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[56]

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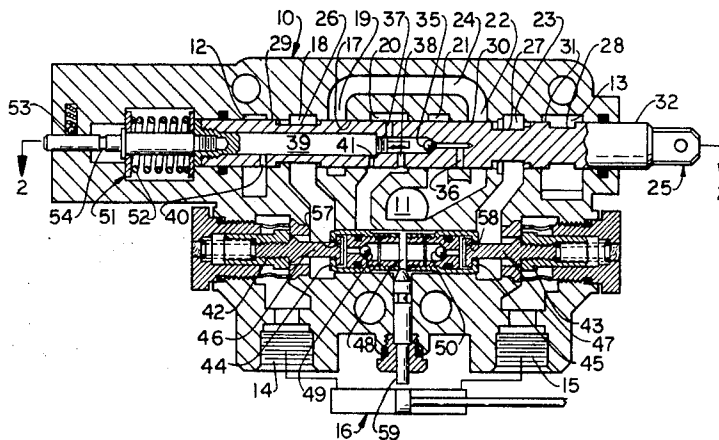
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[54] **HYDRAULIC VALVE**
5 Claims, 6 Drawing Figs.

[52] **U.S. Cl.**..... **91/420,**
91/447, 91/448, 91/464, 137/596.2
[51] **Int. Cl.**..... **F15b13/042,**
F15b 11/08
[50] **Field of Search**..... **91/420,**
448, 447, 464; 137/596.2

ABSTRACT: A manually operated spool type closed center flow control valve having two lockout check valves, one for each end of a double-acting pressure fluid actuated motor. The valve affords precise spool metering of pressure fluid returning from either end of the motor to the hydraulic system reservoir because both lockout check valves are fully opened and maintained open prior to, and entirely independent of, any flow of fluid to or from either end of the motor. Thus fluid flowing through either of the fully open lockout check valves can in no way interfere with precise spool metering of flow through the control valve. The flow metering spool can also be positioned to afford floating movement of the motor plunger and rod in either direction in response to an applied external load.



