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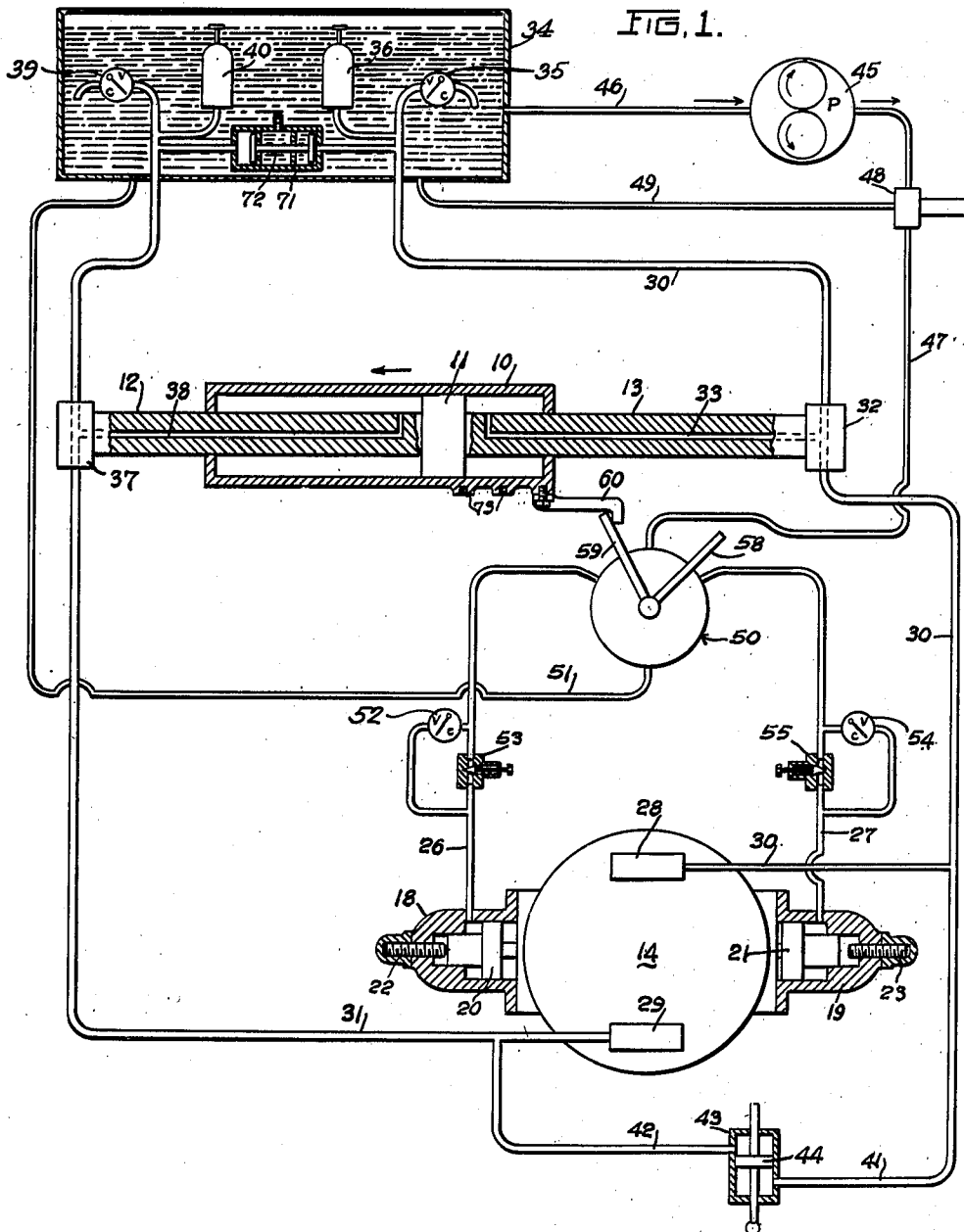
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2,286,358

