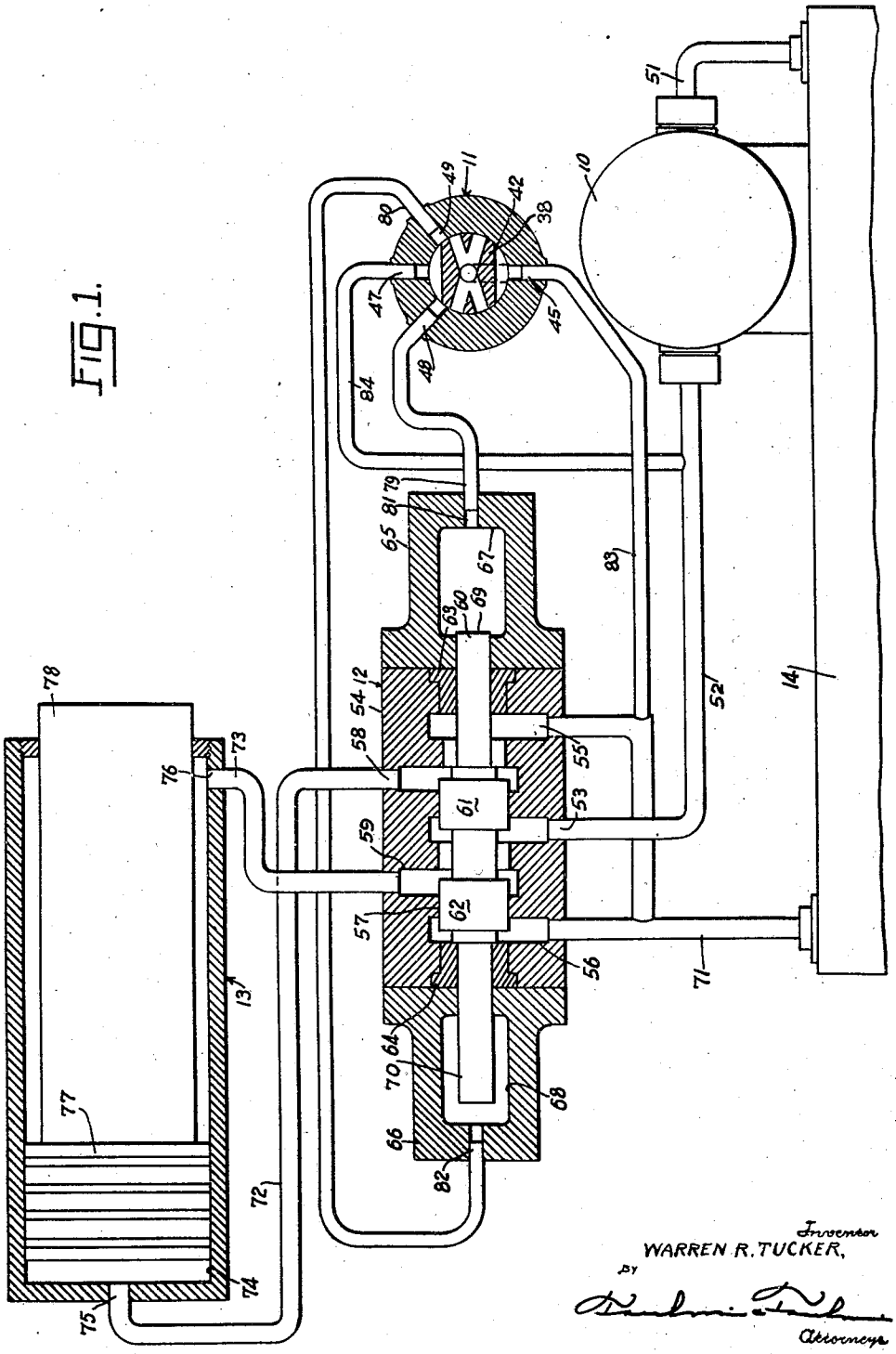
May 19, 1942. W. R. TUCKER 2,283,397

VALVE

Original Filed Oct. 4, 1937 3 Sheets-Sheet 1

Fig. 1.