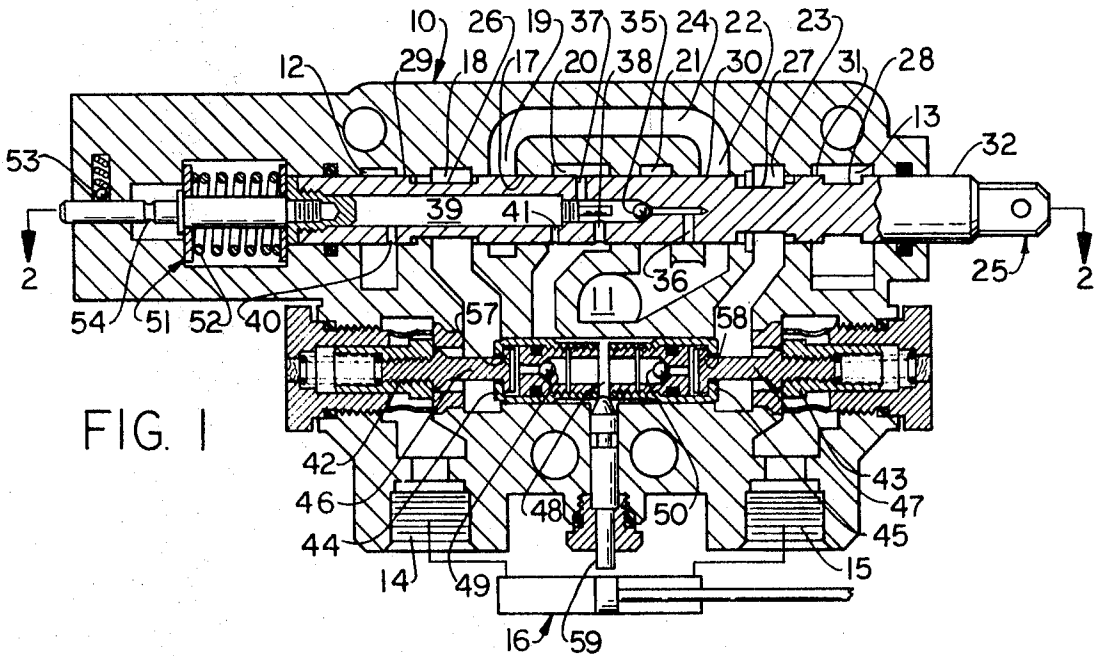


FIG. 1

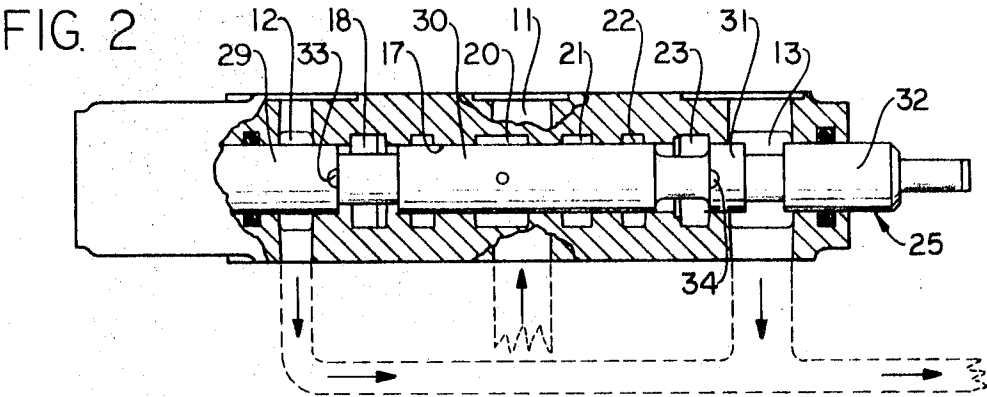


FIG. 2

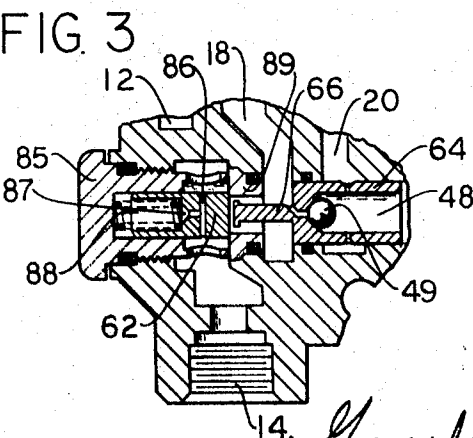


FIG. 3

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