

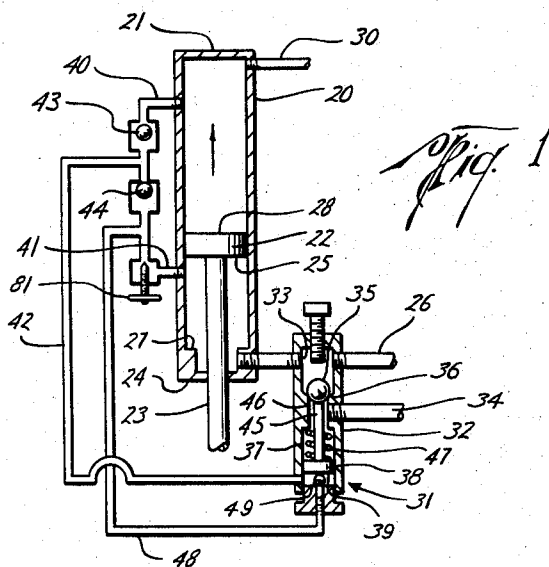
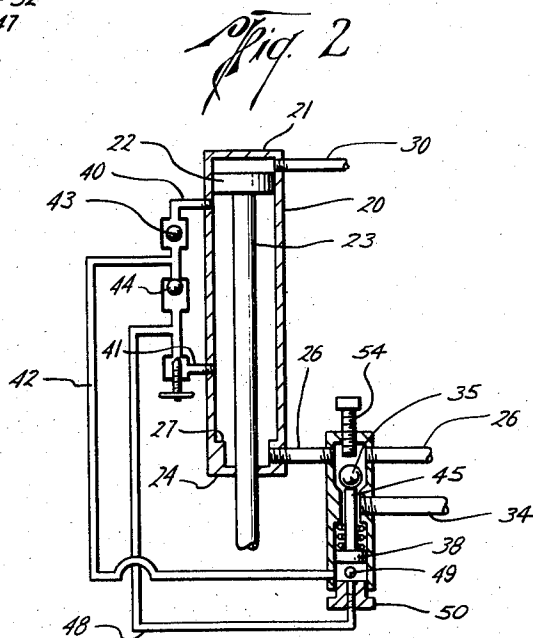
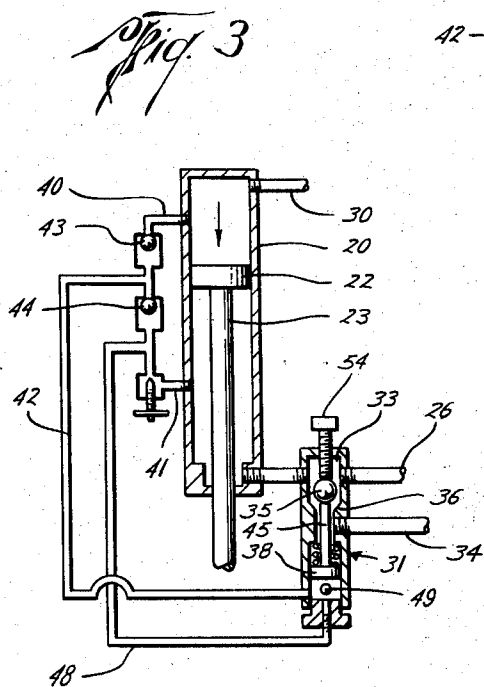
Nov. 24, 1959

R. B. JOHNSTON  
HYDRAULIC PUMPING SYSTEM

2,914,037

Filed Sept. 23, 1957

3 Sheets-Sheet 1



Rufus B. Johnston  
INVENTOR.

