

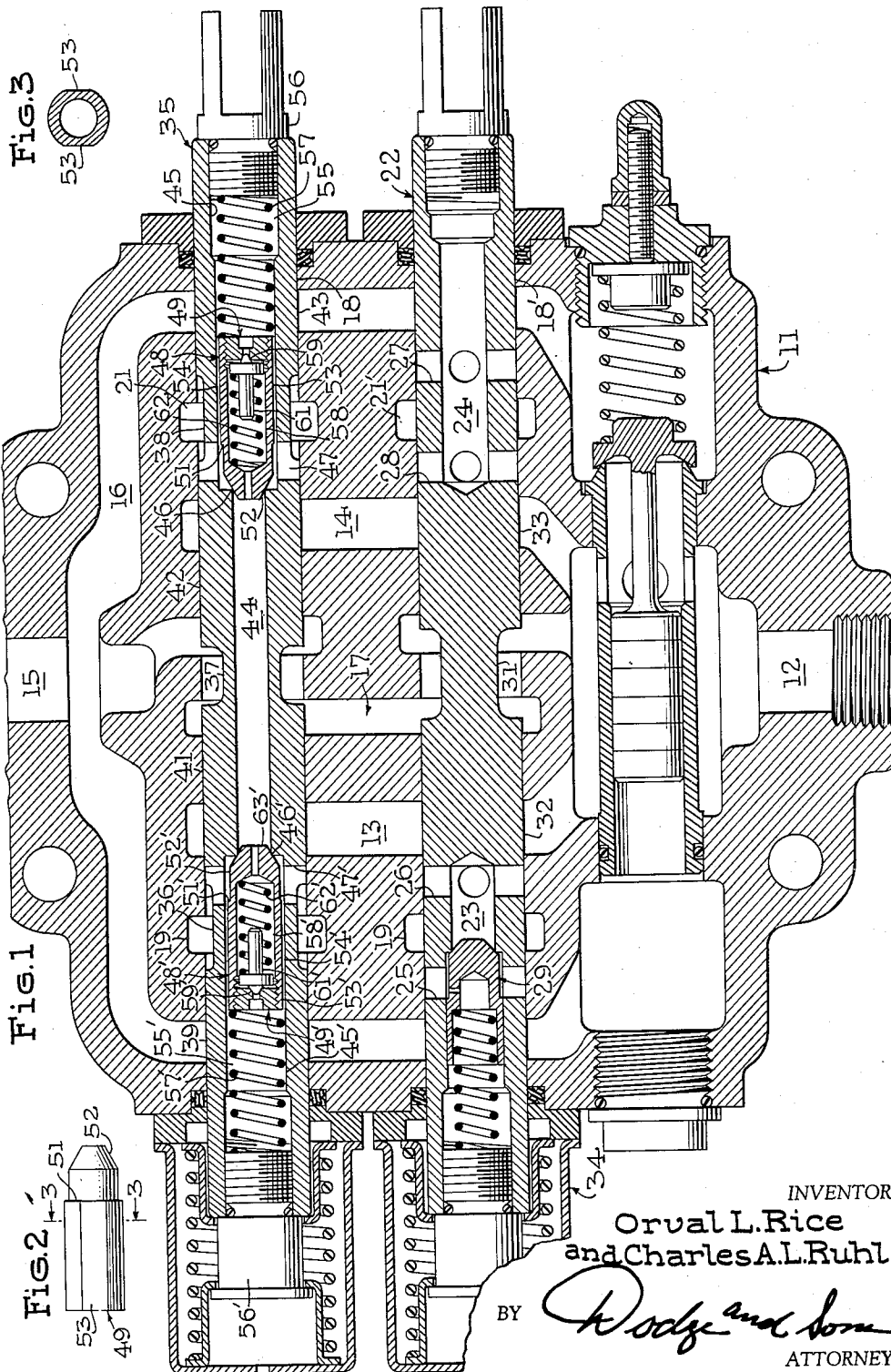
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VALVE

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VALVE

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This invention relates to control valves for hydraulic systems employing double-acting fluid pressure motors.