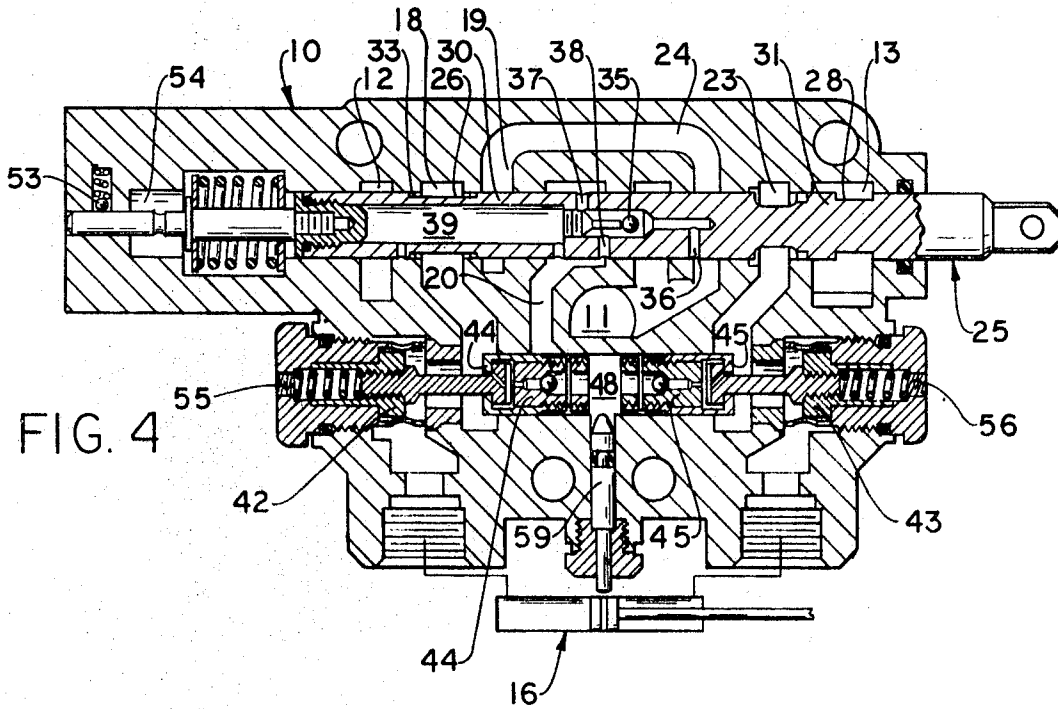
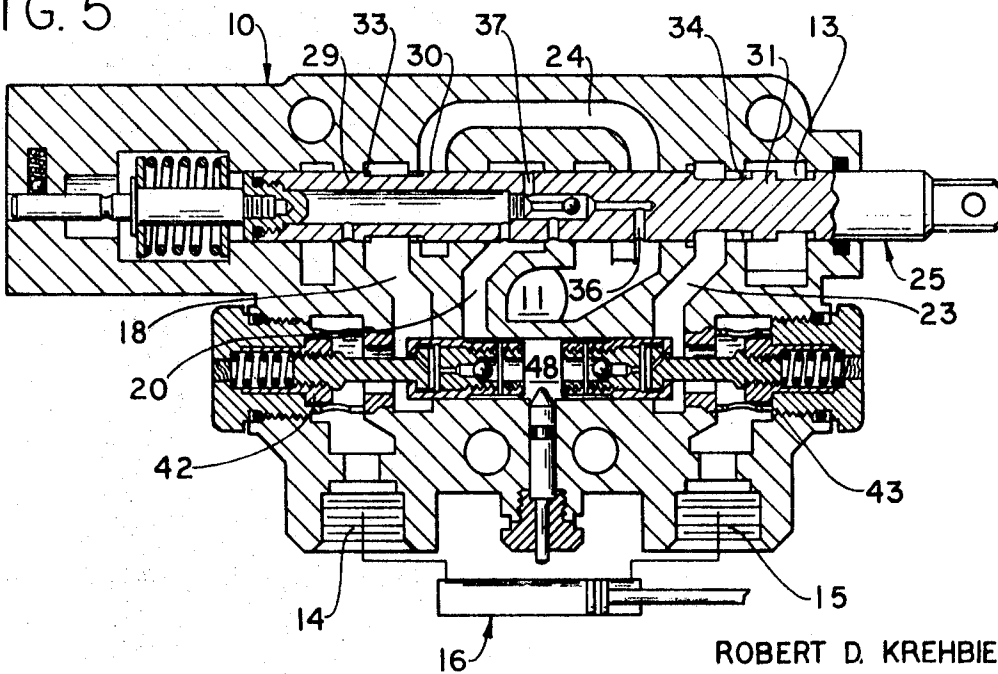


FIG. 5



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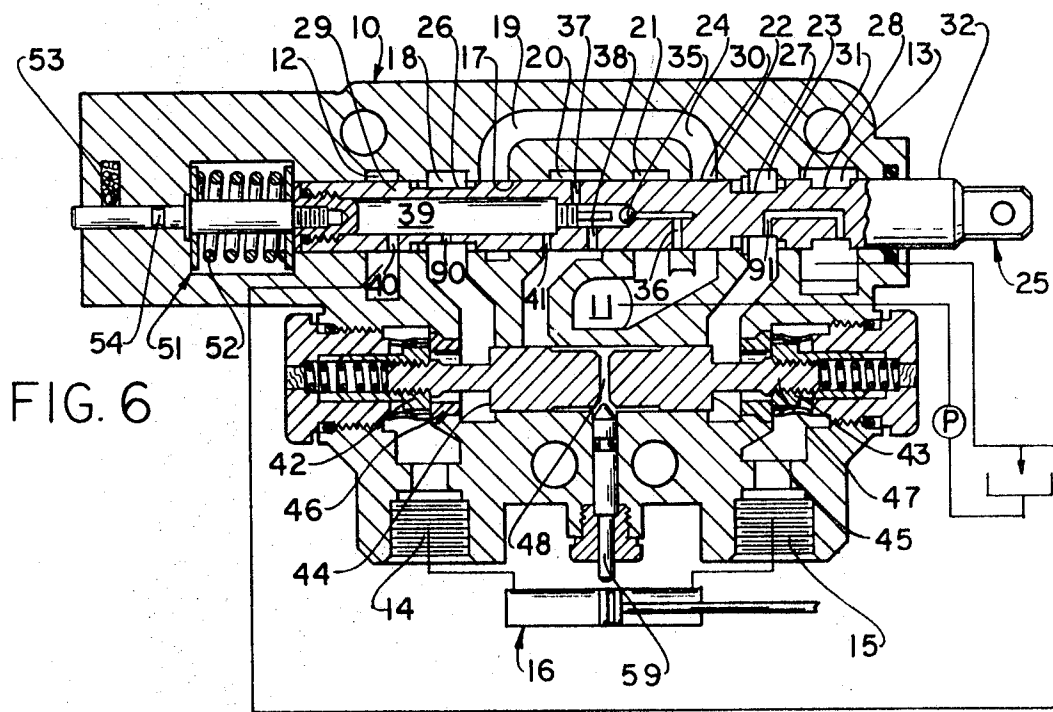