HYDRAULIC CONTROL FOR VARIABLE DELIVERY PUMPS

Filed Feb. 2, 1940

2 Sheets-Sheet 1



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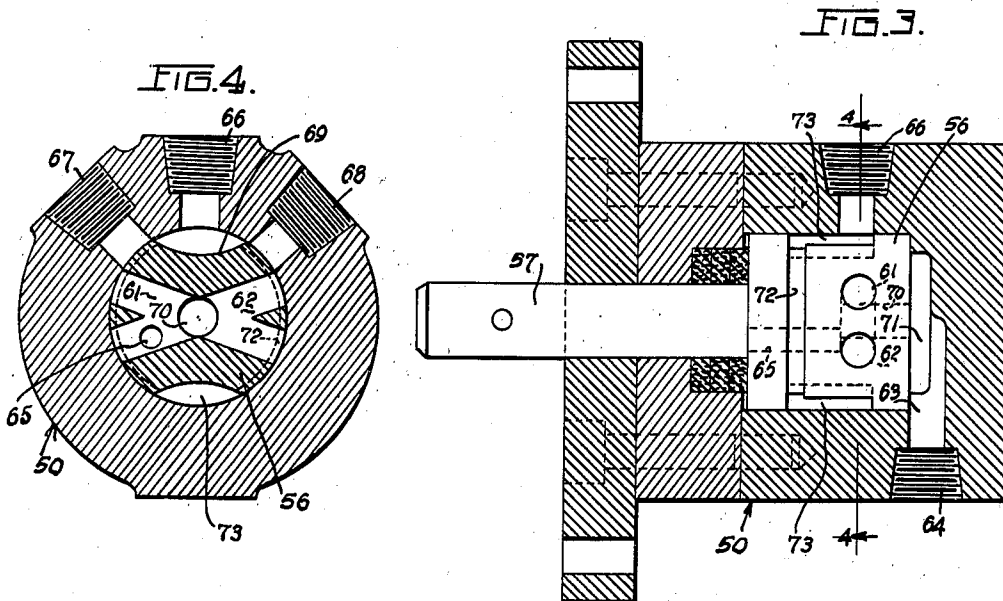
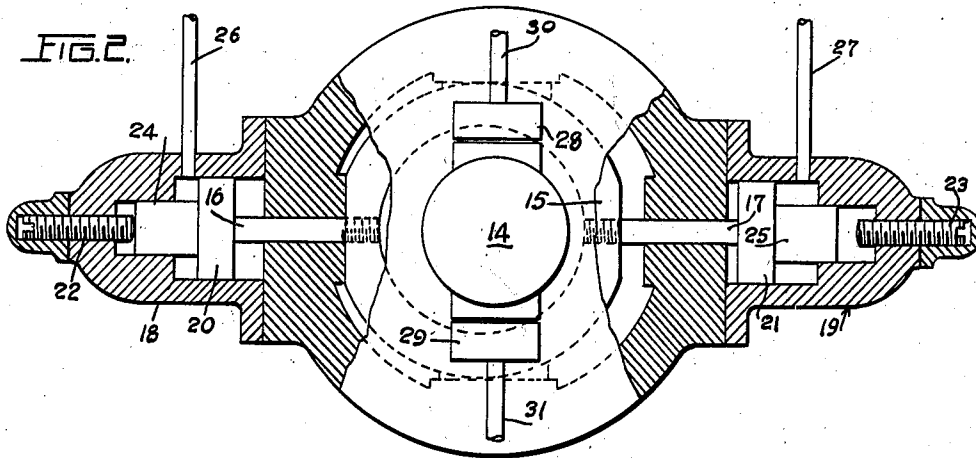
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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,286,358

HYDRAULIC CONTROL FOR VARIABLE DELIVERY PUMPS

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5 Claims. (Cl. 103—38)

This invention relates to a hydraulic control for a pump and more particularly to hydraulic control for a reversible variable delivery pump for effecting the continuous reciprocation of a reciprocable member which may be operatively connected to the motive element of a double-acting hydraulic motor.

