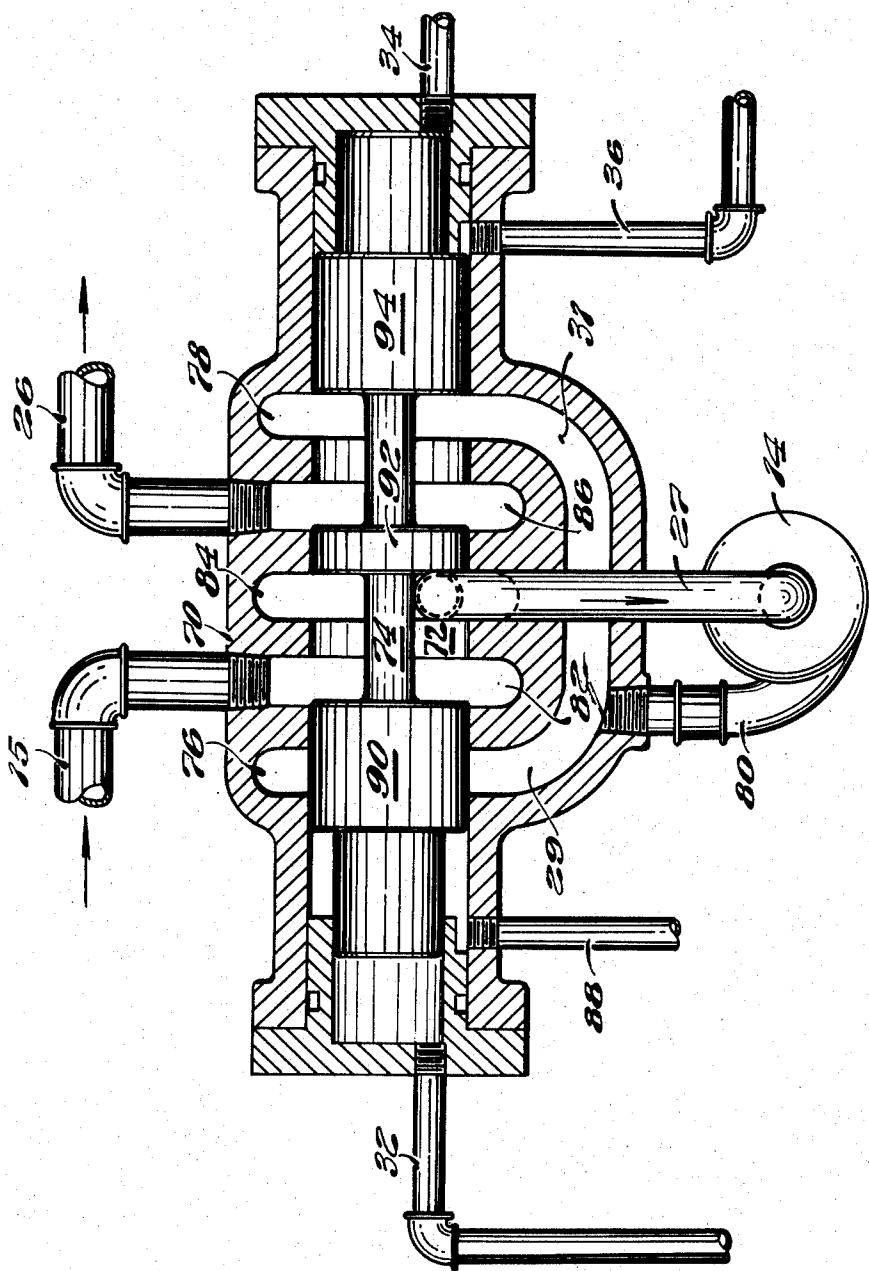


Fig. 5

INVENTOR.