FIG. 6

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HYDRAULIC VALVE

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation of our copending application, Ser. No. 638,226, filed May 15, 1967, entitled "Hydraulic Valve."

Prior art spool-type control valves which have included a spring-closed lockout check valve for each motor port have depended on pressure fluid flowing from the source outward through one or the other motor port of the valve to open both lockout check valves. In such a valve, when the plunger rod of the controlled motor is subjected to a large external load, there is a large pressure variation in the fluid flow path in which each lockout check valve is interposed. As the plunger rod is accelerated, both by fluid pressure and the external load, the high rate of movement of the plunger rod causes a drop in pressure in the supply flow path. This lowers the pressure tending to maintain the lockouts open, and both lockouts are momentarily spring closed. Their closing causes an instant stoppage of plunger travel, and a resultant shock to the assembly. When fluid from the source again builds up sufficient pressure, both lockout checks are reopened and the described cycle is repeated. This phenomenon is known in the valve art as lockout "chatter" or oscillation, and regardless of accuracy efforts the valve operator is incapable of accurately positioning the motor plunger rod and its attached load, or of accurately controlling the rate of movement of the plunger rod, all due to the above-described instability of the lockout checks.

Past efforts to overcome this difficulty and obtain precise control over motor plunger rod movement have involved severe restriction of maximum permitted volume flow both to and from the controlled motor, as well as bulky, intricate and complicated design of lockout check valves. These efforts at solution have created a large operating efficiency loss, and have drastically limited both the speed of movement and the reaction time for plunger operation.

The present invention solves the lockout instability problem by providing a separate pressure chamber and pressure-responsive means: (1) for fully opening both lockout check valves before any pressure fluid is permitted to flow from the pressure source through either motor port to the controlled motor; (2) for maintaining both lockout checks fully open independent of any pressure variations which occur while the motor circuit is open; and (3) for affording closing of both lockout checks only after the flow paths to and from the motor have been closed.

This independent opening and closing of the two lockout checks makes them inherently stable in operation, and affords highly precise operator-controlled valve spool metering of fluid returning from the controlled motor, without any interference due to pressure variations which occur in the flow path supplying pressure fluid to the motor, all of which provides highly accurate operator control over the movement and positioning of the motor plunger rod and its load.

In valves embodying this invention the lockout check valves are held closed not only by spring pressure, but also by the pressure of fluid in the conduit between each lockout check and the respective adjacent end of the controlled motor. In addition, a leakage path is provided to prevent accumulated internal leakage of pressure fluid from unseating or "cracking" either lockout. This makes it possible for the two lockouts to positively lock the plunger of the controlled motor in a selected position and to maintain it in that position indefinitely.

Prior art control valves having double lockout checks have been incapable of permitting the plunger rod of the controlled motor to "float" in either direction under the influence of an external force because one motor port had to be openly connected to the fluid pressure source in order to open the two lockout checks. In this invention, since the lockout checks are held open independent of source fluid flowing to the motor, a "float" position is provided for the flow control spool, and both ends of the controlled motor are connected to a return

conduit, thus affording free movement of the motor plunger in its cylinder.

The invention also includes a means for opening both lockout check valves in case the hydraulic system pressure should drop to zero, and the load supported by the plunger rod of the motor happened to be in a dangerous position. The load can then be lowered to normal position.