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VALVE

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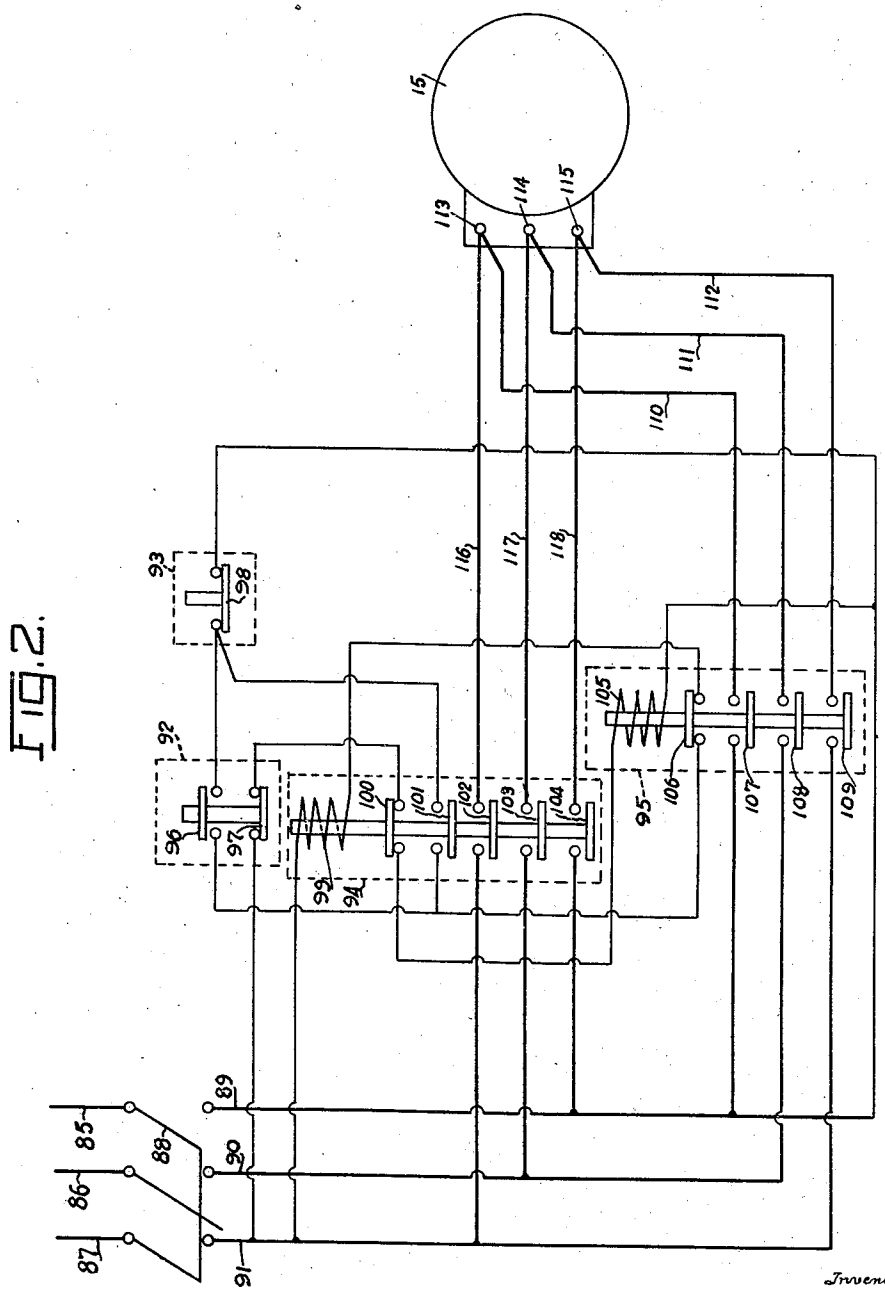

FIG. 2.