BY  
Browning, Simms, Hyer  
& Eickelrodt  
ATTORNEYS

Nov. 24, 1959

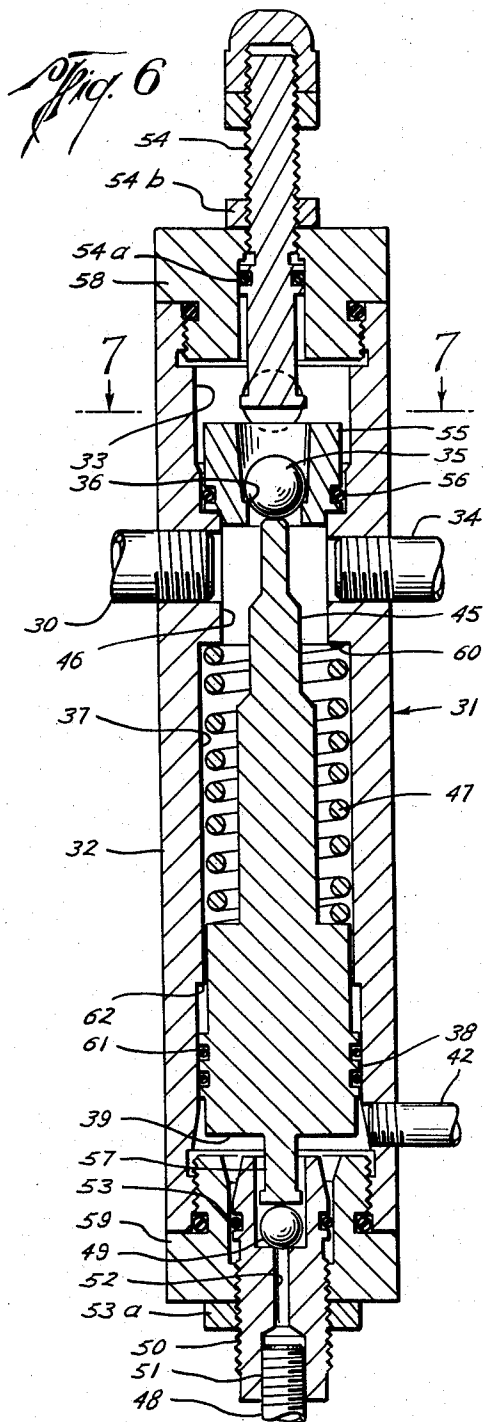
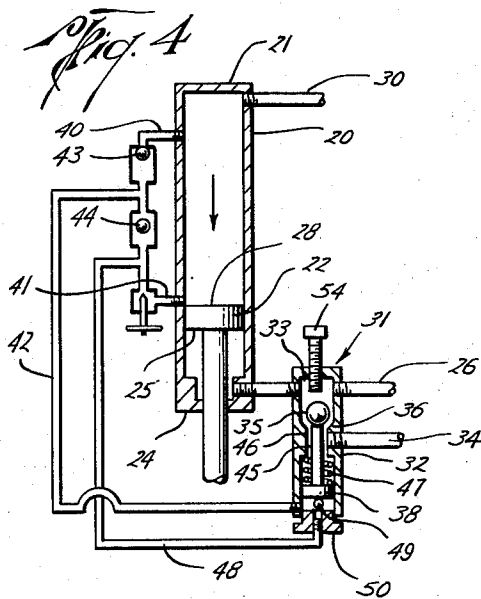
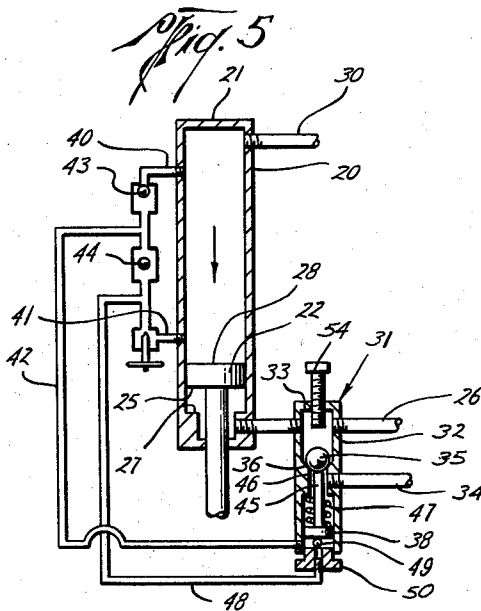
R. B. JOHNSTON

2,914,037

HYDRAULIC PUMPING SYSTEM

Filed Sept. 23, 1957

3 Sheets-Sheet 2



Rufus B. Johnston  
INVENTOR.

BY  
*Browning, Linas, Hyer*  
*& Eickelrodt*  
ATTORNEYS

Nov. 24, 1959

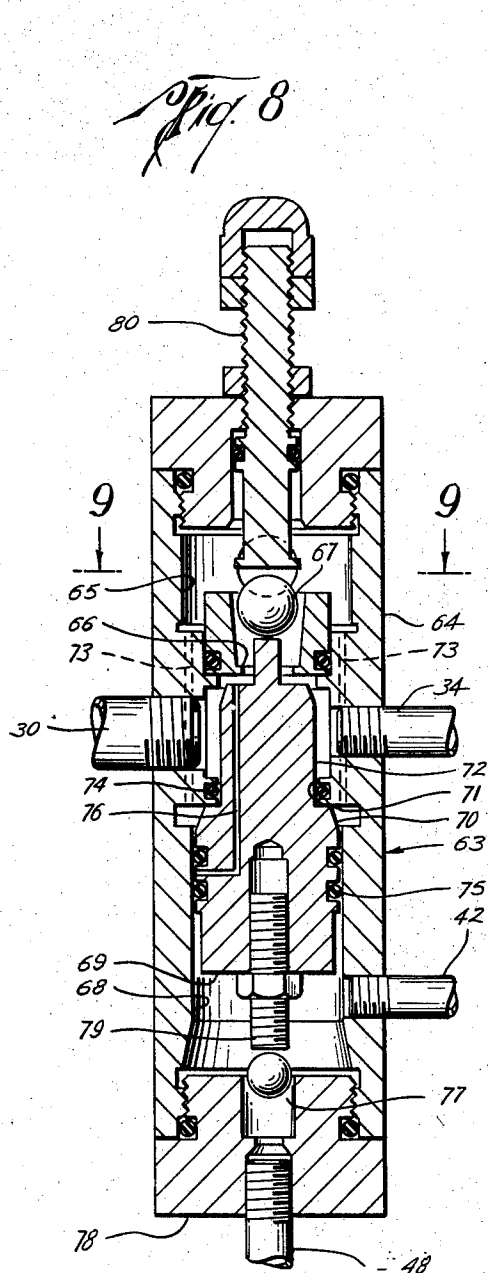
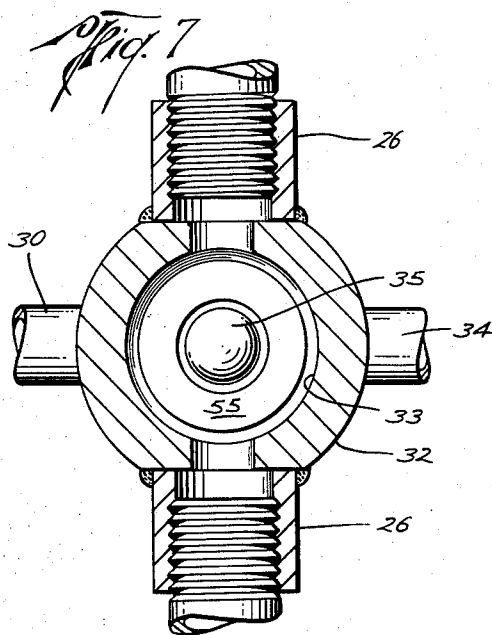
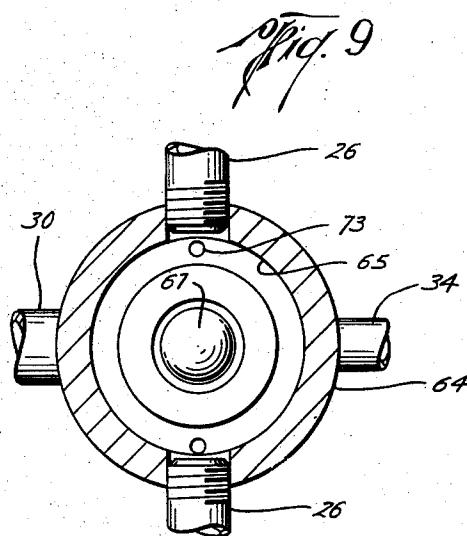
R. B. JOHNSTON