It is an object of the present invention to provide automatic means for the control of a hydraulic pump whereby it is insured that the motive element of a hydraulic motor is continuously reciprocated, this motive element being reversed as it approaches the limit of its travel in one direction and likewise being automatically reversed at the end of its travel in the other direction so as to resume travel in the first direction.

Another object is to provide a hydraulic control of the foregoing type wherein the rate of acceleration and deceleration at each end of the stroke may be adjusted to suit the desired conditions of operation.

Another object is to provide a hydraulic control of the type set out above wherein the speed of operation of the reciprocated member is adjustable in each direction to suit the requirements; the speeds in the two directions may be different if desired.

Another object is to provide a hydraulic control of the foregoing type which is simple and economical to build and in which the cost of operation and of maintenance are very low.

Another object is to provide a hydraulic control wherein means is provided for stopping the motion of the reciprocated member at the will of the operator.

Other objects will more fully hereinafter appear.

In the accompanying drawings:

Fig. 1 is a diagrammatic view showing the details of one embodiment of the present invention.

Fig. 2 is an enlarged partially sectioned view of the reversible variable delivery pump employed in the embodiment of the invention shown in Fig. 1.

Fig. 3 is a central vertical section through the pilot valve shown in Fig. 1 with the operating handle therefor removed.

Fig. 4 is a cross-section along the line 4—4 of Fig. 3.

In accordance with the present invention, the mechanism to which it is desired to impart a reciprocating motion is operatively connected in any suitable manner to the motive element in a double-acting hydraulic motor, this element being reciprocated in accordance with the princi-

ples of the present invention and being referred to hereinafter as the reciprocable member. Means is provided whereby the direction of application of hydraulic fluid to the double-acting hydraulic motor is reversed automatically at the end of each stroke. In this way, continuous reciprocation of the motive element is assured. In a preferred form, the control mechanism comprises a reversible variable delivery pump of known type which is provided with oppositely acting hydraulic motors for shifting the shift element thereof so as to reverse the delivery thereof, the input and output to this reversible pump being connected to opposite sides of the double-acting hydraulic motor which is to be controlled. A continuously operated pilot pump is provided and means is provided for connecting the output thereof to either of the hydraulic motors for shifting the shift ring of the main pump. This means for connecting the pilot pump to operate the hydraulic servomotors of the main pump preferably takes the form of a four-way valve which is actuated in one direction at one end of the stroke of the motive member to be controlled and which is actuated in the opposite direction at the end of the stroke of the motive member in the other direction.

Preferably, means is provided in the form of variable restrictions in the conduits leading from the control valve to the shifting servomotors for adjusting the rate of acceleration and deceleration of the motive member at each end of the stroke.

Referring to the accompanying drawings in detail and first, more particularly, to Fig. 1, 10 designates the reciprocating cylinder of a double-acting hydraulic motor which contains a stationary piston 11 and a pair of stationary piston rods 12 and 13. This cylinder 10 is the reciprocable element and is connected in any suitable manner to the machine or other device which is to be given reciprocating motion. For example, cylinder 10 might be connected to reciprocate the cutting tool of a shaper or lathe. While the embodiment shown in the drawings involves a reciprocating cylinder and piston rods, it will be understood that if desired the cylinder might be held stationary and the piston caused to reciprocate. Pressure fluid for the operation of cylinder 10 is supplied by a radial variable delivery reversible main pump 14. This main pump 14 is of a type known to those skilled in the art and its construction does not per se constitute any part of the present invention. For example, a pump of this type is that shown in Ernst Patent No.

2,021,353. Referring to Fig. 2, it will be seen that this pump 14 embodies a shift ring 15 which is movable transversely of the pump so as to vary the amount and direction of delivery of the pump, shifting of ring 15 being accomplished by the shift rods 16 and 17 which are threadedly received within the shift ring 15 and which are slidable relative to the casing of the pump 14.

