

[54] **DIRECTION CONTROL VALVE
EMBODYING A SLEEVE-LIKE PRESSURE
EQUALIZING VALVE ELEMENT**

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137/596; 137/596.14

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[57] **ABSTRACT**

A directional control valve is provided for controlling the extension and retraction of a two-way hydraulic motor of the type including a piston rod having a piston secured to one end thereof and reciprocably received within a cylinder. The control valve includes a sleeve-like pressure-equalizing valve element having its opposite ends respectively subjected to system pressure and to the pressure at that port which is to be exhausted by actuation of the valve, the valve element being responsive to these pressures to prevent pressure oil from being transmitted to the cylinder at one side of the piston unless the pressure exhausting from the cylinder at the other side of the piston is at or below the system pressure.

3 Claims, 2 Drawing Figures

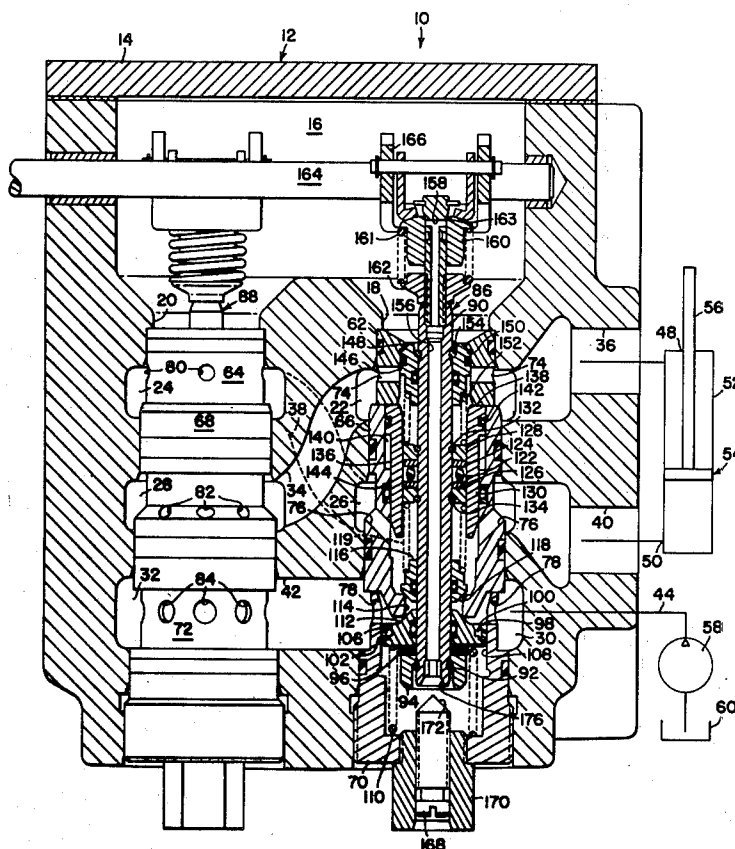


FIG. 1

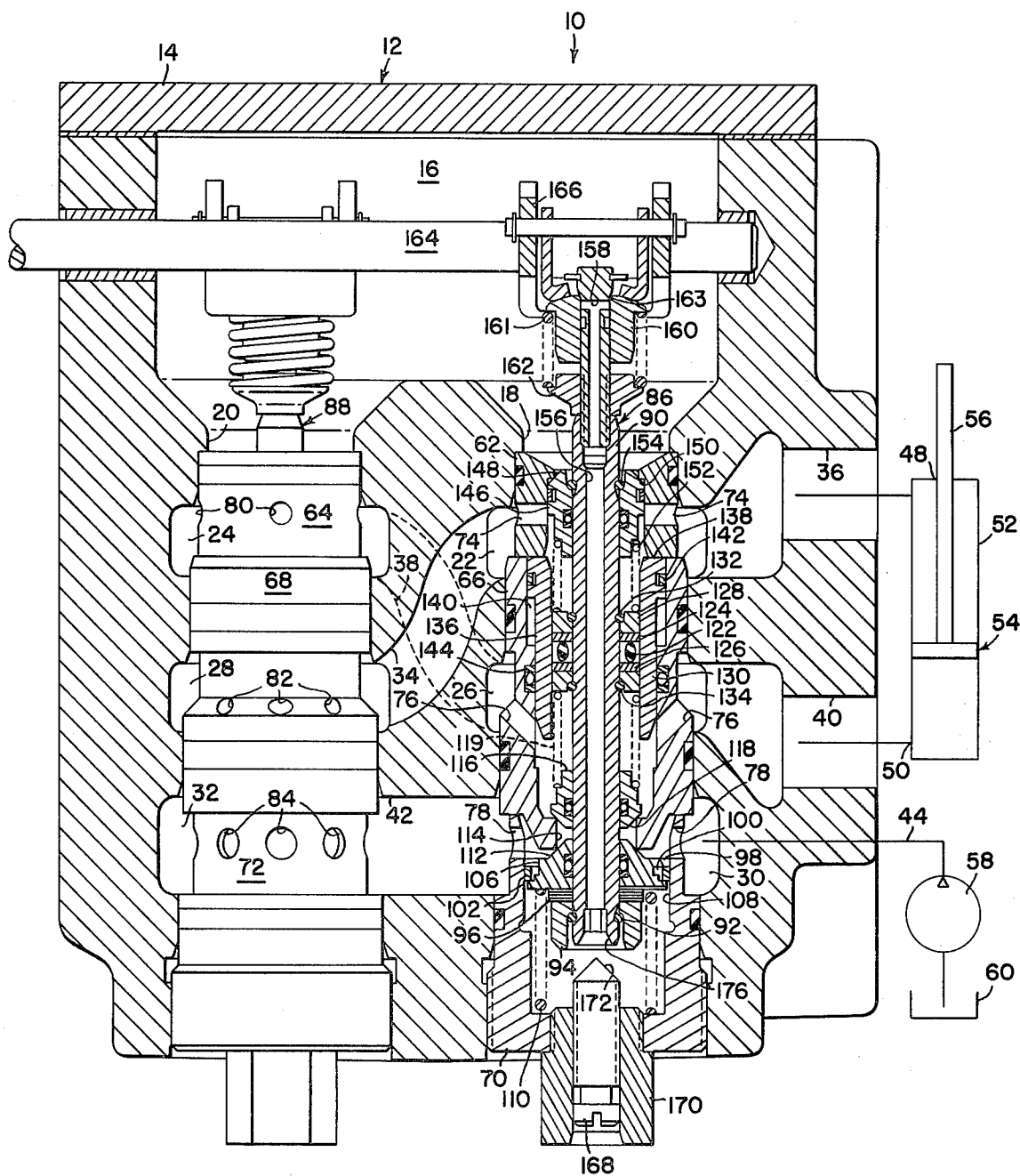
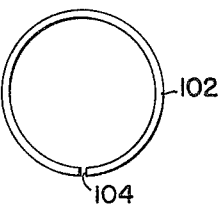


FIG. 2



DIRECTION CONTROL VALVE EMBODYING A SLEEVE-LIKE PRESSURE EQUALIZING VALVE ELEMENT

BACKGROUND OF THE INVENTION

The present invention relates to a direction control valve for controlling the flow of fluid to and from the opposite work ports of a double-acting hydraulic motor.

To maintain a hydraulically tight system, many direction control valves are constructed such that system pressure is connected to one work port of the motor before the other work port thereof is connected to exhaust or sump. Many times this can result in a pressure intensification such as when the pressure is applied to the head end of a motor cylinder before the rod end of the cylinder is connected to return or sump, the intensification being an amount determined by the ratio of the head to rod end piston areas of the cylinder. Pressure intensification can also be caused by the cylinder being preloaded as is the case when a load is being lifted thereby. Such pressure intensification is undesirable since manufacturing tolerances of various elements in the hydraulic system as well as leakage preventing seals must be designed to prevent leakage at these higher pressures.

SUMMARY OF THE INVENTION

According to the present invention there is provided a novel direction control valve for controlling the flow of fluid to and from a two-way, extensible and retractable hydraulic motor.