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VALVE

Original Filed Oct. 4, 1937 3 Sheets-Sheet 3

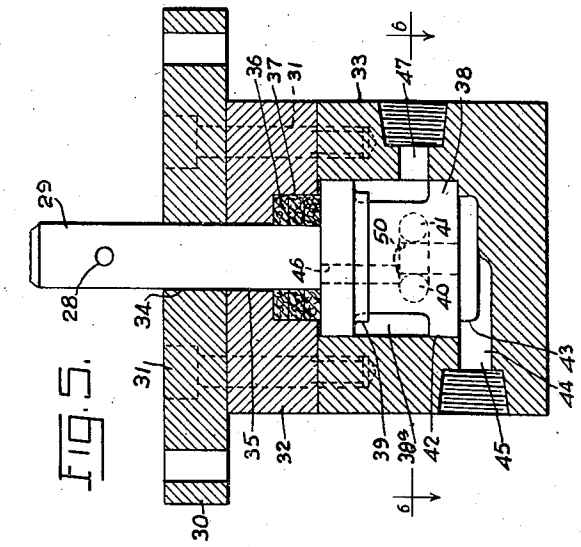

FIG. 5.

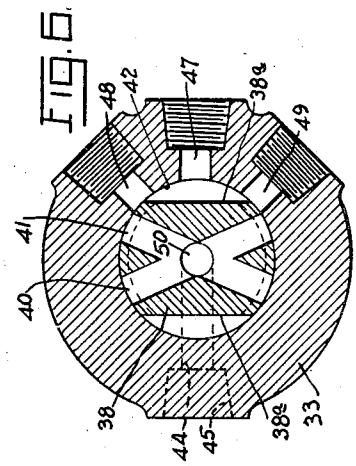

FIG. 6.

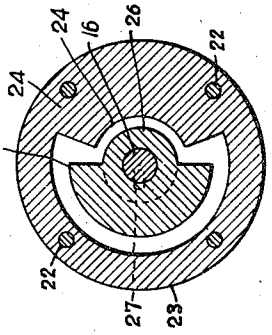

FIG. 4.

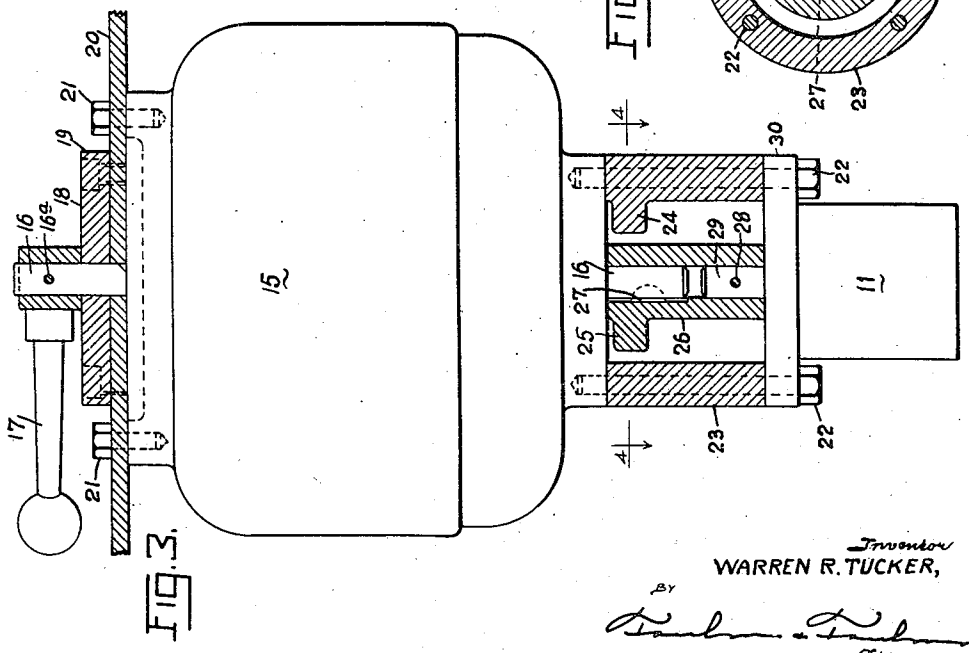

FIG. 3.