In order to actuate the shift rods 16 and 17, there is provided instead of the usual single hydraulic motor and spring-loaded opposing plunger located on opposite sides of the pump, a pair of hydraulic motors having cylinders 18 and 19 respectively and hydraulic pistons 20 and 21 respectively. It will be seen that the two hydraulic motors thus formed constitute in effect a double-acting hydraulic motor for reciprocating the shift ring 15. It will further be seen that when shift ring 15 is shifted to the left of Fig. 2 as shown in that figure by the application of fluid pressure on the right-hand of piston 21, the delivery of pump 14 is in one direction, and when the ring 15 is shifted rightwardly by the application of fluid pressure to the left-hand of piston 20, the direction of delivery is reversed.

Since pump 14 in addition to being reversible in delivery is variable in delivery in either direction, means is provided for individually adjusting the amount of delivery in each direction of delivery. This means takes the form of adjusting screws 22 and 23 provided for control cylinders 18 and 19, respectively, these adjusting screws being adapted to engage reduced portions 24 and 25 respectively of pistons 20 and 21, which reduced portions extend outwardly and are slidably received with the outer portion of cylinders 18 and 19. The actuating hydraulic liquid for control cylinders 18 and 19 is admitted by means of conduits 26 and 27 respectively, which connect with the space behind the control pistons 20 and 21.

The main pump 14 is provided with fluid connections 28 and 29, each of which is adapted to act either as an inlet or as an outlet for pump 14, depending upon the direction of delivery thereof. Connected to these members 28 and 29 are conduits 30 and 31. Conduit 30 is in constant communication with the pressure chamber formed in the right hand of cylinder 10 by means of a T-shaped member 32 and a bore 33, and continues beyond member 32 into communication with a liquid reservoir 34 through a check valve 35 which is adapted to allow liquid to flow from reservoir 34 into connection 28 of pump 14 by way of conduit 30 but to prevent the reverse flow of liquid whereby when pump 14 is delivering its output into conduit 30, the output is compelled to enter into the pressure chamber at the right hand of piston 11. The conduit 30 is provided with the usual safety valve 36 which is adapted to open upon the attainment of an excessive pressure in line 30 to allow discharge therefrom into tank 34.

The other conduit 31 extends from connection 29 to a T-shaped member 37 carried on the end of piston rod 12 into communication with the space on the left hand of piston 11 by way of bore 38 in piston rod 12, and extends beyond the member 37 into tank 34 from which it is adapted to draw liquid by way of check valve 39 which is like check valve 35 described above. A safety valve 40 is provided for conduit 31, this safety valve corresponding to the safety valve 36.

In order to stop the movement of cylinder 10, means is provided for bypassing the output of

main pump 14 regardless of the direction thereof. This means may take the form of conduits 41 and 42 connected to the conduits 30 and 31 respectively and leading to the two-way valve 43 which has a piston 44 adapted to be reciprocated so as to place conduits 41 and 42 into or out of communication with one another. This valve 43 may be operated either manually or automatically, as desired.

Liquid pressure for effecting the operation of control cylinders 18 and 19 is generated in a pilot pump 45 which is of any suitable type such as the positive displacement gear pump diagrammatically illustrated in Fig. 1, this pump drawing liquid from tank 34 by way of conduit 46 and discharging the liquid under pressure into conduit 47. A relief valve 48 is provided in conduit 47 for leading the output thereof back to the tank 34 by way of the conduit 49, after the control has been effected. Pilot pump 45 delivers pilot pressure through conduit 47 to the four-way valve 50 which may be of any suitable type, such as that shown in Figs. 3 and 4, and which is adapted to deliver the pressure liquid supplied to it by conduit 47 either to conduit 26 leading to control cylinder 18 or to conduit 27 leading to control cylinder 19, depending upon the position of the rotatable gate in valve 50, and at the same time to connect the other conduit 26 or 27 which is not connected to conduit 47 to the tank 34 by means of a return conduit 51.