The invention, and its various features, will be more clearly understood when the following description is read in connection with the accompanying drawings in which:

FIG. 1 is an axial vertical section through a valve embodying the invention, the flow control spool being shown in its neutral position;

FIG. 2 is a transverse longitudinal section taken along the line 2—2 of FIG. 1;

FIG. 3 is a fragmentary sectional view of the valve of FIG. 1, and shows details in the construction of a different type of lockout check valve than is shown in FIG. 1;

FIG. 4 is a view similar to FIG. 1 but shows the flow control spool moved slightly to the right of its neutral position to cause fluid pressure opening of both lockout check valves, while flow from the supply passage to either end of the motor remains blocked by the spool;

FIG. 5 is a view similar to FIG. 4 showing the spool moved slightly farther to the right in a position to meter fluid from the right end of the controlled motor, and to simultaneously afford flow of motive fluid from the supply passage to the left end of the motor; and

FIG. 6 is an axial vertical section through a flow control valve embodying the invention in slightly different form, and schematically shows a simple hydraulic system in which such valves may be interposed.

Referring to FIGS. 1 and 2, the valve comprises a housing 10 having a fluid supply passage 11, fluid return passages 12 and 13, and two motor ports 14 and 15, connected to the respective opposite ends of a double-acting hydraulic motor 16. Extending through the housing is a spool bore 17 which is encircled by six longitudinally spaced bore-communicating ducts 18 through 23, in addition to the return passages 12 and 13. Ducts 21 and 22 communicate with each other and with the supply or inlet passage 11. Ducts 19 and 22 communicate with each other by means of a longitudinal passage 24.

Mounted in bore 17 is a slidable flow control spool 25 encircled by spaced grooves 26, 27 and 28 which define lands 29, 30, 31 and 32. Lands 29 and 31 are provided with recessed fluid metering notches 33 and 34, as clearly shown in FIG. 2.

Internally, spool 25 is provided with a ball check valve 35 which closes one end of a duct 36. The ball check chamber also communicates with the spool bore by means of longitudinally spaced lateral ducts 37 and 38. Spool 25 has a second internal chamber 39 which communicates with the spool bore by longitudinally spaced lateral ducts 40 and 41.

Valve 10 houses opposed spring closed lockout check valves 42 and 43, connected respectively to opposed lockout opening plungers 44 and 45 by means of spindles 46 and 47, respectively. Lockout valve 42 is interposed between duct 18 and motor port 14, and when closed blocks flow from the motor port 14 into duct 18. Similarly, lockout valve 43 is interposed between duct 23 and motor port 15, and when closed blocks flow from motor port 15 into duct 23.

Lockout opening plungers 44 and 45 are reciprocable in a pressure chamber 48 which communicates with bore-communicating duct 20. Internally, plungers 44 and 45 are provided respectively with ball check valves 49 and 50, which block communication in one direction between the chamber 48 and the flow ducts 18 and 23, respectively.

Associated with the left end of spool 25 is a conventional spool-centering mechanism 51, which includes a coil spring 52, and which functions to return the spool to its neutral FIG. 1 position when the spool is released by the operator. A spring-pressed ball-type detent 53 mounted in a recess in the housing cooperates with an annular groove 54 near the end of spool 25 to hold the spool in "float" position when the operator desires, as will be later explained in detail.

OPERATION

Prior to operation, supply or inlet passage 11 is connected to a hydraulic pump, and return passages 12 and 13 are connected to a system reservoir, not shown. With the spool in neutral position, as in FIG. 1, the supply and return passages are isolated from each other, as are the two motor ports, and the plunger and rod of motor 16 are locked against movement in either direction.

To move the plunger of motor 16 to the right, the operator moves spool 25 to the right. When the spool reaches its FIG. 4 position pressure fluid flows from supply passage 11 through duct 36, past ball check 35, through ducts 37, 38 and 20 into pressure chamber 48, and instantly forces the two plungers 44 and 45 away from each other, such plunger movement fully opening lockout checks 42 and 43, as shown in FIG. 4. With the spool in its FIG. 4 position spool land 30 blocks the flow of pressure fluid from duct 19 into duct 18, and spool land 31 blocks flow of fluid from the motor through duct 23 into return passage 13. Air pressure behind lockout checks 42 and 43 is relieved by filter-packed atmospheric vents 55 and 56 respectively.

As movement of spool 25 to the right continues to the FIG. 5 position the fluid-metering notches 34 in the left end of spool land 31 afford precise operator-controlled metering of fluid from the rod end of motor 16 into return passage 13, and simultaneously the left end face of spool land 30 affords flow of pressure fluid from supply passage 11 through ducts 24 and 18, and out through motor port 14 to the left end of motor 16. The motor plunger thus moves to the right under precise control of the valve operator.