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2,283,397

UNITED STATES PATENT OFFICE

2,283,397

VALVE

Warren R. Tucker, Mount Gilead, Ohio, assignor to The Hydraulic Development Corp. Inc., Wilmington, Del., a corporation of Delaware

Original application October 4, 1937, Serial No. 167,184. Divided and this application August 22, 1938, Serial No. 226,099

1 Claim. (Cl. 121—46.5)

This invention relates to hydraulic machine control circuits, and in particular, to such circuits controlled by valves which are regulated by electrical circuits.

One object of this invention is to provide an arrangement for the electrical control of a hydraulic machine by means of a motor-actuated valve for directing the flow of pressure fluid to the machine.

Another object is to provide a motor-operated valve for regulating the distribution of pressure fluid to a hydraulic circuit, this valve having a valve member which is rotatable through a partial revolution to differently distribute the pressure fluid.

Another object is to provide a motor-operated valve unit, wherein a reversible high-torque low-current motor adapted for continuous stalled service, serves when oppositely energized, to rotate a valve member through a partial revolution in opposite directions, thereby differently distributing the flow of fluid through the valve.

This application is a division of my application Serial No. 167,184, filed October 4, 1937.

In the drawings:

Figure 1 is a circuit diagram showing diagrammatically the hydraulic machine and the hydraulic circuit of this invention;

Figure 2 is a wiring diagram of the circuit for energizing the motor which shifts the pilot valve in Figure 1;

Figure 3 is a side elevation, partly in central vertical section, showing the valve-actuating motor and the attachment of the pilot valve thereto;

Figure 4 is a cross section along the line 4—4 in Figure 3, showing the stops for limiting the opposite means of the valve;

Figure 5 is a central vertical section through the pilot valve attached to the lower end of the motor in Figure 3; and

Figure 6 is a cross section along the line 6—6 in Figure 5.

General arrangement

In general, the electrically-controlled circuit of this invention consists of a reversible motor connected to rotate a pilot valve member, which in turn, regulates the distribution of pressure fluid to a servo-circuit adapted to shift a four-way main control valve so as to regulate the distribution of pressure fluid from a pump to the hydraulic machine in a reversible manner The valve-actuating motor is controlled by an electrical circuit which is arranged to energize the motor oppositely so as to shift the pilot valve in opposite directions, this shifting being brought about by the operation of switch means actuated manually or automatically. The motor-actuated valve consists of a rotatable valve member attached to the motor, and having stops associated therewith to limit the rotation of the valve member to a partial revolution. This circuit and valve have been found especially valuable in connection with the control of hydraulic presses, and in particular, plastic injection molding presses. The motor-operated valve of the present invention in such machines, has been found to provide a smooth and quiet performance which is decidedly superior to the irregular and noisy solenoidal devices hitherto employed.

Referring to the drawings in detail, Figure 1 shows the hydraulic circuit of this invention as consisting of a hydraulic pump 10, arranged to distribute fluid to a motor-actuated pilot valve 11, which in turn, regulates the motions of a four-way main control valve 12, the latter distributing pressure fluid from the pump 10 in reversible directions to the hydraulic motor 13. A tank 14 supplies fluid for the operation of the hydraulic circuit.

Pilot valve construction

The motor-actuated pilot valve 11 which controls the distribution of the pressure fluid for shifting the main control valve 12 to its opposite positions, includes a reversible electric motor 15, which is preferably of a high-torque low-current type suitable for continuous stalled service. The motor 15 has a motor shaft 16, brought out at opposite ends of the motor. Secured, as at 16a, on the upper end of the motor shaft 16, is a manual valve-operating handle 17. The shaft 16 passes through a plate 18 secured, as at 19, to the upper surface of the motor support 20, the motor 15 being bolted to the lower side thereof, as at 21 (Figure 3).