Disposed in conduit 26 is a check valve 52 which is adapted to allow liquid to flow freely from valve 50 into the control cylinder 18 but to prevent the reverse flow. The reverse flow is compelled to take place through an adjustable choke valve 53 which is in parallel with check valve 52 and which is adjusted to impart a suitable restriction to the outflow of oil from cylinder 18 back to the tank 34 and to thereby control the rate of acceleration and deceleration at the end of the rightward stroke of cylinder 10.

Conduit 27 is likewise provided with a check valve 54 allowing free passage of oil from valve 50 into cylinder 19 but compelling the reverse flow of oil to take place through a restriction 55 which is similar to restriction 53.

The valve member 56 of four-way valve 50 has a shaft 57 to which is fixedly attached in any suitable manner a two arm control member having arms 58 and 59 mounted fixedly at the desired angle with respect to one another and with respect to valve member 56. In order to actuate the valve member 56 so as to reverse the application of the output of pilot pump 45 from control cylinder 18 to control cylinder 19, or vice versa, at the ends of the stroke of cylinder 10, a valve shifter rod 60 is fixedly mounted on cylinder 10 at any desired position. Preferably, the longitudinal position of shifter rod 60 is adjustable in any suitable manner, for example, as indicated in Fig. 1, by providing a series of longitudinally spaced threaded holes 73 in the periphery of cylinder 10. In this way, the stroke of cylinder 10 can be adjusted. As is apparent, the shifter rod 60 is adapted to engage the control arm 59 at the end of the leftward stroke of cylinder 10, thereby shifting valve 50 so as to cause the application of the output of pilot pump 45 to the other control cylinder 18, whereby to shift the direction of delivery of main pump 14, causing reversal of the application of the output of pump 14 and causing reversal of the direction of cylinder 10. As cylinder 10 approaches the limit of its rightward travel, shift rod 60 is

adapted to engage the control arm 58 which will now be in a position somewhat counter-clockwise of that shown in Fig. 1, thereby effecting reversal of the delivery of pump 14 and causing cylinder 10 to resume its travel leftwardly.

A shuttle valve 71 is disposed between the two conduits 30 and 31, this shuttle valve being located within the tank 34. This valve is of the type disclosed as elements 16 to 21 in Ernst, United States Patent No. 1,653,350 and comprises oppositely disposed end chambers connected to conduits 30 and 31 and separated by a central chamber in constant communication with the oil in tank 34. The communication between the central and end chambers is controlled by a valve member 72 having spaced valving heads and being so arranged that when either end chamber is in communication with the central chamber the other end chamber is out of communication with the central chamber. The purpose of this shuttle valve 71 is to take care of difference in displacements between the two ends of the cylinder 10. This difference in displacement may be due to the use of cylinders of different diameters or of a double-acting cylinder 10 with different diameter rods 12 and 13 or through more leakage from one side of piston 11 than from the other.

Assume that the left-hand side of cylinder 10 has a larger displacement than the right-hand side due to some cause. For example, assume that piston rod 12 is smaller than piston rod 13 for obtaining a slower travel of cylinder 10 leftwardly than rightwardly. When pressure is applied to conduit 31 to move the cylinder 10 leftwardly this pressure will immediately cause the valve member 72 in shuttle valve 71 to move rightwardly, cutting off communication of conduit 31 with tank 34 and establishing communication of conduit 30 with tank 34 in addition to that provided by the check valve 35, allowing oil to pass freely into conduit 30 and thence into the pump 14 to meet the demands thereof which will exceed the amount of oil being forced out of the right-hand side of cylinder 10. Now when pressure is applied to conduit 30 to force cylinder 10 rightwardly, the volume of oil squeezed or forced out of the left-hand of cylinder 10 will be greater than that demanded by pump 14 and will have no place to go were shuttle valve 71 not provided. Shuttle valve 71 allows this excess oil to pass back to the tank 31, the valve element 72 thereof having been moved leftwardly to this end by the pressure developed in conduit 30.

