

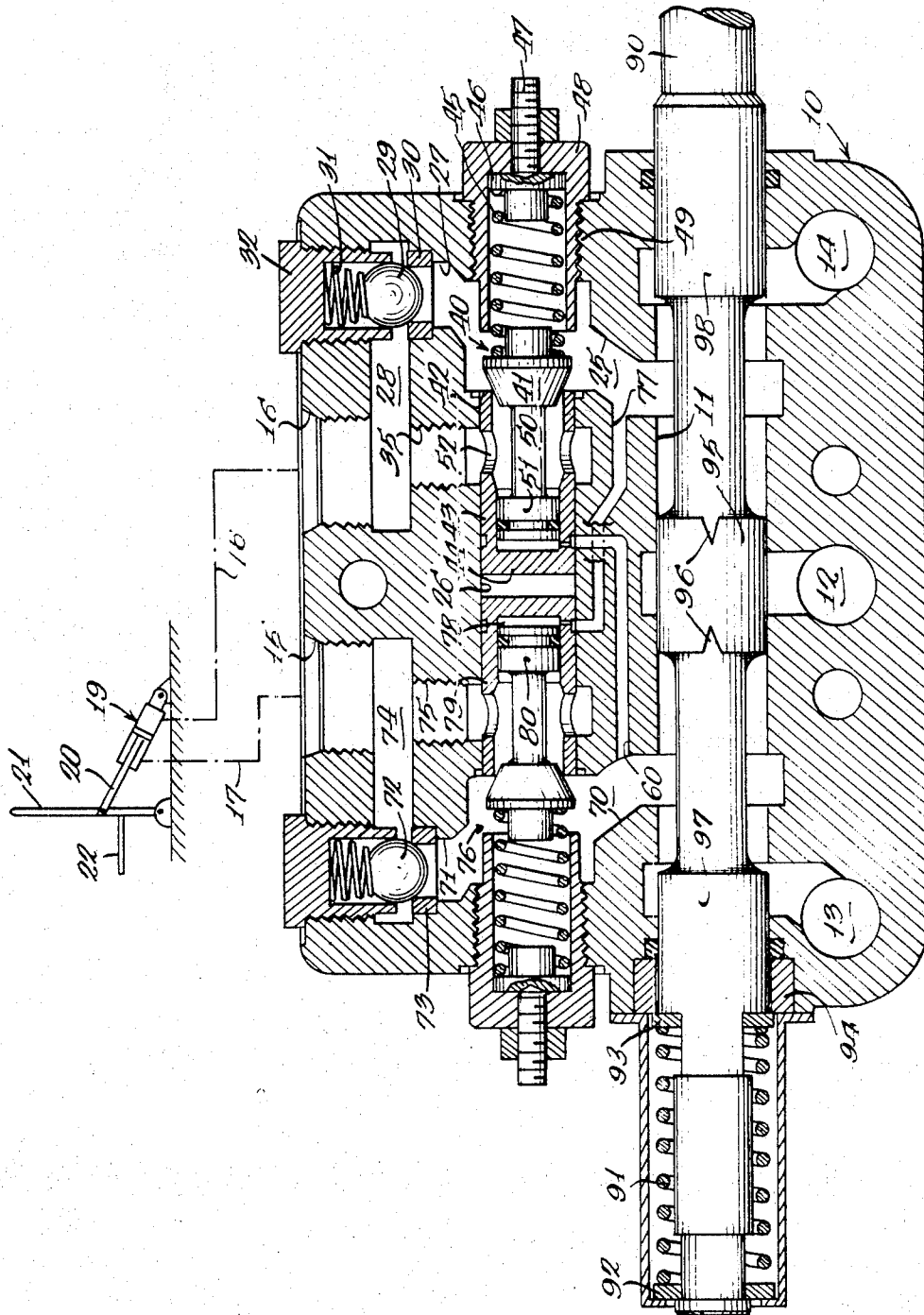
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DIRECTIONAL CONTROL VALVE