Mounted upon the lower side of the motor 15 and bolted thereto, as at 22, is the spacing sleeve 23 having an arcuate projection 24 (Figure 4) forming a lug of a partial circumference. Coacting with this fixed arcuate lug 24 is a movable arcuate lug 25 upon a sleeve 26, which is keyed as at 27 to the lower end of the motor shaft 16. Secured within the sleeve 26, as by the pin 28, is the pilot valve rod 29 of the pilot valve 11. The latter is provided with a supporting plate 30, which is secured to the spacing sleeve 23 and the motor 15 by the same bolts 22. Secured to the supporting plate 30, as by the screws 31, are a spacer and packing retainer 32 and a valve casing 33. The valve rod 29 passes through bores 34 and 35 in the supporting plate 30 and spacer 32, respectively, leakage therearound being prevented by a packing 36 within an annular seat 37.

Mounted on the lower end of the valve rod 29 and integral therewith is the valve member 38 of plug-shaped form. This valve member 38 is

approximately cylindrical in shape, with an annular cut-away portion or passageway 39 thereabout, and with cross passages 40 and 41 therethrough (Figure 6). The valve member 38 rotates within a valve bore 42, the lower end of which is provided with a central recess 43 communicating through an exhaust passageway 44 with an exhaust port 45. The longitudinal passageway 46 connects the top of the valve plug to the exhaust passageway 44 in order to equalize the pressure upon the top and bottom of the valve member 38. The annular passageway 39, on the other hand, equalizes the pressure on the opposite sides of the valve member 38. The valve casing 33 is provided with an inlet port 47 and a pair of service outlet ports 48 and 49, to which connection is made to the pump 10 and four-way main control valve 12, respectively. The valve member 38 also has flat side portions 38a.

If the motor 15 is energized to rotate the valve member 38 so that the passage 41 communicates with the service outlet 48 (the arcuate lugs 25 and 24 cooperating to prevent a further rotation) then pressure fluid is admitted from the pump 10, through the inlet 47, to the valve bore 42, and passes outward through the service outlet 49. Simultaneously the service outlet 48 will be connected to the central passageway 50 leading downwardly to the exhaust passageway 44 and exhaust port 45. If the motor 15 is reversely energized so that the valve member 38 is rotated in the opposite direction, the arcuate lugs 24 and 25 again cooperate to halt the valve member 38 in such a position that the passage 40 communicates with the service outlet 49. Under these circumstances, pressure fluid is admitted from the pump 10, through the inlet 47, to the valve bore 42, and passes outward through the service outlet 48. The service outlet 49 is thus connected to the exhaust port 45 by way of the cross passage 40, the central passageway 50 and the exhaust passageway 44.

Hydraulic circuit

The hydraulic circuit which the pilot valve 11 controls is shown in Figure 1, and has already been described with regard to its general elements. The pump 10 is connected to the tank 14 by means of the suction line 51, the pressure line 52 running therefrom to the pressure inlet port 53 of the main control valve 12. The latter is provided with a casing 54 having exhaust ports 55 and 56 communicating with the valve bore 57, at the ends thereof, and likewise having service ports 58 and 59 located at intermediate points therealong.

Movable to and fro within the valve bore 57 is a valve rod 60 having spaced heads 61 and 62, by which the distribution of the fluid is controlled from the inlet port 53 selectively to either of the service ports 58 or 59. The valve rod 60 passes through plugs 63 and 64, into end casings 65 and 66 forming servo-cylinders and having chambers 67 and 68 respectively. The right-hand end 69 terminates within the chamber 67 and the left-end 70 terminates within the chamber 68 so as to provide, in effect, servo-piston heads for shifting the valve rod 60 and valve heads 61 and 62. The exhaust ports 55 and 56 are connected to the line 71 leading to the tank 14, whereas the service ports 58 and 59 are connected by the lines 72 and 73 to the opposite ends of the cylinder bore or chamber 74 of the hydraulic motor 13 at the ports 75 and 76 on opposite sides of the main piston head 77, forming a part of the main plunger 78.