Note that when spool 25 is in its FIG. 5 position, or further to the right if desired by the operator, pressure chamber 48 remains in communication with supply passage 11 through ducts 36, 37 and 20, and that lockout checks 42 and 43 are thereby maintained in fully open position entirely independent of any flow of fluid to or from the motor 16 through ducts 18 and 23. The lockout checks are thus unaffected by variations in pressure in ducts 18 and 23, or in motor ports 14 and 15, and thus do not in any way affect precise metering of return fluid by spool 25, and consequent precise control by the operator over the speed of movement and positioning of the plunger of motor 16.

When the operator releases the spool 25, the centering mechanism 51 returns the spool to its FIG. 1 neutral position. As it moves to such position, flow of pressure fluid to and from both ends of motor 16 is first blocked by the lands 30 and 31, respectively. Instantly thereafter the two lockouts 42 and 43 are closed by their respective springs, the fluid in chamber 48 flowing through ducts 41, 39 and 40 (Fig. 1) into return passage 12.

To assure that neither of the lockouts 42 or 43 are opened by pressure fluid which may leak into ducts 18 or 23, leakage ducts 57 and 58 (FIG. 1) are provided in the inner ends of spindles 46 and 47. Accumulated leakage fluid may pass through ducts 57 and 58, past ball checks 49 and 50, and enter chamber 48, from which it may travel to return duct 12, as previously described.

When spool 25 is moved to the left of its FIG. 1 neutral position to move the motor plunger to the left, the same sequence of events occurs. Pressure fluid first flows through ducts 36, 37, 38 and 20 into chamber 48, and plungers 44 and 45 force lockouts 42 and 43 to their fully open positions, as in FIG. 4. Further movement of the flow control spool 25 to the left allows flow of pressure fluid from inlet 11 through duct 23, through motor port 15 to the rod end of motor 16, and simultaneously begins the metering of fluid from the left end of the motor through metering notches 33 on spool land 29 into the return passage 12, and the motor plunger moves to the left under the precise control of the spool operator.

MOTOR PLUNGER FLOAT CONDITION

When spool 25 is moved sufficiently far to the left that ball detent 53 seats in spool groove 54, the detent temporarily

holds the spool in that position against the spring force of the spool-centering mechanism 51.

In its detented position, the spool directs pressure fluid from supply 11 to pressure chamber 48 through duct 36, past ball check 35, and through ducts 38 and 20, thus holding lockout checks 42 and 43 fully open. Spool groove 26 connects duct 18 with return passage 12, and spool groove 28 connects duct 23 with return passage 13. Spool land 30 blocks flow of pressure fluid from ducts 11 and 24 into duct 18, and spool land 31 blocks flow of pressure fluid from passage 11 into duct 23. This detented spool position, then, openly connects both ends of motor 16 with the low-pressure system return ducts 12 and 13, and permits the plunger and rod of motor 16 to be moved in either direction by an external load applied to the rod.

To our knowledge such a plunger "float" condition has not previously been possible in a control valve having double lockout check valves because the two lockouts have been opened by pressure fluid flowing from the pressure source to one or the other end of the motor.

While not necessary to the valve invention described above, an auxiliary lockout check valve opening mechanism may be included. It is useful only in case the fluid pressure source should fail, with consequent closing of the two lockouts under spring pressure, which in turn might lock the plunger of the motor at one end of its permitted stroke with the load on the plunger rod in an unstable or dangerous position.

To alleviate such a condition a normally stationary pin 59 is slidably mounted in the valve housing with suitable surrounding packing to prevent leakage. Pin 59 has a generally wedge shaped or conical inner end which is normally positioned adjacent the inner ends of the two lockout opening plungers 44 and 45, as clearly shown in FIG. 1. Should system pressure fail, it is only necessary to tap the outer end of pin 59 to drive its wedge-shaped inner end into contact with the adjacent inner ends of plungers 44 and 45. The plungers are thereby forced outward, and the two lockouts are unseated, allowing the motor plunger to be moved in either direction by its load. Fluid displaced from either end of the motor 16 during such plunger movement passes through either duct 57 or 58 (FIG. 1), as the case may be, into chamber 48, and thence out of the valve through return passage 12, as previously described.