MARVIN L. JONES

BY

Kenneth W. Brown

May 19, 1959

M. L. JONES

2,887,093

HYDRAULICALLY OPERATED PUMPING APPARATUS

Filed Oct. 18, 1956

6 Sheets-Sheet 6

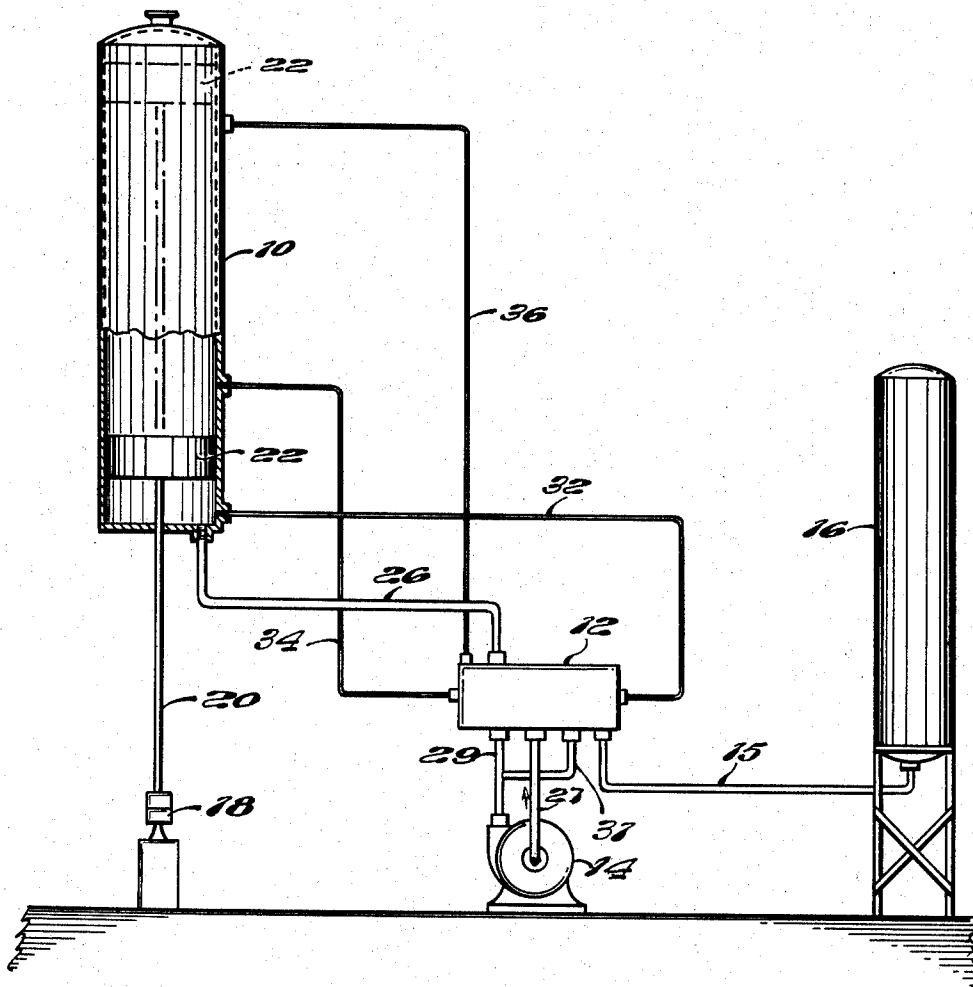


Fig. 6

INVENTOR.

MARVIN L. JONES

BY

Hammer Brown

1

2,887,093

HYDRAULICALLY OPERATED PUMPING APPARATUS

Marvin L. Jones, Pampa, Tex., assignor to Cabot Shops, Inc., Boston, Mass., a corporation of Massachusetts
Application October 18, 1956, Serial No. 616,824
9 Claims. (Cl. 121—150)

This invention relates to hydraulically operated well pumping apparatus and includes within its scope novel means for controlling the flow of hydraulic fluid to and from the lifting cylinder.

This application is a continuation-in-part of my co-pending application, Serial No. 509,814 filed May 20, 1955.

It is almost universal practice to pump nonflowing fluid wells by means of an oil pump located at the bottom of the well. The oil pump plunger is more commonly than not connected to a string of sucker rods which are reciprocated vertically by appropriate apparatus on the surface. Such apparatus may be a walking beam rocked on a fulcrum or a hydraulic cylinder containing a movable piston, each connected by suitable means to the sucker rods. It is this latter type of apparatus to which this invention appertains and which will for convenience hereinafter be referred to as the surface well pump or pumping unit since the oil pump at the bottom of the well constitutes no part of the invention.

To actuate the surface pumping unit a hydraulic fluid is forced into the bottom of a motor cylinder to lift the piston, piston rod and sucker rods. At the top of the stroke the pressure is released to allow the piston to drop under the weight of the rods in the well. Since it is not practicable to reverse or to stop the hydraulic fluid pump it is necessary to provide means for diverting the flow of the fluid at the top and bottom of each stroke of the pumping unit. Furthermore, because of the heavy load of the sucker rods it is desirable to provide some counterbalancing force to reduce prime mover power requirements. These requirements are provided for in the novel apparatus of this invention.