2,914,037

HYDRAULIC PUMPING SYSTEM

Filed Sept. 23, 1957

3 Sheets-Sheet 3



Rufus B. Johnston  
INVENTOR.

BY  
*Browning, Senne, Hyer  
& Eckersolt*  
ATTORNEYS

1

2,914,037

## HYDRAULIC PUMPING SYSTEM

Rufus B. Johnston, Dallas, Tex., assignor to Wilson Supply Company, Houston, Tex., a corporation of Texas

Application September 23, 1957, Serial No. 685,583

10 Claims. (Cl. 121—150)

This invention relates generally to an hydraulic pumping system and, more particularly, to improvements in a single-acting and essentially automatic hydraulic motor of the general type shown in my copending application, Serial No. 577,435, filed April 10, 1956, and entitled "Hydraulic Pumping System."

As pointed out in my earlier application, motors of this general type customarily include a pilot valve control so connected to the motor cylinder as to automatically and positively shift a reversing valve between positions for admitting and exhausting hydraulic fluid to and from the working side of the motor piston in response to movement of the motor piston into the limits of its return and working strokes, respectively. In accordance with my earlier invention, the need for such a pilot valve control was obviated by the provision of a reversing valve in which the valve member was seatable and unseatable in response to reciprocation of a piston having fluid connections with the motor cylinder. These connections were so arranged that the valve piston was movable in opposite directions to unseat and permit seating of the valve member in response to movement of the motor piston into the limits of its working and return strokes, respectively.

Intermediate these limits of motor piston movement, however, the fluid connections were operable to prevent communication between the valve piston and working side of the motor piston. In order to prevent the system from getting on "dead center," the valve piston was provided with a spring-pressed actuator or plunger for maintaining the valve member unseated during the initial stage of return movement of the piston. The valve of my earlier invention also included a spring for retracting the piston to insure seating of the valve member during the initial stage of working movement of the piston. Although this motor enjoyed considerable commercial success, I did encounter some difficulty with breakage of the aforementioned actuator spring, particularly since it was of considerable length and relatively small diameter.

An object of this invention is to provide a single-acting and essentially automatic hydraulic motor of the general type above described in which the reversing valve thereof does not include parts, such as the actuating spring of my earlier invention, which are susceptible of breakage and other maintenance problems.

Another object is to provide a reversing valve for a motor of the general type above described having means for retracting the valve piston with a greater force than the spring of my earlier invention while, at the same time, being more compact.

These and other objects are accomplished by a system which, similar to the system of my earlier invention, includes a motor cylinder having a piston reciprocable therein and a conduit connected to the cylinder for admitting hydraulic fluid to one side of the piston for moving it in a working direction to a first extreme position. The opposite side of the motor piston is continuously vented and means including a reversing valve movable to

2

an open position are provided for exhausting said hydraulic fluid from said one side of the piston to permit its movement in an opposite direction to a second extreme position. More particularly, this valve comprises a body having a passageway therein connecting with the conduit and an outlet from the body, and a valve member seatable upon a valve seat disposed across the passageway intermediate its connection with the conduit and outlet so that said valve member closes the passageway when seated.

This system also includes pressure responsive means movable upon the admission of hydraulic fluid thereto in one direction to unseat the valve member and conduit means connecting the motor cylinder at spaced apart levels therein with the pressure responsive means. Valve means in the conduit means are automatically operable in the first extreme position of the piston to admit said hydraulic fluid from said cylinder on said one side of the piston and through one of said connections to the pressure responsive means and, in the second extreme position of the piston, to exhaust said hydraulic fluid from said pressure responsive means and through said other connection into the cylinder on said other side of the piston. Means to be described more fully hereinafter are provided for urging the pressure responsive means in an opposite direction so that the valve member may seat upon the exhaustion of hydraulic fluid from said pressure responsive means.

This valve means is operable during movement of the piston between said extreme positions to prevent communication through said conduit means between said pressure responsive means and said one side of the piston. As previously mentioned, it is the initial stage of this movement of the piston from the first toward the second extreme position which is critical. The system of my present invention includes additional means automatically operable to admit hydraulic fluid from the cylinder on said one side of the piston to said pressure responsive means during at least the critical stage of motor piston movement when communication through said conduit means between said cylinder on said one side of the piston and said pressure responsive means is prevented.

This additional automatically operable means comprises additional conduit means for communicating the pressure responsive means with the motor cylinder at a level nearer the second extreme position of the motor piston than said one connection, and a second valve member adapted to open said additional conduit means in response to movement of the pressure responsive means in a direction to open the first valve member and to close such communication in response to movement of the pressure responsive member in the opposite direction. Thus, as the motor piston moves into its first extreme position and starts back on its return stroke, the force upon the pressure responsive means due to the hydraulic fluid admitted through the additional conduit means will move said pressure responsive means to a position to maintain the reversing valve member unseated. On the other hand, as the motor piston moves into its second extreme position and starts back on its working stroke, the closing of the second valve member will prevent the application of such a force to the pressure responsive means and thereby avoid premature opening of the reversing valve member.