Shuttle valve 71 is absolutely necessary only in one direction of movement of cylinder 10 because of the provision of check valves 35 and 39. However, in order to supply a standard system adapted to meet any conditions of operation or installation, it is preferred to supply the conventional double-acting shuttle valve. For example, it cannot be predicted on which side of cylinder 10 leakage will be greater. Also, it is frequently not known with what type of cylinder 10 the tank 34 and its elements are to be used. The shuttle valve 71 is operated by pressure on one line to open the other line to the tank and, therefore, correct for a positive or a negative change of volume in said other line.

Referring now to the construction of four-way valve 50 as illustrated in Figs. 3 and 4, this valve comprises a valve member 56 which is approximately cylindrical in shape and which has cross-passages 61 and 62 extending diametrically there-through. The lower end of the valve casing is provided with a recess 63 communicating with an

exhaust port 64. A longitudinal passageway 65 connects the forward portion of the valve member to the exhaust passageway 62 in order to prevent pressure building up on the end surface of valve member 56 due to leakage. Circumferentially, the pressure is equalized by the cross-passages 61 and 62 and by admitting pressure from the cavity formed by curved surface 69 to the exactly similar cavity 73 on the opposite side of the valve member through the circumferential grooves 72 which extend around the sides of the valve member 56 at the left-hand of Figure 3.

The valve casing is provided with an inlet port 66 which is connected to the inlet conduit 47 and with a pair of service ports 61 and 68 which are connected respectively to the conduits 26 and 27. The valve member 56 also has a curved portion 69. The exhaust port 64 is connected to the return line 51. The flat cylindrical space 71 behind valve member 56 is in communication with exhaust space 63 and with the longitudinal exhaust passageway 70 which communicates with the exhaust bores 61 and 62.

If the shaft 57 of the valve 50 is rotated so that the passage 61 communicates with the service outlet 67, then pressure fluid is admitted from inlet conduit 47 and passes outwardly through the service outlet 68 to the conduit 27 and to control cylinder 19. At the same time, the service outlet 67 is connected to the central passageway 70 leading to the exhaust passageway 63 and thus to the exhaust port 64 and to the return line 51, connecting conduit 26 and control cylinder 18 back to the tank 34. If the shaft 57 is reversed and rotated so as to place passage 62 beside service port 68, the inlet conduit 47 will be connected to service port 67 and thence to conduit 26 and control cylinder 18 while at the same time the control cylinder 19 will be connected by way of conduit 27, service port 68, passage 62, longitudinal passage 70, exhaust passage 63 and exhaust port 64 to the return line 51.

Operation

In the position shown in the drawings, the stroke adjusting ring 15 of the main pump 14 has been shifted to the full stroke position to the left. This was accomplished by shifter rod 60 shifting the control arms in a clockwise direction, causing the output of pilot pump 45 to enter the conduit 27 and the control cylinder 19, causing the control pistons 21 to shift the ring 15 leftwardly. As this occurred, the liquid in control cylinder 18 was discharged through the conduit 26 by way of the choke valve 53 to the control valve 50 and thence through conduit 51 back to the oil reservoir 34. Consequently, the radial pump 14 is delivering pressure fluid through line 31 to the left end of cylinder 10, causing cylinder 10 to move leftwardly. As shown, cylinder 10 is approaching the end of its stroke in the left hand direction and the valve shifter rod 60 has come into contact with the arm 59 of control valve 50. Further movement of cylinder 10 to the left will move arm 59 counter-clockwise, causing the delivery from pilot pump 45 to be diverted from line 27 to line 26. This shifting in pressure will move the shift ring of pump 14 to the right, the liquid to the right of control piston 21 being discharged outwardly through restriction 55 back to the tank 34, thus causing a gradual reduction in the pump stroke, causing the pump stroke to pass through neutral and causing the pump stroke to be shifted so as to deliver oppositely.