It is the principal object of this invention to provide a hydraulically controlled and operated surface pumping unit.

It is another object to provide novel means for automatically controlling the flow of the hydraulic fluid.

It is another object of this invention to provide such apparatus, including a novel reversing valve, which is simple to construct, operate and maintain and which is considerably less complicated than similar prior art apparatus, particularly in that no pilot valve is required.

The apparatus organized according to this invention includes a cylinder adapted for mounting over a well, containing a freely movable piston adapted for connection to sucker rods. A series of ports are provided in the cylinder wall for transmission of fluid pressure from the cylinder to the control valve. The control valve, which is a feature of this invention, is so organized as to conduct hydraulic fluid from a reservoir to the bottom of the motor cylinder during the upstroke, and to conduct fluid from the motor cylinder to the reservoir during the downstroke.

The apparatus of this invention will best be understood and appreciated from the following description thereof taken in connection with the accompanying drawings, in which

Fig. 1 is a circuit diagram showing one arrangement of apparatus parts and connecting piping and showing the motor cylinder in cross sectional detail,

Fig. 2 is a cross sectional view of one embodiment of

2

the control valve of the invention showing the control piston in pump upstroke position,

Fig. 3 is the same as Fig. 2 except that the control piston is shown in pump downstroke position,

Fig. 4 is a cross sectional view of another embodiment of the control valve of the invention showing the control piston in pump downstroke position,

Fig. 5 is the same as Fig. 4 except that the control piston is shown in pump upstroke position, and

Fig. 6 is a circuit diagram of another arrangement of piping for incorporation of the control valve of Fig. 4.

The organization of the complete apparatus is shown in Figs. 1 and 6. The components comprise well pump motor cylinder 10, control valve 12, hydraulic fluid pump 14 and counterbalancing reservoir tank 16. Motor cylinder 10 is mounted in conventional fashion over the well so that the well polish rod is connected by coupling 18 in a straight line with the cylinder piston rod 20.

Various conduits for interconnecting the various apparatus parts according to Fig. 1 are as follows. The main pipes for motive fluid consists of pipe 26 running between the bottom of motor cylinder 10 and valve 12, pipe 28 running between reservoir 16 and valve 12 through hydraulic fluid pump 14, and pipe 30 running directly between valve 12 and reservoir 16. In the arrangement shown in Fig. 6 pipe 26 likewise connects motor cylinder 10 and valve 12 while pipe 15 runs directly between reservoir 16 and the valve. Pump 14 connects only into valve 12 through inlet conduit 27 and discharge conduits 29 and 31 as hereinafter more fully described. In both Figures 1 and 6 fluid pressure conducting pipes are provided between motor cylinder 10 and valve 12, these being pressure pipe 32 connecting the bottom area of the cylinder with one end of the valve, and pressure pipes 34 and 36 connecting upper areas of the cylinder with the other end of the valve.

Motive fluid pipe 26 and pressure pipe 32 are connected into cylinder 10 at any convenient points in the bottom zone of the cylinder and below the lowest plane of travel of motor piston 22. Pressure pipe 34 is connected into the side wall of the cylinder 10 above the plane of the top of the piston at its extreme downstroke position and pressure pipe 36 is connected into the cylinder 10 just below the plane of the bottom of the piston at its extreme upstroke position.

By means of this arrangement of ports, the fluid pressure delivered to the valve 12, shown in detail in Figures 2-5, through pipe 32 moves the valve piston 44 or 74 so as to position the gates within the valve appropriately for flow of motive hydraulic fluid out through pipe 26 into motor cylinder 10. As the motor piston 22 rises past the port to pipe 34 in the cylinder wall, fluid pressure is transmitted through fluid pressure pipe 34 to the opposite end of the valve piston. Since fluid pressure through pipes 32 and 34 is acting with equal force on equal areas at each end of the valve piston, the piston is balanced and no movement will occur. As the motor piston 22 moves to the top of its stroke and passes the port to fluid pressure pipe 36 in the cylinder wall, fluid pressure is transmitted to an additional area on the valve piston causing it to become unbalanced. This unbalanced force will move the valve piston with its attached spools to the other end of its path of travel so as to open the gate to motive fluid discharge pipe 30 (Fig. 1), to allow the fluid from both the motor cylinder 10 and hydraulic fluid pump 14 to be returned to reservoir tank 16. As pipe 30 is opened to receive the fluid discharge from the motor cylinder, pressure in the motor cylinder will be relieved and motor piston 22 will drop. As the motor piston 22 moves past the port to fluid pipe 36 in the cylinder wall on its downward movement pressure on the additional area of the