A broad object of the invention is to provide a control valve which includes means for preventing the connection of system pressure to one end of such a hydraulic motor until the pressure at the other end of the cylinder is at or below system pressure. A more specific object is to provide a direction control valve which includes a sleeve-like valve element having its opposite ends exposed to system pressure and the pressure at a first work port of the hydraulic motor when the control valve is being actuated to supply system pressure to a second work port of the motor, the sleeve-like valve element being responsive to a pressure differential at its opposite ends to block the flow of fluid to the second work port of the motor when the pressure at the first work port is above the system pressure.

Still a more specific object is to provide a sleeve-like valve element as described above which is shaped and mounted such that it cooperates with the valve bore to define means for dampening the movement of the sleeve-like valve element caused by different pressures acting on the opposite ends thereof.

These and other objects will become apparent from the ensuing description and the appended drawing.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a mixed sectional and schematic view showing the control valve of the present invention in longitudinal cross section and schematically representing the connection of the control valve with a source of fluid pressure and a fluid motor.

FIG. 2 is a partial top plan view of the sealing ring carried by the pressure equalizing sleeve-like element.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, therein is shown a fluid system embodying a direction control valve constructed according to the principles of the present invention, the fluid system being indicated in its entirety by the reference numeral 10. The fluid system 10 includes a direction control valve 12 comprising a valve body 14 having a cavity in its upper portion which defines a reservoir 16. Extending vertically in the valve body and having upper ends opening into the reservoir 16 are substantially identical right and left bores 18 and 20, respectively. The bores 18 and 20 respectively include top, intermediate and bottom annular recesses 22 and 24, 26 and 28 and 30 and 32, respectively. The top annular recess 22 of the right bore and the intermediate annular recess 28 of the left bore are interconnected by a cross-passage 34, the annular recess 22 further being connected to an upper control port 36 which extends to the outer surface of the valve body 14. The top annular recess 24 of the left bore 20 is connected to the intermediate recess 26 of the right bore 18 through means of a cross-passage 38, the intermediate recess 26 also being connected to a lower control port 40 which extends to the outer surface of the valve body 14. The bottom annular recesses 30 and 32 of the right and left bores 18 and 20 are interconnected by a passage 42, the annular recess 18 also being connected to a pressure inlet port shown schematically at 44. The upper and lower control ports 36 and 40 are connected to first and second work ports 48 and 50 respectively located adjacent the opposite ends of a cylinder 52 forming a part of an extensible and retractable hydraulic motor 54. Mounted for reciprocation in the cylinder between the work ports thereof is the piston of a piston and piston rod assembly 56 oriented such that the rod thereof projects through that end of the cylinder which is adjacent to the first work port 48. A hydraulic pump 58 has inlet and outlet ports respectively connected to a reservoir 60 and the pressure inlet port 44. Respectively tightly fitted in end-to-end relationship in the right and left bores 18 and 20 are top sleeves 62 and 64, intermediate sleeves 66 and 68 and bottom sleeves 70 and 72, respectively. The sleeves 62, 66 and 70 provided in the right bore 18 respectively have sets of ports 74, 76 and 78 which establish fluid communication between the interiors of the respective sleeves and the top intermediate and bottom annular recesses 22, 26 and 30, respectively. Similarly, the top, intermediate and bottom sleeves 64, 68 and 72, respectively provided in the left bore 20 have respective sets of ports 80, 82 and 84 extending through the walls thereof which establish fluid communication between the interiors thereof and the top, intermediate and bottom annular recesses 24, 28 and 32. The right and left bores 18 and 20 and the respective sleeves located therein thus cooperate to define respective right and left valve bore means.