Systems of this kind generally 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 shiftable plunger which has a neutral position in which each motor port is isolated from the other three ports, a second position in which one motor port is connected with the inlet port while the other is connected with the exhaust port, and a third position in which these motor port connections are reversed. In some systems, such as the power steering systems of motor vehicles, the double-acting motor is subjected to reversible shock loads, when the valve plunger is in its neutral position. In order to protect the system components from the resulting pressure surges, each side of the controlled motor is provided with a relief valve. In those cases where the opposite sides of the double-acting motor are of equal area, the system includes a two-way device which relieves the pressure in each side of the motor by bypassing fluid to the opposite side.

Although these two-way relief devices take many forms, they can be segregated into two categories, namely, those which are mounted in a separate housing which is connected between the hydraulic lines leading from the control valve to the double-acting motor, and those which are mounted in the housing of the control valve itself and are connected with the motor ports by internal passages. Rice application Serial No. 757,602, filed August 27, 1958, now Patent No. 2,934,080, illustrates the first type and Vander Kaay application Serial No. 684,745, filed September 18, 1957, now Patent No. 2,874,682, employs the second. Each of these types possesses certain disadvantages. The separate relief device is expensive to manufacture and is space consuming. The second type, on the other hand, is more economical but it increases the size of the control valve, and it cannot be installed in or removed from an existing system without a major modification or complete replacement of the control valve.

According to the present invention, the two-way relief valve is located within the plunger of the control valve and this plunger is so designed that it is interchangeable with conventional plungers. As a result, the relief device can be added to or deleted from the hydraulic system by simply replacing the plunger and without modifying the porting arrangement in the valve housing. This feature is of particular importance in multiple plunger valves because any plunger can be assigned the task of controlling the motor which is subject to the shock loads. Furthermore, since the relief valve is located in and does not increase the physical size of the plunger, it is economical of space.

In its preferred form, the two-way relief valve comprises two separate valving units, each of the pilot-operated type. This arrangement was chosen because of

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the relatively small amount of space within the plunger and also because it affords well defined cracking points, low pressure rises from cracking to full flow, and good reseating characteristics.

5 The preferred embodiment will now be described in detail with reference to the accompanying drawing, in which:

Fig. 1 is a sectional view of a multi-plunger open-center control valve; one of the plungers embodying the teachings of this invention.

Fig. 2 is an elevation view of the by-pass valve.

Fig. 3 is a sectional view taken on line 3—3 of Fig. 2.

As shown in Fig. 1, the control valve comprises a housing 11 having an inlet port 12 which is connected with supply passages 13 and 14, an exhaust port 15 which is connected with a U-shaped exhaust passage 16, and an unloading passage 17 which extends between exhaust passage 16 and inlet port 12. Extending through the housing are two identical valve bores 18 and 18', each of which is encircled by a pair of spaced annular motor chambers 19, 21 and 19', 21'.

Mounted in valve bore 18' is a conventional hollow valve plunger 22 formed with axial bores 23 and 24 which are intersected by radial passages 25 and 26, and 27 and 28, respectively. Mounted in axial bore 23 is a conventional check valve 29. Intermediate its ends, the valve plunger 22 is formed with an annular groove 31 which defines two spaced lands 32 and 33.

The hollow plunger 22 has three operative positions, namely, a neutral position (shown in the drawing) in which plunger groove 31 interconnects unloading passage 17 and inlet port 12 and lands 32 and 33 isolate motor chambers 19' and 21'; a second position in which land 32 interrupts communication between inlet port 12 and unloading passage 17, radial passages 27 and 28 and axial bore 24 connect motor chamber 21' with exhaust passage 16, and radial passages 25 and 26 and axial bore 23 connect motor chamber 19' with supply passage 13; and a third position in which land 33 interrupts communication between inlet port 12 and unloading passage 17, radial passages 27 and 28 and axial bore 24 connect motor chamber 21' with supply passage 14, and radial passages 25 and 26 and axial bore 23 connect motor chamber 19' with exhaust passage 16. The plunger 22 is biased to the neutral position by a centering spring device 34.