valve piston is relieved and the valve piston is again balanced in position by equal pressure acting through fluid pressure lines 32 and 34 on equal areas at opposite ends of the valve piston. As the motor piston 22 moves past the port to fluid pressure pipe 34 in the cylinder wall, fluid pressure is relieved from fluid pressure line 34 and the area of the valve piston connected to line 34. This removal of pressure from one end of the valve piston will leave it again unbalanced and movement will occur so as to position the gates once again for flow of motive fluid into the motor cylinder, repeating the cycle.

The heart of my invention resides in the novel unitary valve 12 shown in cross sectional detail in Figs. 2-5. In the embodiment of Figs. 2 and 3 the valve comprises a body 40 having a cylinder 42, a freely movable piston 44 of lesser diameter therein and various body passages for the transmission of hydraulic fluid. Passage 46 intersects cylinder 42 to provide communication between motive fluid pipes 26 and 28. Another passage 48 connecting into a bay or recess in the cylinder wall provides communication between the cylinder and pipe 30. Pressure pipes 32, 34 and 36 each opens into the cylinder 42 at the appropriate locations to deliver fluid pressure as required for actuation of the valve piston 44. A metering valve 50 is advantageously provided in passage 48 for control of the motive fluid flow from valve to conduit 30 whereby to control rate of descent of the motor piston.

It will be noted that piston 44 is provided with enlarged shoulders or spools 52 and 54, the former serving as a longitudinal pressure bearing surface and the latter as a gate for the passages previously mentioned. When Figs. 2 and 3 are compared it will be seen that when gate 54 is in position as far to the left as possible, passage 48 is blocked off at its end within the valve body, but when the gate is in its extreme right hand position communication is opened between passages 46 and 48 through the cylinder bore and around the piston 44.

To revert to Fig. 1 briefly, the change in flow resulting from movement of gate 54 has this result. When the gate is at the left as shown in Fig. 2 motive hydraulic fluid flows from the valve body through pipe 26 to elevate piston 22 in pump cylinder 10. However, when gate 54 shifts to the right as shown in Fig. 3 the pressure on pipe 26 is relieved due to the diversion of hydraulic fluid into passage 48 and through pipe 30 to the reservoir which is under considerably less pressure than that prevailing in the motor cylinder.

Actuation of piston 44 is effected by hydraulic pressure transmitted through pipes 32, 34 and 36 as previously described. Since motor cylinder pressure is at all times imposed upon line 32 naturally piston 44 will be urged to the left in the absence of countervailing pressure. Such pressure is exerted as motor piston 22 passes the inlets to lines 34 and 36 seriatim during the upstroke and is relieved in inverse order on the downstroke in thiswise.

Since each end 56 and 58 of piston 44 must necessarily have the same cross sectional area, when an equal pressure is exerted in each end of cylinder 42 the piston will remain wherever it chances to be prior to equalization of pressures. However, when pressure is added through line 36 the total force on the left end, i.e., on the end 56 of the piston shaft and on shoulder 52, of the piston is greater than that on the right end so that the piston will shift to the right for the available distance. An air release conduit capped with a filter 60 is provided at the right hand end of cylinder 42 to permit the area behind spool 54, which is never subject to hydraulic pressure, to breathe.

Upon movement of piston 44 to the right the flow of motive hydraulic fluid to motor cylinder 10 is stopped and the fluid already in the cylinder is free to flow out through pipe 26 under the pressure exerted by the gravita-

tionally-urged downward travel of motor piston 22. In the course of motor piston travel the pressure on the inlet to line 36 is first relieved which just balances the forces at each end of valve piston 44. However, when motor piston 22 passes the inlet to line 34, thus relieving the pressure on piston end 56, the piston moves again to the left, closing passage 48 and diverting motive hydraulic fluid through pipe 26 into motor cylinder 10. This cycle continues to be repeated so long as motive hydraulic fluid continues to be delivered to the valve.

