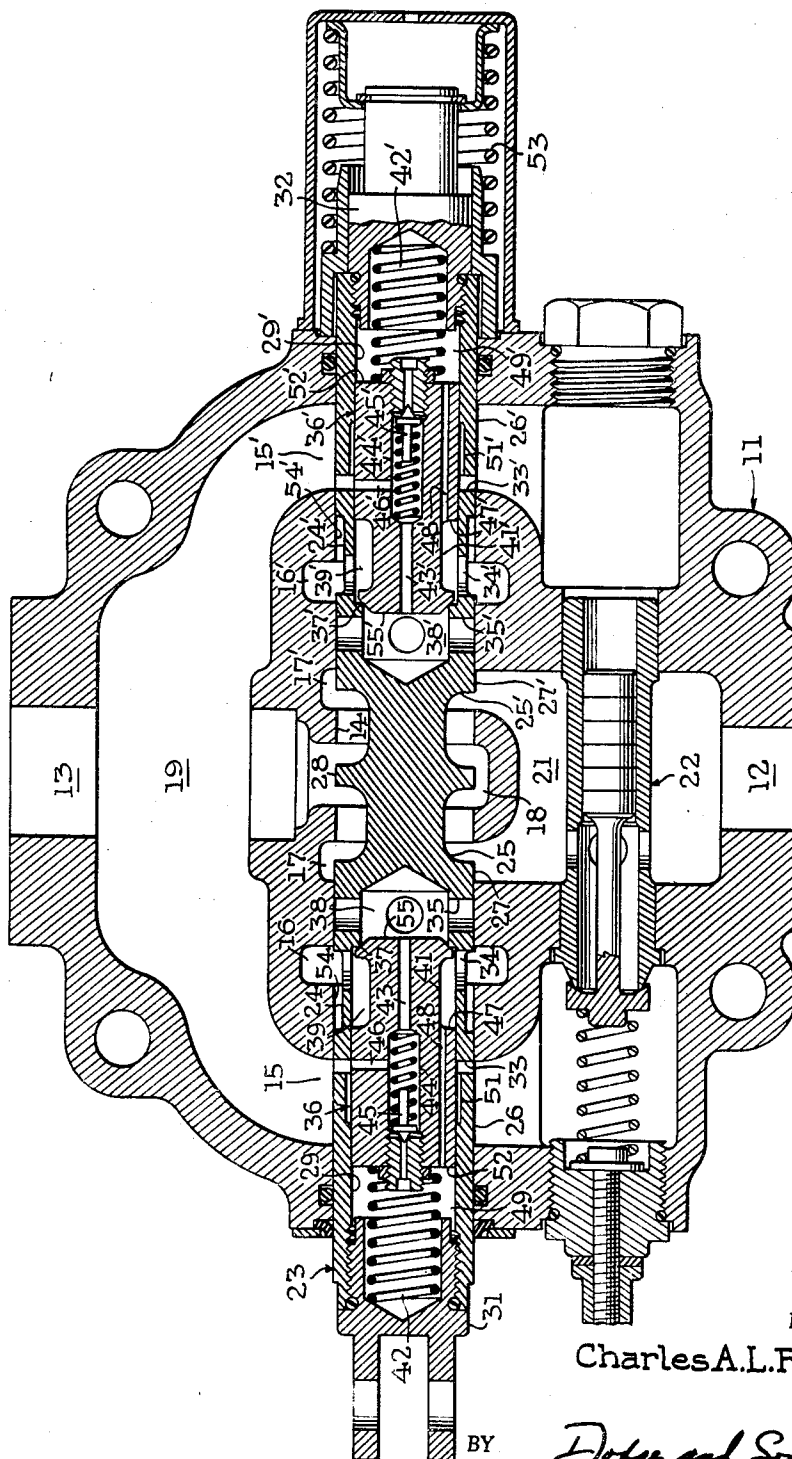


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CONTROL VALVE HAVING A MOVABLE MEMBER CONTAINING
COMBINATION CHECK AND RELIEF VALVE UNIT
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1

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CONTROL VALVE HAVING A MOVABLE MEMBER CONTAINING COMBINATION CHECK AND RELIEF VALVE UNIT

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This invention relates to control valves for fluid pressure motors. Although the invention is useful in control valves for single-acting as well as double-acting motors, it will be described in relation to a control valve of the latter type.

Hydraulic systems for double-acting motors usually include a pump, a sump and a three-position control valve; the control valve having inlet and exhaust ports connected with the pump and sump, respectively, two motor ports connected with opposite sides of the double-acting motor, and a movable valve element which has a first or neutral position in which each motor port is isolated from the other three ports, a second position in which it establishes a supply path connecting the inlet port and one motor port and an exhaust path connecting the other motor port and the exhaust port, and a third position in which the supply and exhaust paths are reversed. Frequently one or both supply paths are provided with a check valve which prevents movement of the controlled motor under the action of external loads at the time the supply path is first established and before the pump has developed operating pressure. Some control valves also include valves for the opposite sides of the controlled motor which relieve the excessive pressures resulting from shock loads imposed on the motor when the movable element is in neutral position and thereby prevent damage to the system components. In prior devices, the check and relief valves were separate units; the check valves being mounted in the movable element of the control valve and the relief valves being mounted in either the housing of the control valve or in housings of their own which are connected into the hydraulic lines leading from the control valve to the double-acting motor. These prior arrangements are relatively expensive to manufacture.