Mounted in valve bore 18 is the improved valve plunger 35 of this invention. This plunger is formed with three spaced annular grooves 36, 37 and 38 which define four valve lands 39, 41, 42 and 43. An axial bore, having a reduced diameter central portion 44 and two enlarged outer portions 45 and 45', is formed in the plunger 35. The junctions between the central portion 44 and the enlarged outer portions define annular valve seats 46, 46'. Radial passages 47 and 47' extend through the plunger 35 adjacent the valve seats 46 and 46' for providing a flow path between motor chambers 21 and 19 and the enlarged outer portions 45 and 45', respectively.

The two-way relief device comprises two identical valving units 48 and 48' which are mounted in the enlarged bore portions 45 and 45', respectively. The unit 48 includes a by-pass valve 49 which reciprocates within bore portion 45 and which carries a reduced diameter portion adjacent its inner end that defines an annular shoulder 51 and a conical valve head 52. Diametrically opposed flats 53 are formed on the outer peripheral surface of the by-pass valve 49 and these flats, together with the surface of bore portion 45, define restricted flow paths 54 which connect the space within bore 45 surrounding the reduced diameter inner end of the by-pass valve with the space 55 between the outer end of this valve and the plug 56 which closes the end of the axial bore in plunger

35. The head 52 of the by-pass valve is biased into sealing engagement with seat 46 by spring 57. Extending through by-pass valve 49 is an axial bore 58 which is provided with an annular valve seat 59 and in which is mounted a poppet-type relief valve 61. A spring 62, reacting between the by-pass valve 49 and the relief valve 61, biases this valve into sealing engagement with seat 59.

The valve plunger 35 has the same three operative positions as valve plunger 22. In its neutral position, the annular groove 37 connects the unloading passage 17 with the exhaust passage 16, and the lands 39 and 41, and 42 and 43 isolate motor chambers 19 and 21, respectively. In the second operative position, which is reached by moving plunger 35 to the right from the neutral position shown in the drawing, the plunger groove 38 connects motor chamber 21 with exhaust passage 16, the plunger groove 36 connects motor chamber 19 with the supply passage 13, and land 41 interrupts communication between the unloading passage 17 and the exhaust passage 16. In the third position, which is on the opposite side of neutral from the second position, plunger groove 36 interconnects motor chamber 19 and exhaust passage 16, plunger groove 38 interconnects supply passage 14 and motor chamber 21, and land 42 interrupts communication between unloading passage 17 and exhaust passage 16.

The faces of shoulders 51 and 51' and the portions of conical heads 52 and 52' located within bore portions 45 and 45', constitute reaction surfaces which are subject to the pressures in these bore portions and which urge the by-pass valves away from their seats 46 and 46'. The outer end faces of the by-pass valves 49 and 49' define reaction surfaces which are subject to the pressures in spaces 55 and 55' and which urge these valves in the opposite direction. During normal operation, the pressures acting on the opposed reaction surfaces of each by-pass valve are equal because of the presence of the restricted passages 54 and 54'. Since the areas of the reaction surfaces on the outer ends of the by-pass valves are greater than the areas of the corresponding surfaces on the inner ends, net pressure forces are developed which aid springs 57 and 57' in holding the by-pass valves on their seats.

If, when plunger 35 is in its neutral position, the double-acting controlled motor, whose opposite sides are connected to motor chambers 19 and 21, is subjected to a shock load which produces a rise in pressure in chamber 21 and a decrease in pressure in chamber 19, the following relief action will take place:

The increased pressure in motor chamber 21 is transmitted to space 55 through radial passages 47 and restricted passages 54. This pressure acts on the end of poppet relief valve 61 and when the force it develops becomes greater than the force of spring 62, this valve is moved away from its seat 59 thereby permitting a pilot flow from space 55 to central bore portion 44. The fluid passing into central portion 44 acts against the end face 63' of by-pass element 48', causing this element to move away from its seat 46' and establish communication between motor chamber 19 and bore portion 44 through plunger groove 36 and radial passages 47'. Since this pilot flow of fluid from chamber 21 to chamber 19 passes through the restricted passages 54, the pressure acting on the reaction surface at the inner end of by-pass valve 49 will become higher than the pressure acting on the reaction surface at the outer end. The pressure differential along by-pass valve 49 will force this valve to the right against spring 57 and cause valve head 52 to move away from seat 46. When this happens, a much larger quantity of fluid can flow from radial passages 47 to central bore portion 44 across seat 46. When the shock pressures have been relieved, poppet relief valve 61 will be moved into engagement with its seat 59 thus interrupting the pilot flow and again equalizing the pres-

sures acting on the inner and outer ends of the by-pass valve 49. Spring 57 and the net pressure force acting on this valve can now move the head 52 into engagement with its seat 46.