The valve 12 as embodied in Figs. 4 and 5 differs somewhat from the embodiment of Figs. 2 and 3 in that it provides for positive withdrawal of motive hydraulic fluid from motor cylinder 10 on downstroke by suction exerted by pump 14. This valve comprises a body 70 having a cylinder 72, a freely movable piston 74 of lesser diameter therein and bays or recesses in the cylinder wall connected to conduits for the transmission of hydraulic fluid. Bays 76 and 78 are connected to branches 29 and 31 respectively of the discharge pipe 80 from pump 14. Bay 82 connects with reservoir conduit 15, bay 84 with intake conduit 27 of pump 14 and bay 86 with motor cylinder conduit 26. Pressure pipes 32, 34 and 36 are provided in the same operative positions and for the same purpose as in the embodiment of Figs. 2 and 3 described above and pipe 88 is provided to permit in and out air flow on movement of the piston in the area of the cylinder behind the end spool which is not exposed to longitudinal hydraulic fluid pressure.

Piston 74 is provided with gate spools 90, 92 and 94, the end spool 94 also providing a longitudinal pressure bearing surface. When Figs. 4 and 5 are compared it will be seen that when piston 74 is in its extreme right hand position (Fig. 5) bays 78 and 86 are open to fluid under pressure from the discharge of pump 14 through branch conduit 31 and conduct the fluid to motor cylinder conduit 26. At the same time bays 82 and 84 are open to pump intake conduit 27 to permit withdrawal of fluid from reservoir 16 through reservoir conduit 15. Upon movement of piston 74 to the other end of cylinder 72 (Fig. 4) bays 76 and 82 effect communication between pump discharge branch conduit 29 and reservoir conduit 15 while bays 84 and 86 effect communication between pump intake conduit 27 and motor cylinder conduit 26 for withdrawal of fluid from the cylinder and delivery to the reservoir.

Otherwise stated, the spools act as gates to change the pattern of communication through valve cylinder 72 between the various bays. Spool 90 alternately opens and closes bay 76 and pump discharge branch conduit 29 while spool 94 does likewise for bay 78 and pump discharge branch conduit 31. Spool 92, on the other hand switches communication of pump intake conduit 27 and bay 84 alternately between reservoir conduit 15 and motor cylinder conduit 26.

It will be evident to those skilled in the art that the above description in terms of left and right positions is used merely for illustration and that it makes no difference for the purposes of this invention whether the various lines, passages and spools are oriented either left or right. Furthermore, any of the bays may be offset with respect to any others of the bays to any desired degree around the axis of the valve cylinder. Also there is no critical ratio between the respective sizes of the valve cylinder, the piston, the piston ends and spools. The various dimensions will be selected to provide the best results under any given conditions of service.

One apparatus constructed according to this invention had the following specifications:

Well pump actuating means 10, 22

Peak load rating	-----lbs.	12,000
Max. stroke length	-----ft.	10
Cylinder diameter	-----ins.	5
Max. operating pressure	-----p.s.i.	700

5

Max. counterbalancing pressure -----p.s.i. 400
 Rated pumping speed—10 ft. stroke -----s.p.m. 5.1
 Min. hydraulic fluid required -----gals. 55

Valve 12

Length cylinder 42 -----Inches 8¼
 Length piston 44 -----7½
 Diameter piston ends 56 and 58 -----1
 Diameter shoulder 52 -----1.5
 Diameter gate spool 54 -----1.5

Having thus described my invention, I claim:

1. A hydraulic pumping apparatus comprising in combination a vertically disposed motor cylinder having a load lifting piston therein, a motive hydraulic fluid conduit and a first fluid pressure transmission line connected into the lower end thereof, second and third fluid pressure transmission lines connected into the side wall of said cylinder at spaced points therealong, a source of hydraulic fluid under pressure, hydraulic fluid supply and return conduits, and a unitary valve for the control of hydraulic fluid flow connected to said hydraulic fluid supply and return conduits and also connected to said first-above-mentioned motive fluid and fluid pressure transmission lines, said valve comprising means including a central cylinder, a spooled piston freely movable therein, the cylinder communicating with said conduits and fluid pressure transmission lines whereby in response to the alternate exertion and relief of pressure in said second and third transmission lines the spooled piston is caused to travel to one end of its cylinder, thereby causing hydraulic fluid from said source first to be delivered to said cylinder motive fluid line and then, upon travel of said load-lifting piston past the cylinder inlet of said third pressure transmission line, the spooled piston is caused to travel to the other end of the cylinder, thereby causing hydraulic fluid to be returned to said hydraulic fluid source together with motive fluid discharged from said cylinder, in continuous repetition of a cycle.