The object of this invention is to provide an improved control valve in which the check and relief valve for each side of the controlled motor are combined in a single unit and this unit is mounted in the movable valve element. This arrangement reduces the cost of manufacture of the control valve and simplifies the fabrication of its housing.

The preferred embodiment of the invention will now be described in detail with reference to the accompanying drawing which is a cross-sectional view of a control valve of the sliding plunger type embodying the invention.

As shown in the drawing, the control valve comprises a housing 11 containing inlet and exhaust ports 12 and 13, respectively, and a through valve bore 14. The bore 14 is encircled by seven spaced annular chambers 15 through 18, and 15' through 17'. Annular chambers 15, 15' and 18 communicate with exhaust port 13 via exhaust manifold 19, and annular chambers 17 and 17' communicate with inlet port 12 via inlet manifold 21. Annular chambers 16 and 16' are connected with motor ports (not shown). A conventional relief valve 22 limits the pressure in inlet manifold 21 by by-passing fluid to the exhaust manifold 19.

Slidable in bore 14 is a valve plunger 23 formed with

2

four spaced grooves 24, 24', 25 and 25' that define five valve lands 26, 26', 27, 27' and 28. Extending inward from opposite ends of the plunger 23 are two axial bores 29 and 29' whose outer ends are closed and sealed by threaded plugs 31 and 32, respectively. The axial bore 29 is intersected by three spaced sets of radial passages 33, 34 and 35 and the axial bore 29' is intersected by three similar sets of passages 33', 34' and 35'. Two combined check and relief valves 36 and 36' are mounted in the bores 29 and 29', respectively. Since these valves are identical, only the valve 36 will be described in detail.

The valve 36 includes a seat 37 which is located between radial passages 34 and 35 and divides axial bore 29 into two chambers 38 and 39. A valve head 41, guided in the bore 29, is biased into sealing engagement with seat 37 by a spring 42. An axial bore 43, having an enlarged central portion 44 that receives a spring-biased relief valve 45, extends through valve head 41. A radial passage 46 connects the enlarged bore portion 44 with the radial passages 33 formed in plunger 23. The valve head 41 is formed with an annular groove that defines a shoulder 47 and is provided with a restricted longitudinal bore 48 which opens through this shoulder and connects the chamber 39 with the chamber 49 at the left end of the valve head. The shoulder 47 is so located relatively to radial passage 46 that when valve head 41 moves to the left to a position in which chamber 39 communicates directly with radial passages 33 across the outer edge of shoulder 47, passage 46 will be in communication with radial passages 33 through the undercut 51.

Operation

When the valve plunger 23 is in its neutral position (shown in the drawing) the hydraulic fluid delivered to inlet port 12 by the pump, passes freely to the sump through inlet manifold 21, annular chambers 17 and 17', plunger grooves 25 and 25', annular chamber 18, exhaust manifold 19, and exhaust port 13. The pressure in that side of the double-acting motor which is connected with annular chamber 16 is transmitted to chamber 49 via radial passages 34, chamber 39, and longitudinal passage 48, and under normal conditions this pressure is insufficient to unseat relief valve 45. Because of this, the pressures in chambers 39 and 49 are equal. Since the area of the outer end face 52 of valve head 41 is greater than the area of shoulder 47, the net pressure force acting on these surfaces together with the force developed by spring 42 maintains valve head 41 in sealing engagement with its seat 37. As a result, annular chamber 16 and that side of the double-acting motor connected with it, are isolated from the other side of the double-acting motor and from the inlet and exhaust ports 12 and 13. For the same reasons, valve head 41' is in sealing engagement with its seat 37' and the opposite side of the double-acting motor (which is connected with annular chamber 16') is isolated.

If the double-acting motor is now subjected to an excessive shock load which produces a rise in pressure in annular chamber 16, relief valve 45 will open and permit fluid to flow from annular chamber 16 to exhaust port 13 through radial passages 34, chamber 39, longitudinal bore 48, chamber 49, bore 43, radial passages 46 and 33, annular chamber 15, and exhaust manifold 19. Since longitudinal bore 48 is restricted, this flow of fluid creates a pressure unbalance between chambers 39 and 49 which produces a net pressure force on valve head 41 urging it to the left against the bias of spring 42 to a position in which chamber 39 communicates directly with radial passages 33 across the outer edge of shoulder 47. This action permits a much larger relief flow from annular chamber 16 to exhaust port 13 and reduces the peak and the duration of the shock pressure. When the

3

shock pressure has been relieved, relief valve 45 closes thereby interrupting the pilot flow from chamber 49 to exhaust port 13 through radial passage 46 and again equalizing the pressures acting on shoulder 47 and outer end face 52. Spring 42 and the net pressure force developed by face 52 and shoulder 47 now move valve head 41 into sealing engagement with seat 37.