Respectively axially disposed in the right and left bores 18 and 20 are identical right and left valve assemblies 86 and 88, respectively. Since the valve assemblies 86 and 88 are identical, much of the detailed description of the left valve assembly is omitted for the sake of brevity. Resuming then with the description of the right valve assembly 86, it includes a valve stem 90 having a cylindrical portion disposed axially within the bore 18. Carried adjacent the lower end of the valve

stem 90 is a snap ring 92 which serves to prevent a retaining collar 94 from slipping off the bottom of the valve stem. Supported by the upper surface of the retaining collar 94 are a plurality of shims 96 which serve to time the opening and closing of valve elements carried by the valve stem in a manner to be described below. Slidably mounted on the valve stem 90 above the shims 96 is a piston-like poppet valve element 98. The valve element 98 is dimensioned for slidably engaging the inner wall surface of the bottom sleeve 70 and, for the purpose of preventing leakage across the valve element 98, it is provided with an annular groove 100 in which is located a sealing ring 102 which is of a split type having a small gap 104 located between ends thereof. Only that peripheral portion of the valve element 98 which is above the sealing ring is in sliding engagement with the bottom sleeve 70, and it is provided with an opening 106 leading to the annular groove 100. The peripheral portion of the valve element 98 which is below the sealing ring 102 is spaced slightly from the inner wall, as indicated at 108, the radial space thus defined being less than the radial thickness of the sealing ring 102. Thus, a restricted fluid passage is provided across the valve element 98 and is defined by the opening 106, the annular groove 100, the gap between the ends of the sealing ring 102 and the clearance space 108. In the neutral condition of the valve shown, the fluid pressure at the opposite sides of the valve element 98 is equalized; however, the axially projected area at the bottom of the element 98 which is exposed to this pressure is larger than the axially projected area at the top of the element resulting on a net upward force acting on the element. This force acts together with a compression coil spring 110 mounted between a shoulder defined by a bottom portion of the bottom sleeve 70 and the bottom surface of the valve element 98 to urge the latter upwardly to bring an upwardly facing conical seating surface 112 thereof into seating engagement with a valve seat defined by a lower edge of an opening 114 located in a bottom portion of the intermediate sleeve 66. Slidably mounted on the valve stem 90 at the opposite end of the opening 114 from the valve element 98 is a load check valve element 116 which has a downwardly facing conical seating surface 118 biased into engagement with the upper end of the opening 114 through means of a coil compression spring 119 compressed between the check valve element 116 and a seal arrangement fixed to the valve stem.

The seal arrangement 120 includes a resilient O-ring 122 which is loosely fitted about the valve stem 90 and located between upper and lower washer-like elements 124 and 126 which are respectively held in place by upper and lower collars 128 and 130, respectively, the collars in turn being held in place by upper and lower snap rings 132 and 134, respectively. The outer surface defined by the seal arrangement is cylindrical and is spaced radially inwardly from the inner wall of the intermediate sleeve 66. Mounted for reciprocation in the space thus defined between the seal arrangement and the intermediate sleeve 66 is a sleeve-like pressure equalizing valve element 136. The inside diameter of the upper portion of the intermediate sleeve 66 is larger than the inside diameter of the lower portion of the sleeve and the valve element 126 has an enlarged upper end 138 sized for engaging the upper portion of the sleeve. When the pressure equalizing valve element 136 is in a normal upper open position as illustrated, an

annular space 140 is present beneath the enlarged upper end 138 of the valve element. While not discernible from the drawing, the upper end 138 of the valve element 136 is dimensioned such that there is sufficient clearance between it and the inner wall of the sleeve 66 to permit the flow of fluid to and from the space 140. In order to control this flow of fluid, the enlarged upper end 138 of the valve element 136 is provided with an annular groove in which is located a sealing ring 142 which is similar to the above-described sealing ring 102 in that it is split and has a gap between opposite ends thereof. The gap thus serves to meter fluid to and from the annular space 140 which expands and retracts during upward and downward movement of the pressure equalizing valve element 136. A fluid tight seal means 144 is mounted in the sleeve 66 below the space 140 and engages the lower portion of the valve element 136. The pressure equalizing valve element 136 is dimensioned such relative to the ports 76 of the intermediate sleeve 66 that when the pressure acting on the top end of the sleeve is greater than that acting upon the bottom end, the sleeve will shift downwardly and block the ports 76. It is to be noted that the respective effective areas of the top and bottom of the pressure equalizing valve element 136 which are exposed to fluid pressure are the same and that the valve element will shift downwardly only when pressure acting on the top thereof is greater than system pressure.