The pilot valve 11 is connected to the servo-cylinder chambers 65 and 66 by means of the lines 79 and 80. The line 79 runs from the service outlet 48 to the port 81 of the servo-cylinder chamber 67, whereas the line 80 runs from the service outlet port 49 to the port 82 of the servo-cylinder chamber 68. From the exhaust port 45 of the pilot valve 11 the line 83 runs to join the exhaust line 71 leading back to the tank 14. From the pump pressure line 52 the pilot fluid supply line 84 runs to the inlet port 47 of the pilot valve 11. The main control valve 12 is so connected to the pilot valve 11 and pump 10 that when pressure fluid is admitted to either of the servo-cylinder chambers 67 or 68, the valve rod 60 and piston heads 61 and 62 are shifted toward the opposite end of the valve 12, thereby connecting one of the ports 58 or 59 to the inlet port 53, and connecting the other port to one of the exhaust ports 55 or 56, depending upon the position of the piston heads 61 and 62.

Electrical control circuit

In the electrical control circuit (Figure 2) the three-phase power mains 85, 86 and 87 are connected through the line switch 88 to the power lines 89, 90 and 91, which serve to provide power current for the energization of the pilot valve-actuating motor 15.

The electrical circuit shown in Figure 2 contains a two-pole switch 92 and a single pole reversing switch 93; also a five-pole magnetic contactor 94 and a four-pole magnetic contactor 95. The two-pole switch 92 has an upper normally open switch bar 96 and a lower normally closed switch bar 97. The reversing switch 93 has a single normally closed switch bar 98. The five-pole contactor 94 is provided with an operating coil 99 and five switch bars 100, 101, 102, 103 and 104, the switch bar 100 being normally closed and the others normally open. The four-pole contactor 95 is provided with an operating coil 105 and switch blades 106, 107, 108 and 109. The switch blade 106 is normally closed and the other switch blades normally open.

Either the two-pole switch 92 or the reversing switch 93 may be operated manually or mechanically by direct action or by time delay mechanism, or by pressure-responsive mechanism, as desired, and as most suitable for the particular installation. This invention contemplates the use of any one or a combination of these switch-actuating arrangements. For purposes of simplicity, however, the switches 92 and 93 of Figure 2 are illustrated as being manually operated. For thermal control either of the switches 92 or 93 may be operated by a suitable operating coil, energized by thermally-actuated contacts. Either of these switches may be operated by a photo-electric cell controlling a suitable relay, which in turn, controls the energization of the switch-operating coil.

Operation

The operation of the individual elements of the hydraulic circuit and of the pilot valve 11 has been described in connection with those elements. In the operation of the electric and hydraulic circuits (Figures 1 and 2), let it be assumed that the line switch 88 is open, thereby deenergizing the power lines 89, 90 and 91. The switches and contactors 92, 93, 94 and 95 assume the positions shown in Figure 2, under such con-

ditions. The operator now closes the line switch 88, whereupon current passes from the line 91, through the normally closed switch blade 97 of the two-pole switch 92, the normally closed upper switch blade 100 of the contactor 94 and the operating coil 105 of the contactor 95, back to the power line 89. The switch blades of the contactor 95 immediately shift so that the blade 106 is opened and the blades 107, 108 and 109 closed.

The motor 15 is then connected to the power lines 89, 90 and 91 through its lines 110, 111 and 112 leading from the motor terminals 113, 114 and 115, respectively. The opening of the switch blade 106 opens the circuit containing the operating coil 99 of the magnetic contactor 94, and prevents its energization. The energization of the motor 15 causes it to rotate its shaft 16, whereby shifting the valve member 38 of the pilot valve 11 into its extreme position in one direction. The arcuate stops 24 and 25 (Figure 3) cooperate to halt the valve in this position.

Under these circumstances the pump 10 takes in fluid through the suction line 51, and discharges its pressure fluid through the pressure line 52, the pilot pressure line 84 and the inlet port 47 of the pilot valve 11, into the pilot valve chamber 42, whence it passes through the service outlet port 48, along the line 79 and through the port 81, into the right-hand servo-cylinder chamber 67. The pressure fluid acts against the right-hand end 69 of the valve rod 60 and shifts the latter to its extreme left-hand position. The valve heads 61 and 62 thereby assume the positions of Figure 1, and permit pressure fluid to pass from the pump 10, along the line 52, through the port 53 and valve bore 57, out the port 59 and along the line 73, into the return side of the hydraulic cylinder bore 74 by way of the port 76. The pressure fluid acts against the main piston head 77 and forces the main plunger to its left-hand position. The fluid displaced from the forward side of the main cylinder bore 74 is discharged through the port 75, the line 72, the port 58, the valve bore 57, the port 55 and the exhaust line 71, into the tank 14.