A shock load in the opposite direction, i.e., one which produces a rise in pressure in annular chamber 16', is relieved in the same manner. In this case, however, it is the combined check and relief valve 36' which opens to afford relief flow.

The double-acting motor is moved in one of its two directions of motion by shifting control valve plunger 23 to the right against the bias of centering spring 53 to its second operative position. In this position, lands 27 and 28 interrupt communication between annular chambers 17 and 17', respectively, and annular chamber 18 (and thus load the pump), and a supply path including inlet manifold 21, annular chamber 17, radial passages 35, axial bore 29, radial passages 34, and annular chamber 16 is established between inlet port 12 and one side of the double-acting motor. Simultaneously an exhaust path comprising annular chamber 16', plunger groove 24', annular chamber 15', and exhaust manifold 19 is established between the other side of the double-acting motor and the exhaust port 13. Annular chamber 16', radial passages 35', chamber 38', axial bore 43', and radial passages 46' and 33' define a parallel exhaust path. This shift of plunger 23 causes the radial passages 33 to be closed by the fixed land 54 between annular chambers 15 and 16, and, therefore, relief valve 45 will remain closed and the pressures in chambers 39 and 49 will remain equal. As a result, the pressure in chamber 38 acting on the inner end face 55 of valve head 41 will shift this member to the left and permit flow through the supply path. In this second position, the combined check and relief valve 36' will remain closed because the pressures in chambers 38', 39' and 49' are equal.

In some cases, the external loads acting on the double-acting motor may be such as to produce a positive pressure in annular chamber 16. The combined check and relief valve 36 prevents release of this pressure when the plunger 23 is shifted to its second position and thus maintains the motor in its current position during the time interval required for the pump to build-up operating pressure in chamber 38.

The double-acting motor is moved in the other of its two directions of motion by shifting the plunger 23 to the third operative position on the left side of neutral. In this position, lands 27' and 28' interrupt communication between inlet and exhaust ports 12 and 13; inlet manifold 21, annular chamber 17', radial passages 35', axial bore 29', radial passages 34' and annular chamber 16' define the supply path leading from inlet port 12 to one side of the double-acting motor; and annular chamber 16, plunger groove 24, annular chamber 15, and exhaust manifold 19, and radial passages 35, chamber 38, axial bore 43, radial passages 46 and 33, and annular chamber 15 define the exhaust paths leading from the other side of the double-acting motor to the exhaust port 13. For the reasons discussed above, the combined check and relief valve in the supply path (in this case valve 36') prevents movement of the double-acting motor under the

4

action of external loads during the time required for the pump to build-up operating pressure and thereafter opens to admit pressure fluid to that motor, and the combined check and relief valve in the exhaust path (in this case valve 36) remains closed.

As stated previously, the drawings and description relate only to a preferred embodiment of the invention. Since many changes can be made in the structure of this embodiment without departing from the inventive concept, the following claims should provide the sole measure of the scope of the invention.

What is claimed is:

1. A control valve having a housing containing a bore intersected by three ports which are spaced apart by two fixed valve lands, there being an inlet port, an exhaust port, and an intermediate outlet port; a valve element movable in the bore to control communication between said ports; first and second chambers formed in the movable valve element; first and second passages extending through the surface of the movable valve element and communicating, respectively, with the first and second chambers; a by-pass valve mounted in the movable valve element and having a seat and a head which is shiftable in opening and closing directions for controlling communication between the first and second chambers; a third chamber formed in the movable valve element; a restricted passage interconnecting the second and third chambers; a pilot passage extending through the surface of the movable valve element and communicating with the third chamber; a relief valve normally preventing flow through the pilot passage; resilient means biasing the by-pass valve head in the closing direction; first and second means responsive, respectively, to the pressures in the first and second chambers and urging the by-pass valve head in the opening direction; and third means responsive to the pressure in the third chamber and urging the by-pass valve head in the closing direction, the parts being so arranged that the movable control valve element has: a first position in which the first passage is closed by the fixed land between the inlet and outlet ports, the second passage communicates with the outlet port, and the pilot passage communicates with the exhaust port; a second position in which the first passage communicates with the inlet port, the second passage communicates with the outlet port, and the land between the exhaust and outlet ports closes the pilot passage; and a third position in which the second passage communicates with the outlet and the exhaust ports.

2. The control valve defined in claim 1 in which a portion of the pilot passage extends through the head of the by-pass valve; and the relief valve is located in that portion of the pilot passage.

3. The control valve defined in claim 1 including a passage connecting the first chamber with that portion of the pilot passage downstream of the relief valve; and in which, in the third position, the first passage communicates with the outlet port and the pilot passage communicates with the exhaust port.

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