The second valve member as well as the pressure responsive means are contained within the body of the reversing valve. For this purpose, the body also includes a cylinder offset from the passageway connecting the conduit for admitting hydraulic fluid to the cylinder and an outlet from the body. Ports are provided in the cylinder for connection with the conduit means and additional con-

duit means, and a valve seat for the second valve member is disposed intermediate the cylinder and the port which is connectable to the additional conduit means. The pressure responsive means of the valve comprises a piston reciprocally mounted in the cylinder and extending between said valve members to provide a force transmitting connection operable to unseat the first valve member when the piston is urged in one direction by the admission of hydraulic fluid to said cylinder and to seat the second valve member when the piston moves in the opposite direction upon the exhaustion of hydraulic fluid from said cylinder.

In accordance with another novel aspect of the present invention, the piston of the reversing valve may be provided with a surface forming a part of a pressure chamber within the cylinder and so arranged as to urge the piston in a direction to permit seating of the first valve member upon the admission of pressure fluid to the chamber and the exhaustion of hydraulic fluid from the opposite side of the piston. More particularly, this chamber is connected with the passageway in the valve body so that the piston is retracted by the force of hydraulic fluid acting upon said piston surface.

It is important that the two valve members of the reversing valve are seated substantially simultaneously, because if there is too much lag between their seating, the system may get on "dead center," as will be apparent from the description to follow. Even when the valve members are properly installed, only a small amount of slack or wear of the parts therebetween is sufficient to cause relatively large lag between their seating.

Therefore, it is a more particular object to provide a reversing valve of the general character defined which may be easily and quickly adjusted in such a manner as to insure the substantially simultaneous seating of both valve members.

For this purpose, means are provided for changing the effective length of the force transmitting connection between the valve members. This may be accomplished either by adjusting the position of at least one of said seats with respect to the other seat or by adjusting the length of the piston. In a preferred form, the passageway and cylinder in the valve body are substantially axially aligned, and one of the valve seats is formed on an axially movable bushing to permit the aforementioned adjustment. The valve member seatable on the other seat may be releasably located in seated position by means of an axially movable stem so as to facilitate the aforementioned adjustment.

It is desirable to gradually decelerate movement of the motor piston toward the end of its return stroke so as to reduce shock loads on the system. When the motor is used to reciprocate a sucker rod for a down-the-well-pump, debris will often accumulate below the valves of the pump, and it is necessary to "bump bottom" with the pump in order to shake this debris loose.

A further object of this invention is to provide a system which is adjustable in a manner to perform both of these functions.

This latter object is accomplished by means of a system of the general type described which includes an adjustable choke in the conduit means intermediate the pressure responsive means and the other connection of said conduit means into the motor cylinder. Thus, this choke controls the rate at which hydraulic fluid is exhausted from the pressure responsive means so that, if it is desired to bump bottom, the choke is closed down to substantially restrict exhaust through the conduit means. On the other hand, the choke may be adjusted to cushion the return movement of the motor piston to any desired degree.

Other objects, advantages and features of this invention will be apparent to one skilled in the art upon a consideration of the written specification, attached claims and the annexed drawings.

In the drawings wherein like reference characters are used throughout to designate like parts:

Figure 1 is a schematic sectional view of the motor of the hydraulic system of this invention during an intermediate portion of the working stroke of the motor piston;

Figure 2 is a view similar to Figure 1 but with the motor piston at one extreme position or limit of its working stroke;

Figure 3 is another similar view of the motor during an intermediate portion of the return stroke of the motor piston;

Figure 4 is a view similar to Figure 3, but in which the motor piston has descended still further in its return stroke;

Figure 5 is a further similar view with the motor piston at its other extreme position or limit of its return stroke;

Figure 6 is an enlarged sectional view of one embodiment of the reversing valve of the motor of Figures 1-5, with both valve members in seated position;

Figure 7 is a cross-sectional view of the valve of Figure 6, taken substantially along broken line 7-7 thereof;

Figure 8 is an enlarged sectional view of another embodiment of a reversing valve suitable for the purposes of the present invention, with both valve members in unseated position; and

Figure 9 is a cross-sectional view of the valve of Figure 8, taken substantially along broken line 9-9.

Referring first to the schematic views of Figures 1-5, the motor of the present invention includes a motor cylinder 20 which is closed at its upper end 21, a piston 22 reciprocable in the motor cylinder, and a rod 23 on the piston extending through the lower end 24 of the cylinder. In accordance with a preferred usage of the motor, the rod may be a polish rod for connection with a down-the-well pump, in a manner well known in the art. The piston is moved in a working or upwardly direction by means of hydraulic fluid supplied to the working or lower side 25 thereof through a conduit 26 connected to the lower end of the cylinder 20. The conduit 26 may be connected with a suitable reservoir (not shown) of hydraulic fluid under pressure. The lower end of the cylinder is provided with a reduced diameter portion having an upwardly facing shoulder 27 which prevents movement of the piston 22 over the connection of conduit 26 with the interior of the cylinder. The opposite or upper end 28 of the motor piston 22 is continuously vented by means of a conduit 30 connecting the upper end of the cylinder with any suitable source at a pressure substantially less than that of the hydraulic fluid and similar to that to which such fluid is exhausted from the working side 25 of the motor piston, in a manner to be described hereinafter.