As the pump 14 passes through the neutral position, the cylinder 10 reaches the limit of its leftward movement, and as the pump 14 is now on stroke in the opposite direction so as to deliver into conduit 30 and suck oil from tank 34 through conduit 31, the output of pump 14 is now delivered to the right-hand side of piston 11 and causes cylinder 10 to begin moving towards the right-hand. As cylinder 10 reaches the limit of its rightward travel, its shifter rod 60 will contact control arm 58 and will shift the pilot pump 14 back to the position shown in the drawings.

From the foregoing, it will be noted that the control pressure liquid being supplied to a control cylinder 18 or 19 has free access through a check valve and that the liquid making its exit from the other control cylinder has restricted flow outwardly through a check valve. This is true for either reversal of the pump 14. No attempt is made to control the flow of control pressure liquid to a control cylinder 18 or 19 but the control of the spaced reversal of pump 14 is effected solely through controlling the discharge from the control cylinder on the opposite side of the pump 14. For example, when the control liquid pressure is being supplied to cylinder 18, the discharge from cylinder 19 must all go through choke valve 55 which can be adjusted to slow down the movement of the pump shift ring 15 by any desired amount. Similarly, when the control liquid is being applied to the cylinder 19, the discharge from the cylinder 18 must all go through choke valve 53. Choke valves 53 and 55 may be individually adjusted so as to give a different restriction to fluid flow therethrough and in this way the rate of deceleration and acceleration at one end of the stroke of main cylinder 10 may be made different from the rate of deceleration and acceleration at the other end of its stroke. Thus, a different cushioning action is possible. In other words, it is possible to produce an operating stroke having a very high acceleration and a very slow deceleration and a return stroke having a slow acceleration and a high deceleration or the opposite by mere manual adjustment of restricting valves 53 and 55.

It will further be noted that by adjustment of the adjusting screws 22 and 23 provided for the control cylinders, it is possible to limit the delivery of the pump 14 in either or both directions and thus to limit the maximum operating speed of cylinder 10 in either or in both directions. If desired, the speeds of cylinder 10 in the two directions may be made different by adjusting screws 22 and 23 differently.

For stopping the movement of cylinder 10, the two-way valve 43 will be opened either manually or automatically by suitable manipulation of the piston 44 therein, whereby the pump 14 will be by-passed.

It will further be noted from the foregoing that when pump 14 is delivering into conduit 31, this pressure liquid so delivered is effectively applied to cylinder 10 since it cannot return to the tank 34. However, when conduit 31 is the suction conduit, liquid is sucked both from tank 34 through check valve 39 and from the space at the left-hand of piston 11. The same is true of the other conduit 30 with appropriate changes in the reference characters.

While in the foregoing description the shifter rod 60 is shown as a hook for contacting the control arms 58 and 59, it might equally well be a control rod with cams, or an arm, or an oil actuated plunger, or a pair of limit switches, any

of which could be positioned so as to actuate a torque motor connected to the pilot valve shaft 57 of valve 50. The actuation of a pilot valve by means of a torque motor adapted to operate in continuous stalled service is disclosed in the co-pending application of W. R. Tucker, Serial No. 167,184 filed October 4, 1937.

It will further be noted that by adjusting the control arm 60 longitudinally relative to the cylinder 10, the stroke of cylinder 10 in one direction may be varied relative to the stroke of cylinder 10 in the other direction. In other words, if arm 60 is moved from its present position relative to the cylinder 10 to the next following position numbered 73, the extreme left hand position of cylinder 10 on its leftward stroke will be shifted toward the right by a distance equalling the distance between the present position of arm 60 and the said next following position numbered 73.