FIG. 3 LOCKOUT VALVE CONSTRUCTION

An alternative lockout check valve and plunger construction is illustrated in FIG. 3. In this construction the lockout valve 62 is mounted in a manner similar to the mounting of lockout 42, but it is not physically connected to the spindle 66 of the lockout opening plunger 64, although plunger spindle 66 opens the lockout in the same manner as does spindle 46. Lockout 62 is reciprocable in a blind bore of a plug 85 but the plug bore is not vented to the atmosphere, as is the case in the mounting of lockouts 42 and 43.

Lockout 62 is provided with a lateral duct 86 and a communicating axial duct 87 which allows pressure fluid from motor port 14 to enter the otherwise closed chamber 88 behind the lockout.

With such construction, the closing force exerted on the lockout 62 by the pressurized fluid in chamber 88 is greater than any pressure-created force exerted on the other end of the lockout through the lockout seat 89, because the seat-exposed area is less than the total cross-sectional area of the lockout. Thus, in this alternative construction the lockout 62 is held in seated position not only by spring force but also by fluid pressure created force.

FIG. 6 EMBODIMENT

In the valve illustrated in FIG. 6 the leakage ducts 57 and 58 of the FIG. 1 valve, and the ball check valves 49 and 50, and their respective leakage passages have been eliminated. The lockout check valve opening plungers 44 and 45 have been made solid, and all provision for leakage fluid passage from conduits 18 and 23 into chamber 48 has been omitted.

In the FIG. 6 valve, pressurized fluid which leaks from the supply duct 11 past spool 25 when the spool is in neutral position, and which accumulates in duct 18, is disposed of via an added spool port 90 (FIG. 6), spool chamber 39, port 40, into return passage 12. Similarly, leakage fluid which accumulates in duct 23 is disposed of via an added leakage duct 91, which directly communicates with return passage 13 when spool 25 is in neutral.

Thus in the FIG. 6 valve there is no fluid communication between chamber 48 and the two ducts 18 and 23.

Operation of the FIG. 6 valve is identical to the operation of the valve shown in FIGS. 1 to 5.

Having described the invention with sufficient clarity to enable those familiar with this art to construct and use it, we claim:

1. A hydraulic system flow control valve comprising:

a housing having

a. supply and return ports (11, 12, 13)

b. two motor ports (14, 15)

c. a bore for a slidable flow control spool and

d. passageways (18, 23) interconnecting said ports and the spool bore;

a flow control spool (25) slidable in said bore, said flow control spool having spaced grooves (26, 27, 28) therein defining lands (29, 30, 31, 32) for selectively controlling flow of pressure fluid to motor passageways (18, 23) and said return ports (12, 13);

a pair of opposed lockout check valves (42, 43) respectively interposed in the motor passageways (18, 23) connecting the respective motor ports with the spool bore;

a second bore (48) in the housing disposed in axial alignment with the two opposed lockout check valves, the two open ends of said second bore being respectively located adjacent said check valves;

a pair of plungers (44, 45) slidable in said second bore and projectable from the opposite ends thereof to forcibly open the respective check valves, the second bore and said plungers defining between the adjacent ends of the plungers a pressure chamber (48);

duct means (20) in said housing affording introduction of pressure fluid into said pressure chamber (48);

spool duct means in said flow control spool including an internal duct means within the spool affording introduction of pressure fluid into said duct means (20) and said pressure chamber (48); and

said spool duct means being positioned to assure communication thereof with the supply port (11) upon communication of a motor passageway (18, 23) with the supply port via said grooves (26, 27).

2. A valve according to claim 1 wherein said internal duct means includes check valve means (35), said check valve means being mounted to be unseated by supply pressure.

3. A valve according to claim 1 wherein said internal duct means is positioned to communicate with a return port (12, 13) and said duct means (20) when said spool is in neutral flow-blocking position.

4. A valve according to claim 1 wherein said spool (25) is movable to a float position and wherein said spool duct means is positioned to provide communication between said supply port (11) and said pressure chamber (48) when said spool is in said float position.

5. A valve according to claim 3 including a check valve controlled duct (57, 58) in each of said plungers (44, 45, 64) effective when the spool (25) is in its neutral position to afford flow of leakage fluid from the motor passageways (18, 23) into the pressure chamber (48), and to block flow of fluid from the pressure chamber into said passageways.

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