A reversing valve 31 includes a body 32 having a passageway 33 therein connecting with the conduit 26 and an outlet 34 therefrom. A valve member 35 is seatable upon a valve seat 36 disposed across the passageway 33 intermediate its connection with conduit 26 and outlet 34 so as to close the passageway. When the valve member 35 is seated, as shown in Figures 1 and 5, hydraulic fluid conducted through conduit 26 will be admitted to the cylinder on the lower side 25 of the piston 22 so as to move the piston in a working direction. However, when the valve member is unseated, in a manner to be described below, the hydraulic fluid on the lower side of the motor piston will be exhausted from the cylinder and through the conduit 26 and passageway 33 into the outlet 34. As previously mentioned, it is contemplated by the present invention that conduit 30 and outlet 34 will connect at their outer ends (not shown) with sources having the same, or at least substantially the same, pressure. For example, in a continuous pumping system of this type, each of the conduit 30 and outlet 34 may connect with the upper end of a hydraulic fluid reservoir (such as that connecting with conduit 26) which may be at an atmospheric pressure. In such a case, conduit 30 may connect with the portion of the passageway

33 in the valve body 32 beneath seat 36 and opposite the outlet 34, as shown in Fig. 6.

The valve 31 is also provided with pressure responsive means in a form of a cylinder 37 in the body 32 thereof and a piston 38 in the cylinder which is movable upon the admission of hydraulic fluid to the lower side 39 thereof in a direction to unseat the valve member 35. Each of a pair of conduits 40 and 41 is connected to the motor cylinder at one of two spaced apart levels and both conduits have a common connection through a conduit 42 with the valve cylinder beneath the valve piston 38. Disposed within conduit 40 is a check valve 43 automatically operable, upon movement of the piston to the extreme position of Figure 2, to admit hydraulic fluid from the cylinder beneath the motor piston 22 to the valve cylinder 37 beneath the valve piston. This check valve 43 may comprise any suitable construction, such as is shown schematically in Figures 1-5, which is urged to an open position by fluid pressure in the end of the conduit 40 connecting with the cylinder 20. A check valve 44 within conduit 41 is automatically operable, upon movement of the motor system to the limit of its return stroke (Figure 5), to exhaust the hydraulic fluid from beneath the valve piston 38 through conduits 42 and 41 into the motor cylinder 20 on the side 28 of the motor piston. More particularly, the check valve 44 is of suitable construction which is urged to a closed position by means of fluid pressure in the end of conduit 41 connecting with the motor cylinder.

The valve member 35 comprises a ball and the piston 38 is provided with an actuator 45 which extends through an opening 46 connecting passageway 33 and cylinder 37 of the body so that when the piston is moved upwardly by the admission of hydraulic fluid to the valve cylinder beneath piston 38, the upper end of the actuator forces the ball off of its seat. A coil spring is disposed about the actuator between the cylinder and the piston 38 to urge the latter in a downward direction. Thus, upon the exhaustion of hydraulic fluid from beneath the piston 38, the valve piston will be retracted so as to permit the valve member 35 to seat. In a manner to be described more fully hereinafter, the coil spring 47 may be replaced by other suitable means, such as fluid pressure, for urging the valve piston in a direction to permit seating the valve member 35.

Obviously, the valve is so designed that, in the Fig. 4 position of the motor, the combined force on the valve member 35 and in the spring 47 will be sufficient to retract the valve piston, while, in the Fig. 2 position thereof, the force due to hydraulic fluid acting upon the side 39 of the piston will be sufficient to overcome the force in the spring and on the valve member so as to move the piston upwardly.

It will be understood that as the motor piston 22 begins to move downwardly from its extreme position of Fig. 2, it will cover the connection of conduit 40 with the cylinder 20 and thereby prevent communication through the conduit 42 between said cylinder beneath the motor piston and the valve cylinder 37 beneath the valve piston 38. If it were not for the novel apparatus of this invention, and this return movement of the motor piston were so fast that the valve member 35 was barely lifted from its seat, this shutting off of hydraulic fluid from the bottom of piston 38 might cause the valve member 35 to seat prematurely and the system to get on "dead center" wherein the motor piston would reciprocate in short, incomplete strokes.

This novel apparatus comprises a conduit 48 connecting the valve cylinder 37 beneath the piston 38 with the conduit 41 intermediate the check valve 44 and the connection of said conduit 41 with the motor cylinder 20, and a valve member 49 seatable upon the connection of conduit 48 with the cylinder 37 to open said conduit in response to movement of the piston 38 in an upward direction to unseat the valve member 35 and to close

said conduit in response to downward movement of the piston. Thus, even as the motor piston 22 moves downwardly from its Fig. 2 position over the connection of conduit 40 with the cylinder 20, the valve piston 38 will be moved upwardly into its position fully unseating valve member 35 by the admission of hydraulic fluid to the bottom of said valve piston through the conduits 41 and 48 and past valve member 49. On the other hand, even as the motor piston 22 moves upwardly from its Fig. 5 position over the connection of conduit 41 with the motor cylinder 20, the valve member 35, which has seated due to the exhaustion of hydraulic fluid from beneath the valve piston 38, will not be prematurely unseated by means of hydraulic fluid flowing into the cylinder 37 through conduit 48 because the conduit 48 has been closed by the valve member 49.

The valve member 49 also comprises a ball, the upper end of which is engaged by the lower side 39 of the valve piston 38 as the latter moves downwardly to permit seating of the valve member 35. Obviously, however, both valve members may take other forms. For example, the valve member 49 may be integral with the piston 38. Also, if desired, both valve members may be of a sleeve type cooperable with ports in the valve body.

As previously mentioned, it is important that both valve members 35 and 49 are seated substantially simultaneously. That is, if, upon movement of the motor piston into the Fig. 5 position, the valve member 49 does not seat substantially simultaneously with the valve member 35, the motor piston may rise above the connection of conduit 41 with the motor cylinder prior to seating of the valve member 49. As a result, the valve piston 38 may be raised and the valve member 35 unseated prematurely.