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DIRECTIONAL CONTROL VALVE

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10 Claims

ABSTRACT OF THE DISCLOSURE

A directional control valve wherein a pair of flow paths between a fluid power source and a controlled motor have a pair of parallel branch passages with one branch passage having a check valve permitting flow to a control port and the other branch of the path having a pilot operated relief valve for blocking flow through said other branch to the associated control port but permitting flow from the control port to tank whenever the pressure at the control port exceeds the setting of the relief valve as can occur when the motor is being operated, or under either overload or thermal conditions, and with the relief valve being pilot operated to open position by a pilot passage extending from the other flow path.

This invention relates to directional control valves and, more particularly, to a directional control valve having components providing holding action and also overload and thermal relief protection.

An object of this invention is to provide a new and improved directional control valve having holding valve components and providing overload and thermal relief protection.

Another object of the invention is to provide a directional control valve in which a pair of flow paths are provided through a valve body extending from a control valve bore to a respective pair of control ports connectable to a motor, with each flow path having a pair of parallel branch passages with one branch passage having a check valve permitting flow to a control port associated with the path at such times when the pressure upstream of the check valve is in excess of the pressure at the control port and the other branch of the path having a pilot-operated relief valve for blocking flow to the associated control port but permitting flow from the control port to tank whenever the pressure at the control port exceeds the setting of the relief valve and with the relief valve being pilot-operated to open position by way of a passage extending from the other of said flow paths whereby when pressure in the latter flow path is supplied to a motor to be controlled the fluid flow from the opposite end of the motor can pass through the opened relief valve to tank.

Still another object of the invention is to provide a directional control valve as defined in the preceding paragraph in which the relief valve in addition to being opened by pressure existing in the associated control port is operated by pilot pressure from the other flow path with there being a ratio in the order of 5 to 1 between these two different pressures whereby a small amount of pilot pressure as compared to control port pressure can open the relief valve.

An additional object of the invention is to have the check valves in the flow paths permit flow to the associated control port from the pressure source when a suction condition exists at the control port to prevent cavitation in the communicating side of the motor.

Further objects and advantages will become apparent from the following detailed description taken in connection with the accompanying drawing in which:

The figure is a vertical central longitudinal section

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through the directional control valve and shown with connections to a motor.

While this invention is susceptible of embodiment in many different forms, there is shown in the drawing and will herein be described in detail an embodiment of the invention with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiment illustrated. The scope of the invention will be pointed out in the added claims.

The directional control valve has a valve body indicated generally at 10 with a first valve bore 11 extending longitudinally thereof. A pressure port 12 communicates with the valve bore 11 through a connecting passage at a location centrally of the length of the valve bore. A pair of tank ports 13 and 14 communicate with opposite ends of the valve bore 11 and at opposite sides of the pressure port 12.

The valve body 10 has a pair of control ports 15 and 16 which, as shown, connect by lines 17 and 18 to a motor indicated generally at 19 which may be a linear motor such as an hydraulic cylinder. As shown, the motor has a piston rod 20 connected to a pivotal mounting member 21 which has a load support 22, shown diagrammatically. The directional control valve controls the supply of fluid to the motor 19 through either of the lines 17 or 18, with the alternate line being connected to tank for flow of fluid from the outlet end of the motor 19.

A first flow path from the valve bore 11 to the control port 16 includes a passage 25 formed in the valve body which intersects a second longitudinal bore 26 extending in spaced parallel relation to the valve bore 11. The first flow path has two branch passages 27 and 35 leading from the bore 26 with the branch passage 27 communicating with a passage 28 extending to the control port 16. A ball check valve 29 is positioned in the branch passage 27 and is urged against a valve seat 30 by a relatively light spring 31. The ball check and spring are mounted in the body by a threaded cap 32 which is threaded to the valve body 10. With the pressure fluid delivered to the right-hand end of the control valve bore 11 this fluid flows through passages 25 and 27 to passage 28 by lifting the ball check valve 29 whereby fluid can flow through control port 16 to the motor 19. As more fully described subsequently, fluid can also flow from tank port 14 through the described flow path and past check valve 29 when a suction condition exists in the right-hand end of motor 19 and atmospheric pressure at tank causes lifting of the check valve 29 and flow of fluid out of control port 16. This flow results in preventing cavitation at one end of the motor 19.