5 A shock load in the opposite direction, which produces an increase in pressure in motor chamber 19, will be relieved in the same manner. In this case, however, it is the poppet relief valve 61' which unseats to provide the pilot flow.

10 Since the arrangements of ports and passages which intersect valve bores 18 and 18' are identical, and since the plungers 22 and 35 have the same operative positions, it should be apparent that the two-way relief valve incorporated in the system controlled by plunger 35 can be removed from that system simply by replacing plunger 35 with plunger 22. Similarly, the two-way relief valve can be included in the system controlled by plunger 22 by replacing this plunger with the plunger 35.

15 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.

20 What is claimed is:

1. In a control valve of the type including a housing having an inlet passage, an exhaust passage, and two motor passages, and a movable valve element having a first position in which one motor passage is connected with the inlet passage and the other motor passage is connected with the exhaust passage, a second position in which these motor passage connections are reversed, and a third position in which each motor passage is isolated from the other three passages, the improvement which comprises a two-way relief device mounted in the movable valve element and connected with the two motor passages, said device serving to relieve the pressure in either motor passage by by-passing fluid to the other of said passages.

40 2. In a control valve of the type including a housing having an inlet passage, an exhaust passage, and two motor passages, and a movable valve element having a first position in which one motor passage is connected with the inlet passage and the other motor passage is connected with the exhaust passage, a second position in which these motor passage connections are reversed, and a third position in which each motor passage is isolated from the other three passages, the improvement which comprises a common flow passage formed in the valve member; first main and pilot passages in the valve member for providing parallel flow between one of the motor passages and one end of the common passage; second main and pilot passages in the valve member for providing parallel flow between the other motor passage and the other end of the common passage; a flow restrictor located in each pilot passage; a relief valve located in each pilot passage between the restrictor and the junction with the common passage; a by-pass valve located in each main passage, said valve being shiftable between passage-closing and passage-opening positions; a spring biasing each by-pass valve toward its passage-closing position; a first reaction surface carried by each by-pass valve and subject to the pressure downstream of the flow restrictor in the associated pilot passage for urging the valve toward its passage-closing position; a second reaction surface carried by each by-pass valve and subject to the pressure upstream of the restrictor in the associated pilot passage for shifting the valve toward its passage-opening position; and a third reaction surface carried by each by-pass valve and subject to the pressure in the common passage for shifting the valve toward its passage-opening position.

3. In a control valve of the type including a housing having a valve bore which is intersected by two longitudinally spaced motor chambers and inlet and exhaust chambers, and a reciprocable valve plunger mounted in

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the valve bore and shiftable in opposite directions from a neutral position in which each motor chamber is isolated from the other chambers to reversely connect the motor chambers with the inlet and exhaust chambers, the improvement which comprises an axial bore formed in the plunger and having two outer portions and an intermediate central portion; valve seats, one located at the junction of each outer portion and the central portion and each encircling the bore; walls closing the outer ends of the outer portions of the bore; by-pass valve members, one reciprocable in each of said outer portions of the bore, the inner ends of these members being of reduced diameter and carrying valve heads which cooperate with the seats to control communication between the central and outer portions of the bore; a spring reacting between each of said walls and each by-pass valve member for biasing the heads of these members into sealing engagement with their seats; sets of radial passages extending through the plunger, the passages in one set connecting one motor chamber with one of said outer bore portions in the region of the inner end of the by-pass valve mem-

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ber and the passages of the other set connecting the other motor chamber with the corresponding region of the other of said outer bore portions; restricted passages, one defined by the mating surface of each by-pass valve member and the associated outer bore portion and each interconnecting the space between the outer end of the valve member and the wall with the space surrounding the inner end of the valve member; an axial bore extending through each by-pass valve member; and a relief valve located in each axial bore and responsive to the pressure in the space between the outer end of the member and the wall for providing flow between this space and the central portion when that pressure exceeds a predetermined value.

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