Theoretically, in order for the valve members 35 and 49 to seat simultaneously, the piston 38 and actuator must provide a force-transmitting connection equal in length to the distance between the seated positions of the valve members. This adjustment of the valve parts may be made, either upon the installation of the system or after wear upon the parts, by means which, in the reversing valve 31 of Figs. 6 and 7, comprises a bushing 50 threadedly received in the lower end of the valve body for movement axially of the cylinder 37 and passageway 33 and having the seat for valve member 49 formed thereon. The bushing 50 is provided with a threaded socket 51 for receiving the conduit 48, and a passageway 52 therethrough connecting the socket and cylinder 37 to form a continuation of the conduit 48. Thus, the bushing may be moved inwardly or outwardly, as desired, to bring the piston 38 and its actuator 45 into engagement at its opposite ends with the seated valve members 35 and 49. An O-ring 53 surrounds the bushing to seal with the remainder of the body, and a nut 53a on an outer threaded portion of the bushing permits it to be locked in adjusted position.

The motor piston descends at a rate which is determined by the rate of flow past the unseated valve member 35. This rate of flow is, in turn, controlled by means of a stem 54 threadedly received in the opposite end of the valve body for extension axially of the passageway 33. This stem may be adjusted so as to determine the extent of movement of the valve member 35 off of its seat 36, and thus the rate of flow past such seat. This adjustable stem 54 also aids an operator in "feeling" the movement of actuator 45 into engagement with valve member 35 during manipulation of bushing 50. Obviously, after the adjustment has been made, the stem may be retracted into a position limiting unseating movement of valve member 35 to a desired amount. The stem is sealed with respect to the remainder of the body by an O-ring 54a and may be locked in either valve member locking or limiting position by means of a nut 54b.

The valve seat 36 is also formed on a separate bush-

7

ing 55 having an O-ring 56 thereabout for sealing with the passageway 33. More particularly, both valve seats are formed on countersunk portions of their respective bushings to guide them during seating and unseating. The lower end of stem 54 and a short stem 57 on the piston face 39 prevent the escape of the valve members 35 and 49, respectively, when such valve members are unseated.

The upper and lower ends 58 and 59 of the valve body are removable to permit the assembly and replacement of the various parts of the valve. Coil spring 47 is held between an annular shoulder 60 at the upper end of cylinder 37 and an annular surface on the top of piston 38 surrounding actuator 45. An enlarged diameter portion of the piston is provided with seal rings 61 thereabout for sealably sliding within an enlarged diameter portion of the cylinder 37. An annular shoulder 62 at the top of this last-mentioned cylinder portion provides a stop to upward movement of the piston 38.

The embodiment of reversing valve shown in Figs. 8 and 9 is, in many respects, similar to that above-described in connection with Figs. 6 and 7. Thus, as shown in Figures 8 and 9, this valve 63 comprises a valve body 64 having a passageway 65 therein provided with ports for connection with the conduit 26. A valve seat 66 is disposed across the passageway intermediate its intersection with conduit 26 and an outlet 34 therefrom so that a ball valve member 67 is seatable thereon to close the passageway. Also, the valve body is provided with a cylinder 68 therein substantially axially aligned with the passageway 65, and ports in the cylinder for connection with conduits 42 and 48 below the lower side 69 of a piston 70 reciprocable within the cylinder.

As in the case of the previously described embodiment, the valve body 64 has an opening 71 therethrough connecting its passageway and cylinder, and the piston 70 has an actuator 72 extending through said opening for engagement at its upper end with the ball valve member 67. Thus, upon the admission of hydraulic fluid to the valve cylinder 68 beneath the piston 70, the piston and actuator 72 will be moved upwardly so as to unseat the valve member 67. On the other hand, upon the exhaustion of hydraulic fluid from beneath the piston 70, the piston will move downwardly to permit seating of the valve member 67.

As distinguished from the previously described embodiment, however, the piston 70 of the valve 63 is urged downwardly by pressure responsive means which is capable of providing a larger retracting force and which takes up less space than the coil spring 47 of said other embodiment. Thus, the body 64 of the valve is provided with one or more ports 73 therethrough (shown rotated in Fig. 8) for connecting the passageway 65 above seat 66 with an annular chamber in the cylinder 68 formed on opposite sides between the actuator 72 of the piston and the valve cylinder and sealed below by seal rings 75 about an enlarged diameter of the piston 70 and above by a seal ring 74 carried by the body in the opening 71 for sealing about the actuator 72. It will be understood that the pressure of the hydraulic fluid in the passageway 65 above the seat 66 will urge the piston 70 downwardly.

Although this pressure responsive retracting means may be preferred over the coil spring of the Figs. 6 and 7 embodiment for the reasons previously noted, there are some auxiliary advantages of a coil spring which may make it desirable to use same in conjunction with the pressure responsive retracting means. For example, a coil spring arranged as shown in Fig. 6 will compensate for a certain amount of slack in the system by forcing the lower valve member to a seated position upon a prior seating of the upper valve member. A coil spring is also useful in prepositioning the valve piston when starting the system.

8

The seal rings 75 on the piston 70 are spaced apart and the piston and its actuator 72 are ported at 76 to connect the portion of the passageway 65 intermediate seat 66 and seal ring 74 with an annular space about the piston between the rings 75. Inasmuch as the fluid in this portion of the passageway is substantially atmospheric, or less than system pressure, it prevents leakage from the annular chamber above the topmost ring into the cylinder beneath the piston 70.

As in the case of the previously described embodiment, the bottom 69 of the piston 70 is engageable with a valve member 77 so as to move it into seated position upon the seat formed at the intersection of conduit 48 with the cylinder 68. In this embodiment of the invention, the seat for valve member 77 is formed upon the removable lower end 78 of the body, and the adjustment for insuring substantially simultaneously seating of the valve member 66 and 67 comprises an axially adjustable stem 79 on the lower end 69 of the piston. As in the case of the adjustable bushing 50 of the valve embodiment of Figs. 6 and 7, this valve also includes an adjustable stem 80 for limiting the extent to which the valve member 67 may be unseated and thus controlling the rate of flow past the seat 66.