It will be understood that the pump 14 is still on stroke after the valve 50 has begun to be shifted because the pressure in the then effective servomotor cylinder 18 or 19 cannot escape. Accordingly, the output of pump 14 will continue to move the cylinder 10 so as to shift the valve 50 to neutral and slightly beyond, whereupon the then effective servomotor cylinder 18 or 19 will be connected slightly to exhaust. The connections to exhaust and to intake are effected simultaneously in the same amount by the valve member 56. The pump 14 will now begin to shift slowly towards neutral, not being able to shift rapidly because the slight connection to exhaust operates as a restriction on the discharge of fluid from the then effective servomotor cylinder. Accordingly, the pump 14 will continue on stroke so as to move the cylinder 10 still further until it shifts valve 50 sufficiently and a sufficient period of time has elapsed to allow emptying of the previously effective servomotor cylinder and filling of the opposing servomotor cylinder to an extent sufficient to shift pump 14 through neutral onto stroke in the other direction.

I wish it to be understood that I intend to include as within this invention such modifications as may be necessary to adapt the same to varying conditions and uses and as fall within the scope of the appended claims.

Having thus fully described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A hydraulic mechanism comprising a reversible-delivery liquid pump, reciprocable means for reversing the direction of delivery of said pump, a hydraulic motor having a motive element operatively connected to move said reciprocable means in one direction, a second hydraulic motor having a motive element operatively connected to move said reciprocable means in the other direction, a source of fluid pressure, and valve means for selectively connecting said fluid pressure to one or the other of said motors, and control means interposed between said valve means and each of said hydraulic motors and adapted to allow unrestricted flow of fluid from said valve means to each of said hydraulic motors, while permitting only a restricted flow from each of said motors to said valve means.

2. A hydraulic mechanism comprising a reversible-delivery liquid pump, reciprocable means for reversing the direction of delivery of said pump, hydraulic motor means movable in opposite directions and operatively connected to said reciprocable means for actuating the latter, a

source of fluid pressure, valve means for selectively connecting said source of fluid pressure to one or the other side of said motor means, two chokes respectively interposed between said valve means and each side of said motor means for restricting the flow of fluid from said motor means to said valve means, and means associated with each of said chokes and adapted responsive to the flow of fluid from said valve means to said motor means for making the respective choke ineffective.

3. A hydraulic mechanism comprising a reversible-delivery liquid pump, reciprocable means for reversing the direction of delivery of said pump, a pair of hydraulic motors oppositely operatively connected to said reciprocable means, a source of fluid pressure, a pair of conduit means, each of which connects to one of said motors, valve means for alternatively connecting said source to either of said conduit means, and adjustable choke means respectively arranged in each of said conduit means for restricting the flow of fluid from said fluid pressure source to either of said motors, and two check valves respectively associated with said conduits for short circuiting the choke means of one of said conduit means, while the choke means of the other conduit means is effective.

4. A hydraulic mechanism comprising a reversible-delivery liquid pump, reciprocable means for reversing the direction of delivery of said pump, a pair of hydraulic motors oppositely operatively connected to said reciprocable means,

a source of fluid pressure, a pair of conduit means, each of which connects to one of said motors, valve means for alternatively connecting said source to either of said conduit means, a pair of adjustable choke valves respectively arranged in said conduit means for restricting the flow of fluid from said motors to said valve means, and a pair of check valves respectively by-passing said choke means and responsive to the supply of pressure fluid from said source of fluid pressure to said conduit means to allow free passage of fluid from said source to said motors.

5. A hydraulic mechanism comprising a reversible-delivery liquid pump, reciprocable means for reversing the direction of delivery of said pump, a pair of hydraulic motors oppositely operatively connected to said reciprocable means, a source of fluid pressure, a pair of conduit means, each of which connects to one of said motors, means for alternatively connecting said source to either of said conduit means, means in each of said conduit means for allowing free passage of fluid to the hydraulic motor associated therewith and for preventing the reverse flow of liquid, restriction means in parallel with each of said last-named means for restricting the flow of fluid when said flow is from said hydraulic motor, and a pair of pump stroke adjusting means respectively associated with said hydraulic motors for independently varying the pump stroke in either direction.

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