The operator now moves the switch 92 so as to close the switch blade 96 and open the switch blade 97, thereby breaking the energizing circuit through the operating coil 105 of the magnetic contactor 95. The switch blades 107, 108 and 109 thereof open while the switch blade 106 closes, in response to this deenergization. Current now passes from the power line 91, through the operating coil 99 of the magnetic contactor 94, thence through the normally closed switch blade 106 of the magnetic contactor 95, and through the normally open but now closed upper switch blade 96 of the switch 92, and the normally closed switch blade 98 of the reversing switch 93, back to the power line 89. This action energizes the operating coil 99 of the contactor 94, thereby closing the switch blades 101, 102, 103 and 104, and opening the switch blade 100. The switch 96 may then be released and permitted to return to its normal position without breaking the energization circuit of the contactor coil 99 because a holding circuit therefor is made through the switch blade 101 bridging around the normally open upper switch blade 96 of the two-pole switch 92.

With the magnetic contactor 94 thus energized, the terminals 113, 114 and 115 of the motor 15 are connected through the lines 116, 117 and 118, and the switch blades 102, 103 and 104 to the power lines 91, 90 and 89, respectively. This reversal of connections of the motor 15 reverses its energization and causes it to move the valve member 38 of the pilot valve 11 in the opposite direction until the cooperating lugs 24 and 25 again halt the valve member 38 in its opposite extreme position.

When this occurs the flow of pressure fluid from the pilot valve inlet port 47 proceeds through the service outlet port 49, along the line 80 to the left-hand servo-cylinder chamber 68, where it acts against the valve rod end 70 and shifts the heads 61 and 62 to their extreme right-hand positions from those shown in Figure 1. The hydraulic connections of the ports 75 and 76 of the hydraulic motor 13 are then reversed so that pressure fluid enters the port 75 and fluid is discharged from the port 76. The piston head 77 and the main plunger 78 are then forced to the right. The motion of the main plunger 78 is reversed at any moment by opening the reversing switch 93, whereupon the energization of the operating coil 99 of the magnetic contactor 94 is broken, thereby opening its switch blades 101, 102, 103 and 104, and closing its switch blade 100. This again energizes a circuit through the magnetic contactor operating coil 105 of the contactor 95, thereby energizing the valve-actuating motor 15 in the reverse direction, and causing a reversal in the hydraulic circuit and a consequent return movement of the main plunger 78 to its left-hand position shown in Figure 1. Thus, regardless of the position of the piston head 77, the direction of its movement may be reversed at any time by manipulating the switches 92 or 93, as the case may be.

It will be understood that I desire to comprehend within my invention such modifications as come within the scope of the claim.

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

A valve unit comprising a valve casing having an exhaust port, an inlet port and a pair of service ports, a rotary valve member having a pair of diametrically-extending relatively-angled cross passages communicating with each other and adjacent laterally disposed cutaway portions connected with each other to form a balanced valve but not communicating with said cross passages, said valve member also having an axial exhaust passageway therethrough constantly communicating with said cross passages and exhaust port, a longitudinal passageway connecting the stem end of the valve to the exhaust passageway for equalizing pressure upon the stem end and opposite end of the valve member, said rotary valve member being operable to open communication between said inlet port and one of said service ports through a cutaway portion while establishing communication between said exhaust port and the other service port through the exhaust passage, an electric stall motor having its motor shaft rigidly connected to said motor valve member for selectively moving said valve member in one or the other direction, and means for limiting the rotation of said rotary valve member to a partial revolution in its opposite directions of motion.

WARREN R. TUCKER.