Flow between the first work port 48 of the hydraulic motor 54 is controlled through means of a poppet valve element 146. The valve element 146 includes an upwardly facing conical seating 148 disposed for engagement with a valve seat 150 defined by a shoulder at the open upper end of the top sleeve 62. For the purpose of normally maintaining the poppet valve element 146 against the valve seat 150 there is provided a coil compression spring 152 which acts between the lower end of the valve element 146 and the upper collar 128 of the seal arrangement 120. So that the poppet valve element 126 will be unseated by downward movement of the valve stem 90, a snap ring 154 is carried by the valve stem and is disposed for engaging the valve element 146.

Downward shifting movement of the valve stem 90 is accomplished by imposing a pressure drop across the piston-like poppet valve element 98 which results in downward shifting movement of the valve element 98 and hence downward movement of the valve stem. For the purpose of initiating flow across the valve element 98 the valve stem 90 is provided with a central passage 156 having its lower end in fluid communication with the space beneath the valve element 98 and having cross ports 158, at its upper end, which extend through the outer surface of the valve stem 90. When the valve is in the neutral condition as illustrated, a collar 160 which is shiftably mounted on the upper end of the valve stem 90 is held in blocking relationship to the cross ports 158 by means of a coil compression spring 161 which acts between a shoulder on the collar and a shoulder on an element 162 located below the collar and forming part of the valve stem. Leakage between the collar 160 and stem 90 is prevented by a poppet surface 163 formed on the upper portion of the stem which is normally seated against the top inner portion of the collar 160. For the purpose of selectively shifting the collar 160 downwardly so as to place the cross ports 158 in fluid communication with the reservoir 16, there

is provided a control rod 164 which extends into the reservoir 16 and is rotatably mounted in the walls of the valve body 14. The control rod 164 is provided with an arm 166 which engages the top of the collar and is operative upon clockwise rotation of the control rod, as viewed from its left end, to move the collar downwardly. It is here noted that rotation of the control rod 164 in the counterclockwise direction will initiate pilot operation of the left valve assembly 88 in a manner similar to that of the operation of the right valve assembly 86, which operation is to be set forth below.

Once the control rod 164 is rotated clockwise so as to cause the collar 160 to be shifted downwardly to unseat the poppet surface 163 and to uncover the cross ports 158, the space below the piston-like poppet valve element 98 will be connected to the reservoir through the central passage 156 and the cross ports 158 and flow will occur across the valve element 98 as permitted by the gap 104 between the ends of the sealing ring 102. Since the flow across the valve element 98 is restricted, a pressure drop will occur thereacross resulting in the valve element being pressure-shifted downwardly against the force of the coil compression spring 110. Downward movement of the valve element 98 will be transferred to the valve stem 90 and to the upper poppet valve element 146 through means of the snap ring 154. When the piston-like valve element 98 moves downwardly, the conical seating surface 112 thereof will become unseated from the lower edge of the opening 114 to thus place the bottom end of the load check valve 116 in fluid communication with a system pressure supplied by the pump 58. When this occurs, the pressure will unseat the check valve 116. If the pressure at the first work port 48 of the motor 54 is equal to or less than the system pressure, the sleeve-like pressure equalizing valve element 136 will remain in its upper open position shown in FIG. 1 to thus permit fluid pressure to enter the second work port 50 of the motor 54 by way of the port 76 of the intermediate sleeve 66.

The speed that the piston and piston rod assembly 56 of the motor 54 will be moved during actuation is controlled by controlling the downward displacement of the valve stem 90 to thus control the amount of separation of the respective seating surfaces 112 and 148 of the piston-like poppet valve element 98 and the poppet valve element 146 from their respective seats. This control is accomplished through means of an axially adjustable stop 168 in the form of a special screw threaded in an end plug 170 which is in turn threaded in the bottom of the bottom sleeve 70. The upper end of the stop 168 is provided with a conical surface 172 which is disposed for moving closely adjacent to a conically shaped surface 176 forming the lower end of the central passage 156. The conically shaped surface 176 is such that when the conical end 172 of the stop 168 is in close proximity thereto, flow between the conical end and the conical surface is restricted to such an extent that forces acting axially on the valve stem 90 are brought into equilibrium. Thus, it will be appreciated that since the left valve assembly 88 is similar to the right valve assembly 86 and controls the flow of pressure fluid to the first work port 48 of the motor 54, that the speed of flow of fluid to opposite ends of the motor 54 may be regulated so as to be at different speeds.