The second branch passage 35 of the first flow path communicates with passage 28 and connects therethrough to the control port 16. This passage 35 also communicates with the second valve body bore 26. The branch passage 35 with associated passages defines a relief and discharge flow path for control port 16 whereby fluid can flow from the control port to the tank port 14 and by-pass the check valve 29. This flow is controlled by a holding valve in the form of a pilot operated relief valve indicated generally at 40 having a poppet valve member 41 engageable against a valve seat 42 formed at an end of a sleeve 43 fitted in the second bore 26 having a closed end 44. The central area of valve bore 26 is drained to tank, so that a differential pressure keeps sleeve 43 in place. The poppet valve member 41 is urged against the seat 42 by a spring 45 engaged between an end of the valve member 41 and a plunger 46 which is adjustable to control the compression of the spring. The plunger 46 is adjusted by a member 47 threaded into a cap 48 which is threaded into the valve body as indi-

cated at 49. The relief valve is a differential relief valve with a valve stem 50 having a piston 51 movable within the left-hand end of the sleeve 43 as viewed in the figure and which is of a diameter less than the diameter of the valve seat 42 defined by the sleeve. The branch passage 35 communicates through sleeve openings 52 with the space surrounding the valve stem 50. The differential area created by the difference in the diameter of the piston 51 and the diameter at which the valve member 41 engages the seat 42 enables pressure fluid in control port 16 and branch passage 35 to act against the spring 45. The spring 45 has a setting in excess of the normal pressure encountered and the relief valve being in the form of a poppet valve member positively locks the motor in one position by blocking flow from an end thereof. The relief valve still permits overload relief when a shock is transmitted to the motor 19 and also thermal relief upon expansion of fluid in the system with the spring 45 yielding to permit opening of the relief valve.

The valve 40 also functions to prevent runaway by controlling the rate at which the motor 19 can move. Assuming that pressure fluid passes out of control port 15 through line 17 to the left end of motor 19, there can only be movement of the motor 19 as permitted by flow of fluid from the right-hand end thereof through the valve 40. In order to accomplish this, the relief valve is pilot-operated through a pilot passage 60 formed in the valve body and leading from a flow path yet to be described to the interior of sleeve 43 at the closed end thereof to work on the left-hand end of the piston 51 of the relief valve. The ratio between the areas acted on by pilot pressure in passage 60, as against the area acted on by pressure existing in control port 16, is approximately 5 to 1 whereby a small amount of pressure existing in the pilot passage 60 will add to pressure existing in control port 16 to overcome the setting of spring 45 and open the relief valve 40 to permit movement of the motor to the right.

A second flow path which is structurally the same as the first flow path is provided in the left-hand part of the valve body, as viewed in the figure, to connect the valve bore 11 with the control port 15. This flow path includes passage 70 with a first branch passage 71 having a check valve 72 in the form of a spring pressed ball engageable against a seat 73 which is openable by pressure to permit flow of pressure fluid through a passage 74 to the control port 15. The action of the ball check 72 is the same as that previously described with respect to the ball check 29. A second branch passage 75 communicates between the second valve bore 26 and the control port 15 for directing flow from the control port 15 through a relief valve indicated generally at 76 which upon opening connects the branch flow passage 75 to the valve bore 11. The relief valve 76 is of the same construction as the relief valve 40 and performs the same functions as described relative thereto, with there being a pilot passage 77 connecting the first flow path passage 25 to a chamber 78 at the right-hand end of a sleeve 79 whereby pilot pressure can act against a piston 80 of the relief valve 76.