Referring again to Figs. 1-5, the adjustable choke 81 is shown disposed within conduit 41 intermediate the connection of said conduit with motor cylinder 20 and the conduit 48. As previously described, this choke is adjustable to cushion the descent of the motor piston to a desired extent. At the same time, it cushions the rise of the piston in a manner obvious from the drawings. If the adjustable choke 81 is also to be used in "bumping bottom," the down-the-well pump is so supported from the rod as to be spaced just a few inches above the bottom of the well. Thus, the pump will be caused to "bump bottom," for the purposes above-described, upon closing down of the choke.

Reviewing now the overall operation of the system, particularly with respect to the reversing valve 31, it will be understood that with the pump for the hydraulic fluid shut off, the locating stem 54 may be moved inwardly to seat the valve member 35 on its seat and the bushing 50 moved inwardly to force the upper end of the actuator 45 against the bottom side of the valve member 35. The locating stem may then be retracted to permit a desired amount of travel for the valve member 35.

At this time, both the motor piston and valve piston are in the lowered positions of Fig. 5 and the valve members 35 and 49 are seated. As the pump is started, hydraulic fluid is admitted to the cylinder 20 beneath the motor piston to move it upwardly past the connection of conduit 41 with the motor cylinder. However, the check valve 44 is effective to prevent hydraulic fluid beneath the motor piston from admission to the lower side 39 of the valve piston through the conduit 42. Since the area across seat 36 is greater than that across the seat for valve member 49, it is obvious that the force due to system fluid acting upon valve member 35 plus the force of spring 47 is greater than the force due to such fluid acting upon valve member 49 so that the valve piston remains in its lower position to maintain the valve member 49 seated despite the fact that hydraulic fluid is conducted through the conduit 48 beneath the piston to the lower side of the valve member 49.

When, however, the motor piston moves upwardly past the connection of conduit 40 with the motor cylinder (Fig. 2), the check valve 43 is effective to permit hydraulic fluid to be admitted through conduit 42 to the lower side of the valve piston 38. Since the force due to system fluid acting upon the surface 39 of piston 38 is greater than that due to the spring 47 and the fluid at reduced pressure on the opposite surface of the piston, the valve piston is raised so as to unseat the valve

member 35 and thereby permit exhaustion of hydraulic fluid from beneath the motor piston through the outlet 34. At the same time, this movement of the valve piston permits the valve member 49 to unseat due to the influence of hydraulic fluid acting upon its lower side. Thus, even though the motor piston might drop quickly past the connection of conduit 40 with the motor cylinder, the force upon the lower side of the piston due to the admission of hydraulic fluid through the conduit 48 will insure sufficient travel of the valve member 35 in an unseating direction so as to prevent the system from getting on "dead center."

To explain further, as soon as the motor piston 22 moves above the intersection of conduit 40 with the motor cylinder, the system fluid will be admitted to the pressure responsive surface 39 of piston 38 of the reversing valve so as to unseat ball valve member 35. As the ball valve member is unseated, system fluid will be vented from beneath the motor piston through the outlet 34. If the upwardly directed force upon the piston of the reversing valve is not sufficient to fully unseat the ball 35, there may be a pressure drop across the restriction between the ball and its seat which, together with venting of system fluid through the outlet 34, may be sufficient to draw the ball back down onto its seat. On the other hand, even if the ball valve member 35 is not prematurely seated, if it is not fully unseated, the motor piston will not move downwardly at the intended speed. It is to avoid these shortcomings that motors of this type have heretofore included a pilot valve control of the type previously described.

This last mentioned force is effective during the travel of the motor piston downwardly to a position in which it covers the connection of conduit 41 with the motor cylinder. As the motor piston drops further past this last mentioned connection, the check valve 44 is effective to permit hydraulic fluid to be exhausted from beneath the valve piston through the conduit 42. As a result, intermediate the positions Figures 4 and 5, the valve piston will be lowered to permit seating of the valve member 35. Thus, hydraulic fluid conducted through conduit 26 will again be directed to the working side of the motor piston so that it is again urged in an upwardly or working direction. This exhaustion of hydraulic fluid from beneath the valve piston and the resulting downward movement of such piston also causes the valve member 49 to be seated. In this way, even though the motor piston might start back upwardly at a fast rate, the valve member 49 will be seated prior to the uncovering of the connection of conduit 41 with the motor piston upon upward movement of the motor piston.

From the foregoing it will be seen that this invention is one well adapted to attain all of the ends and objects hereinabove set forth, together with other advantages which are obvious and which are inherent to the apparatus.

It will be understood that certain features and sub-combinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of the claims.

As many possible embodiments may be made of the invention without departing from the scope thereof, it is to be understood that all matter herein set forth or shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

The invention having been described, what is claimed is:

1. In an hydraulic pumping system, a motor comprising a cylinder and a piston reciprocable therein, means for admitting hydraulic fluid to one side of the piston for moving it in a working direction to a first extreme position, means for continuously venting the other side of the piston, means including a reversing valve movable to an open position for exhausting said hydraulic fluid

from said one piston side to permit its movement in an opposite direction to a second extreme position, pressure responsive means movable, upon the admission of hydraulic fluid thereto, in a direction to open the valve and, upon the exhaustion of hydraulic fluid therefrom, in a direction to permit closing of the valve, conduit means connecting the cylinder at spaced apart levels therein with the pressure responsive means, valve means in said conduit means automatically operable, in the first extreme position of the piston, to admit said hydraulic fluid from said cylinder on said one side of the piston and through one of said connections to the pressure responsive means and, in the second extreme position of the piston, to exhaust said hydraulic fluid from said pressure responsive means and through said other connection into the cylinder on said other side of the piston, said valve means being operable during movement of the piston between its first and its second extreme positions to prevent communication through said conduit means between said pressure responsive means and said one side of the piston, and means automatically operable to admit hydraulic fluid from the cylinder on said one side of the piston to said pressure responsive means during said prevention of communication upon movement of the piston from its first toward its second extreme position.