2. The apparatus of claim 1 further characterized by the spooled piston in the valve cylinder having a longitudinal pressure bearing surface of equivalent area at each end and an additional longitudinal pressure bearing surface adjacent one end, each of said surfaces being in communication with a different one of the fluid pressure transmission lines.

3. The apparatus of claim 1 further characterized by the valve cylinder having a series of recesses therealong each communicating with a different motive hydraulic fluid conduit and the piston having gate spools affixed thereto in position to alter the pattern of communication between various of said recesses on movement of the piston.

4. A unitary hydraulic valve adapted to control the actuation of a reciprocating hydraulic motor, said valve comprising a body member, a cylinder therein, a plurality of recesses connected to motive hydraulic fluid ports, a freely movable piston therein having a longitudinal pressure bearing surface of equivalent area at each end and an additional longitudinal pressure bearing surface adjacent one end, at least one gate spool secured to the piston and engaging the bore of the cylinder with a substantially fluid-tight fit and adapted to close the entrance to various of said recesses, fluid pressure conduits communicating with the cylinder in the areas of the longitudinal pressure bearing surfaces, said conduits being connected to zones of variable pressure in the reciprocating hydraulic motor, the valve being so arranged that motive hydraulic fluid will be caused to flow through the cylinder and certain of the recesses and connecting ports in alternation in response to changes in position of the spooled piston brought about by changes in pressure conducted through said fluid pressure conduits.

6

5. The valve of claim 4 further characterized by having five recesses in the cylinder wall, the middle one communicating with a hydraulic fluid exhaust port, the two flanking recesses communicating with alternating hydraulic fluid supply and discharge ports and the two end recesses communicating with a pressurized hydraulic fluid inlet port and the piston thereof having three gate spools, each end spool having a travel path across the entrance of its corresponding end recess and the center spool having a travel path across the middle recess with its at rest position on either side thereof.

6. The valve of claim 4 further characterized by having two recesses in the cylinder wall, one communicating with a pressurized hydraulic fluid inlet port and the other with a fluid exhaust port and the piston thereof having a shoulder and a gate spool, the path of travel of the gate spool being across both recesses and having an at rest position alternately blocking the entrance of each recess.

7. A hydraulic pumping apparatus comprising in combination a vertically disposed motor cylinder having a load lifting piston therein, a motive hydraulic fluid conduit and a first fluid pressure transmission line connected into the lower end thereof, second and third fluid pressure transmission lines connected into the side wall of said cylinder at spaced points therealong, a fluid pressure line, an exhaust line, and a unitary hydraulic fluid flow control valve connected by conduits to said fluid pressure and exhaust lines and motor cylinder and by said fluid pressure transmission lines to said motor cylinder, said valve comprising a casing having a central cylinder open to said conduits and pressure transmission lines and a spooled piston reciprocable therein in response to the alternate exertion and relief of pressure in said second and third transmission lines, said piston and spools constituting gate means for the control of hydraulic fluid flow through the valve cylinder between said several conduits whereby hydraulic fluid from said fluid pressure line is delivered to said motor cylinder on upstroke therein and then, upon travel of said load lifting piston past the cylinder opening to said third pressure transmission line, is returned to the exhaust line together with motive fluid discharged from said cylinder on downstroke therein, in continuous repetition of a cycle.

8. A unitary hydraulic valve comprising a body member enclosing a cylinder, conduits to and intersecting said cylinder as hereinafter described, a freely movable piston therein, the opposing end areas of which being of substantially equal area, a shoulder spool adjacent one end and a gate spool adjacent the other end of said piston said spools engaging the bore of the cylinder with substantially fluid-tight fit, fluid pressure conduits communicating with the areas of said cylinder bounded by each end and the shoulder of the piston respectively, said conduits being connected to a source of variable pressure, two motive hydraulic fluid passages entering the valve body at spaced apart points and terminating in the cylinder in approximately the same longitudinal plane, and a third motive hydraulic fluid passage opening into the cylinder at a point spaced in the direction of the gate spool from the cylinder termination point of the first mentioned hydraulic passages and being closable against hydraulic fluid flow when the gate spool is moved into position across its opening, said hydraulic fluid passage opening being of larger diameter than that of the cylinder bore.

9. The valve of claim 8 further characterized by a metering valve being positioned in said third motive hydraulic fluid passage.

References Cited in the file of this patent

UNITED STATES PATENTS

2,048,550 Helenberg ----- July 21, 1936
 2,745,386 Wildeman ----- May 15, 1956