The operation of the control valve 12 is briefly summarized as follows. Assuming that the control valve 12

is in its neutral condition, as illustrated in FIG. 1, the collar 160 will be in its upper position wherein it prevents the flow of fluid from the space at the bottom of the piston-like poppet valve element 98 to the reservoir 16 by way of the central passage 156. The pressure at the opposite sides of the valve element 98 will thus be balanced and this pressure acting on the differential area of the element 98 and the spring 110 will maintain the valve element 98 firmly seated. If it is then desired to cause extension of the motor 54, the operator will rotate the control rod 154 in the clockwise direction, as viewed from the left end of the control rod. The collar 160 will thus be shifted downwardly on the valve stem 90 to the extent that the cross ports 158 are uncovered, it being noted that the spring 161 against which the collar acts is weaker than the forces normally keeping the valve element 98 seated. Once the cross ports 158 are uncovered, the high pressure fluid supplied by the pump 58 flows through the piston-like poppet valve element 98 by way of the opening 106, the annular groove 100, the gap 104 between the ends of the sealing ring 102 and the clearance 108 between the valve element 98 and the wall of the bottom sleeve 70. It is here noted that the movement of the sealing ring 102 against the wall of the bottom sleeve 70 will act to keep contaminants in the hydraulic fluid from accumulating in the gap. The flow of fluid across the piston-like poppet valve element 98 will immediately result in a pressure drop across the valve element which results in the latter being moved downwardly. If the control rod 154 has been moved an amount commanding maximum flow to the motor 54, the valve stem 90 will move downwardly until the conical surface 116 at its lower end moves towards the upper end of the stop 168 until the flow between the stop and surface is restricted to such an extent that the axial forces acting on the stem become equalized. If the control rod 154 has been moved to some intermediate position commanding less than maximum flow to the motor 54, the stem 90 will shift downwardly until the poppet surface 163, adjacent the upper end thereof, restricts the flow occurring through the top of the collar 160 to the extent that the axial forces acting on the stem 90 become balanced. Downward movement of the poppet valve element 98 will of course result in the same becoming unseated and will effect the unseating of the poppet valve element 146. In order to maintain a fluid tight system, the opening of the poppet valve element 146 is timed relative to the opening of the piston-like poppet valve element 98 so as to open just after the valve element has opened. This timing is accomplished through means of the shims 96, the numbers of which can be increased or decreased so as to accomplish the timing desired.

Assuming a condition when the piston-like poppet valve element 98 has just opened and the poppet valve element 146 has not yet opened or has opened only slightly, pressure fluid will move the load check valve 116 off its seat to thus connect the pump 58 to the second work port 50 of the motor 54 by way of the port 76 of the intermediate sleeve 66. Due to the area differential across the piston and piston rod assembly 56 and due to the valve element 146 not being open or only slightly open, the pressure on the upper side of the piston will be intensified thus creating a pressure unbalance across the sleeve-like pressure equalizing valve element 136. The greater pressure acting on the top of the pressure equalizing valve element 136 will cause it

to shift downwardly to block the ports 76 and thus acts to block the system pressure from the motor 54. As the piston-like poppet valve element 98 moves farther downwardly, the poppet valve element 146 will be unseated to thus permit fluid to exhaust from the first work port 48 of the motor 54 to the reservoir 60. Once the fluid begins to exhaust, its pressure will drop and the pressure equalizing valve element 136 will be returned to its upper, open position, as shown, to thus permit system pressure to once again enter the second work port 50 of the motor 54. It is to be noted that the movement of the pressure equalizing valve element 136 in either the upward or downward direction is damped due to the fact that the space 140 below the enlarged upper end 138 of the valve element is connected in fluid communication with the first work port 48 of the motor 54 by a restricted passage comprising the clearance space between the enlarged upper end 138 and the inside wall surface of the intermediate sleeve 66 and the end gap (not shown) between the opposite ends of the sealing ring 142.