The direction of operation of motor 19 as well as lock-up positioning thereof is determined by a control spool 90 movable longitudinally in the valve bore 11 and which is spring-centered by a spring 91 engaged between a collar 92 carried at one end of the spool and a collar 93 engaged against a ring 94 fitted within a recess at one end of the valve body. The control spool 90 has a central land 95 with metering notches 96 which controls the flow of pressure fluid through the valve. In the embodiment shown herein with the valve spool 90 centered, flow from the pressure port 12 is blocked so that the motor 19 does not move in either direction. The control spool also has a pair of lands 97 and 98 adjacent opposite ends thereof and at opposite sides of the central land

95 for controlling flow to the tank ports 13 and 14, respectively. With the valve spool 90 centered, the lands 97 and 98 do not block communication between the valve bore 11 and the tank ports 13 and 14. The spacing is such as to provide a restriction to flow whereby if an excessive pressure should occur at either end of the motor 19 to provide a sufficient flow volume which opens either of relief valves 40 or 76 the flow past the restriction provided by the particular land 97 or 98 will create a pressure differential which will act to oppose further opening of the particular relief valve 40 or 76 that has opened. Alternative to this the spring 45 could have a higher spring rate.

When the control spool 90 is shifted by a suitable means (not shown) in one direction or the other from the centered position, pressure will flow through one or the other of the described flow paths to the motor 19 with return flow through the other path to one of the tank ports. Assuming that the valve spool 90 moves toward the left as viewed in the figure, the control pressure will flow through the first described flow path and specifically passage 25 past ball check 29 and out control port 16 to the right-hand end of motor 19. At the same time, pilot pressure will pass through passage 77 to act in a direction to open the relief valve 76. This pilot pressure with the area ratios described along with pressure of fluid from the left-hand end of motor 19 acting through control port 15 opens the relief valve 76 whereby return fluid can flow to valve bore 11 and out tank port 13. With the control spool 90 having shifted to the left, the land 98 has blocked off tank port 14. The motor can be moved in the opposite direction by shifting of the control spool 90 to the right from the center position with the action being similar to that described but through the alternate flow path. With the closed center system shown herein, the directional control valve would normally be used with a variable volume pump. If desired to use the valve with a fixed displacement pump, the control spool could be modified as well as the porting to the valve bore 11 to provide an open center system.

With the direction control valve as described, a motor can be operated with the rate of movement controlled by the pressure in the system because of the pilot pressure operation of the relief valve in the return line. The relief holding valve provides for positive lock of the motor 19 in a predetermined position with the relief valve providing for relief due to thermal or shock conditions and also as encountered by fast movement of the control spool to centered position with resulting high inertia forces in the motor 19. The locked condition of the motor 19 can be relieved if pressure should not be available to the direction control valve by backing up the spring compression of one of the springs 45 of the relief valves to let pressure in passage 35 open the relief valve and lower the load.

Because the motor 19 can only operate at a rate determined by the control pressure supplied thereto through the pilot pressure operating on the relief valve in the return flow passage, runaway of the motor 19 is prevented.

I claim:

1. A directional control valve with holding valve components and providing overload and thermal relief operation comprising, a valve body having a bore, pressure and tank ports connected to said bore, a directional control valve spool movable in said bore, a pair of control ports in said body connectable to a motor to be controlled, first and second flow paths in said body defined by passages extending from spaced-apart sections of said bore and to respective ones of said control ports, each of said flow paths having a pair of branch passages in parallel, a pair of pilot operated poppet relief valves, each flow path having one of said relief valves in one branch and spring-loaded to closed position against a valve seat to oppose fluid flow entering said associated control port

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and in said closed position having a part thereof exposed to said associated control port to be responsive to motor fluid pressure acting against the spring-loading and in a direction exerting valve opening force, a check valve in the other branch of each of said paths and openable by pressure flow to said associated control port, each of said relief valves having a pilot member and a pilot pressure passage leading from one flow path to the pilot member for the relief valve positioned in said one branch of the other flow path to open the latter flow path when pressure fluid is in said one flow path.