2. A motor of the character defined in claim 1, wherein said automatically operable means comprises additional conduit means for communicating said pressure responsive means with the cylinder at a level nearer the second extreme position of the motor piston than said one connection, and a valve member for opening the additional conduit means in response to movement of the pressure responsive means in a direction to open the valve and for closing said additional conduit means in response to movement of the pressure responsive means in a direction to permit closing of the valve.

3. A motor of the character defined in claim 2, wherein said additional conduit means is connected to said first-mentioned conduit means intermediate said valve means and said other connection.

4. A motor of the character defined in claim 3, including an adjustable choke in said first-mentioned conduit means intermediate the connection of said additional conduit means therewith and said other connection.

5. In an hydraulic pumping system, a motor cylinder and a piston reciprocable therein, a conduit for admitting hydraulic fluid to one side of the piston for moving it in a working direction to a first extreme position, means for continuously venting the other side of the piston, a valve body having a passageway therein connecting with the conduit and an outlet therefrom, a valve seat across the passageway intermediate its connection with the conduit and the outlet, a valve member seatable upon the seat to close the passageway, pressure responsive means movable, upon the admission of hydraulic fluid thereto, to unseat said valve member and thereby permit hydraulic fluid on said one side of the piston to be exhausted through said outlet and, upon the exhaustion of hydraulic fluid therefrom, to permit seating of the valve member, means automatically responsive to movement of the piston into said first extreme position to admit said hydraulic fluid from the cylinder on said one side of the piston to said pressure responsive means and, responsive to movement of the piston from said first toward said second extreme position, to prevent communication between the cylinder on said one side of the piston and said pressure responsive means, and means automatically operable during the prevention of communication between said cylinder on said one side of the piston and pressure responsive means to admit hydraulic fluid from the cylinder on said one side of the piston to said pressure responsive means.

6. In an hydraulic pumping system, a motor comprising a motor cylinder and a piston reciprocable therein, a conduit for admitting hydraulic fluid to one side of the piston for moving it in a working direction

to a first extreme position, means for continuously venting the other side of the piston, a valve body having a passageway therein connecting with the conduit and an outlet therefrom, a valve seat across the passageway intermediate its connection with the conduit and the outlet, a valve member seatable upon the first seat to close the passageway, means including a piston having oppositely disposed pressure responsive surfaces and movable in one direction to unseat said valve member, and thereby permit hydraulic fluid on said one side of the piston to be exhausted through said outlet, and in an opposite direction to permit said valve member to seat, means automatically operable, in the first extreme position of the motor piston, to admit hydraulic fluid from said cylinder on said one side of the piston to one surface of said second-mentioned piston for moving it in said one direction and, in the second extreme position of the motor piston, to exhaust hydraulic fluid from said one surface of said second-mentioned piston into the cylinder on said other side of the piston to permit said second-mentioned piston to move in said other direction, the opposite surface of said second-mentioned piston forming part of a chamber sealed off from the passageway intermediate the seat and outlet, and means for conducting hydraulic fluid from the cylinder beneath the motor piston to the chamber during the exhaustion of hydraulic fluid from said second-mentioned piston, to move it in said opposite direction.

7. A motor of the character defined in claim 6, wherein said conducting means includes a conduit connecting the chamber with the passageway of the valve body intermediate the seat and its connection said first-mentioned conduit.

8. In an hydraulic pumping system, a motor cylinder and a piston reciprocable therein, means for admitting hydraulic fluid to one side of the piston for moving it in a working direction to a first extreme position, means for continuously venting the other side of the piston, means including a reversing valve movable to an open position for exhausting said hydraulic fluid from said one piston side to permit its movement in an opposite direction to a second extreme position, pressure respon-

sive means movable, upon the admission of hydraulic fluid thereto, to open the valve and, upon the exhaustion of hydraulic fluid therefrom, to permit the valve to close; conduit means having two connections with the cylinder at spaced apart levels therein with the pressure responsive means, valve means in said conduit means automatically operable in the first extreme position of the piston, to admit said hydraulic fluid from said cylinder on said one side of the piston and through one of said connections to the pressure responsive means and, in the second extreme position of the piston, to exhaust said hydraulic fluid from said pressure responsive means and through the other of said connections into the cylinder on said other side of the piston, and an adjustable choke in the conduit means intermediate said pressure responsive means and said other connection into the cylinder.

9. In an hydraulic pumping system of the character defined in claim 5, wherein said automatically operable means comprises conduit means for communicating said pressure responsive means with the cylinder, and a valve member for opening the conduit means substantially simultaneously with opening of the valve and for closing said conduit means substantially simultaneously with closing of the valve.

10. In an hydraulic pumping system of the character defined in claim 9, including means for choking said conduit means.

#### References Cited in the file of this patent

##### UNITED STATES PATENTS

|           |               |                |
|-----------|---------------|----------------|
| 2,048,550 | Helenberg     | July 21, 1936  |
| 2,377,115 | Van Der Werff | May 29, 1945   |
| 2,404,796 | Grant et al.  | July 30, 1946  |
| 2,669,972 | Cross         | Feb. 23, 1954  |
| 2,708,912 | Vanalstyne    | May 24, 1955   |
| 2,726,642 | Zinty et al.  | Dec. 13, 1955  |
| 2,853,057 | McAuley       | Sept. 23, 1958 |

##### FOREIGN PATENTS

|         |        |              |
|---------|--------|--------------|
| 992,937 | France | Oct. 6, 1944 |
|---------|--------|--------------|