Actuation of the motor 44 to cause it to retract is affected in a manner similar to that just described by actuating the left valve assembly 88 and for the sake of brevity no discussion is given of this operation. Suffice it to say that the maximum flow of fluid to whichever end of the motor that which is being pressurized is controlled through means of the adjustable stop 168 and the corresponding stop of the left valve assembly 88 which stops limit the distance that the poppet valves may be separated from their seats.

During operation, flow reversals from the opposite ends of the extensible and retractable motor 54 due to loads thereon are prevented through means of the load check valve 116 in the right valve assembly 86 and its counterpart in the left valve assembly 88.

We claim:

1. A hydraulic direction control valve for controlling the flow of fluid to and away from an extensible and retractable hydraulic motor, comprising: a valve bore means; serially arranged first, second, third and fourth fluid passage means connected to said valve bore means at axially spaced locations and being respectively adapted for connection to a reservoir, to a first motor work port, to a second motor work port and to a source of fluid pressure; said bore means including first and second valve engageable surface means respectively located between the first and second passage means and between the third and fourth passage means; a valve stem axially shiftably mounted in said valve bore means and having first and second valve means mounted thereon for movement therewith between a neutral position wherein the first and second valve means are in sealing engagement with said first and second valve engageable surface means to respectively present the flow of fluid between the first and second passage means and between the third and fourth passage means, and an operative position wherein the first and second valve means are respectively unseated from the first and second valve engageable surface means for respectively establishing fluid communication between the first and second passage means and between the third and fourth passage means; partition means in said bore means between said second and third passage means for blocking fluid communication therebetween and including a third

valve means in the form of an annular sleeve-like member axially shiftably mounted on said valve stem and slidably engaged with the bore means for movement between a normal position wherein opposite first and second ends thereof are respectively in fluid communication with said second and third fluid passage means and a closed position wherein said first end remains in fluid communication with the second fluid passage means while surface means adjacent the second end are in blocking relationship to the third passage means; and said third valve means being dimensioned and mounted such that equal fluid pressures acting on the opposite ends of the third valve means will develop balancing pressure forces on the third valve means whereby when the pressure at said second fluid passage is greater than the pressure at said third fluid passage, the third valve means will shift to said closed position.

2. The direction control valve defined in claim 1 wherein said first end of said third valve means is enlarged, and said bore means including an enlarged section for slidably accommodating the enlarged first end of the third valve means throughout the shifting movement of the third valve means; said bore means cooperating with said enlarged first end to define an expansible and collapsible annular space; and restricted fluid passage means connecting the second fluid passage means in fluid communication with said annular space whereby the movement of said third valve means is damped.

3. A direction control valve for an extensible and retractable hydraulic motor of the type including a cylinder having a piston and rod assembly reciprocally mounted therein for movement between first and second work ports in the cylinder, the control valve comprising: a valve body; a valve bore in said body; a pressure fluid inlet in said body opening into said bore and being adapted for connection to a source of fluid pressure; first and second control ports in the body respectively adapted for connection to the first and second work ports of a hydraulic motor and being spaced from each other along and opening into the bore to one side of the inlet port; an exhaust fluid outlet in the body communicating with the bore adjacent the second work port; first and second valve means being axially shiftably mounted in said bore and normally respectively cooperating with first and second surface means of the bore for blocking fluid communication between the inlet port and the first control port and between the exhaust fluid port and the second control port and selectively shiftable for connecting the inlet port to the first control port and for connecting the exhaust port to the second control port; partition means including a third axially shiftable valve means located in the valve bore between the first and second control ports and blocking the flow of fluid therebetween; said third valve means having opposite ends respectively disposed so as to be exposed to the fluid pressure at said fluid inlet and said second control port when said first and second valve means are shifted so as to connect the pressure fluid inlet to the first control port; and the opposite ends of the third valve means being dimensioned such and the third valve means being so disposed relative to the first control port, such that it will shift to block the first control port when the pressure at the second control port is greater than that at the inlet.

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