2. A directional control valve as defined in claim 1 in which said control spool is spring-centered with a central land controlling flow from said pressure port to one or the other of the flow paths when moved from center position, and a pair of lands at opposite sides of said central land for controlling the connection of said flow paths to the tank ports, said pair of lands providing a flow restriction to the tank ports when the control spool is centered whereby substantial flow through one of said relief valves causes a pressure drop across the restriction which increases the effective pressure setting of said one relief valve.

3. A directional control valve as defined in claim 1 wherein each poppet relief valve has a pilot piston defining the pilot member and which is of a lesser diameter than the associated valve seat to provide a differential area subject to pressure urging the associated relief valve open.

4. A directional control valve as defined in claim 3 wherein each pilot passage associated with each pilot piston communicates with the side of the piston remote from the associated valve seat.

5. A directional control valve as defined in claim 3 wherein each of the relief valves has a spring engaging the associated relief valve and urging the associated relief valve member against the associated valve seat, and means for adjusting the compression of each of the springs and reducing the spring force to a sufficiently low value to permit a relatively small pressure to open the associated relief valve due to the differential area and permit fluid flow from the motor.

6. A directional control valve with holding and relief action comprising, a valve body with a first valve bore, a pressure port communicating centrally with said valve bore, a pair of tank ports communicating with said bore adjacent the ends thereof, a second bore in said body, a pair of control ports connectable to opposite ends of a motor for controlling the operation thereof, a first pair of spaced passages in said body each extending from said first valve bore at spaced locations between the pressure port and a tank port and intersecting the second bore and leading one to each of said control ports, a pair of check valves one in each of said first pair of passages in a section thereof between the second bore and the associated control port and openable by a pressure in said first valve bore greater than at the associated control port to supply fluid to the associated control port, a second pair of spaced passages connecting the second bore with respective ones of said control ports to bypass the sections of said first pair of passages having said check valves, a pair of pilot operated spring-loaded relief valves in said second bore each having a valve member with a pilot section and a valve seat with the valve members

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positioned to close against their respective valve seats to block communication between a passage of the first pair and a passage of the second pair and positioned to open when pressure in the passage of the second pair exceeds the setting of the relief valve to connect the second pair passage to the first pair passage and therefore to the associated tank port, a pilot passage in the body extending from each of the first pair passages to the pilot section of the relief valve associated with the other of the first pair passages whereby pressure in a first pair passage will cause the control port associated with the other first pair passage to be connected to the associated tank port, and a control spool in said first valve bore for controlling the application of pressure fluid to one or the other of said first pair passages.

7. A directional control valve as defined in claim 6 wherein said relief valves are of the poppet type and each have a piston connected thereto of a lesser diameter than the associated valve seat to provide a differential area subject to pressure urging the relief valve open.

8. A directional control valve as defined in claim 7 in which said pistons comprise actuated members of the pilot sections of the relief valves and the pilot passages communicate with the side of the pistons remote from the valve seats.

9. A directional control valve as defined in claim 7 and having a pair of springs associated one with each of the relief valves to engage the valve members and to urge the valve members against their associated valve seats, and means for adjusting the compression of each spring and reducing the spring force to a sufficiently low value to permit a relatively small pressure to open the associated relief valve due to the differential area and permit fluid flow from the motor.

10. A directional control valve as defined in claim 7 in which each of said relief valves is mounted in an individual sleeve positioned in the second bore having one closed end and an open end defining the associated valve seat, said sleeve having an interior chamber of two different diameters with the larger diameter being at said associated seat and the smaller diameter adjacent the closed end with the associated piston being positioned in the smaller diameter portion of the chamber, and openings through the wall of the sleeve intermediate the ends thereof connecting the sleeve interior to a second pair passage.

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