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R. B. OLEN

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RELIEF-CHECK ASSEMBLY FOR DIRECTIONAL CONTROL VALVE

Original Filed Jan. 6, 1965

2 Sheets-Sheet 1

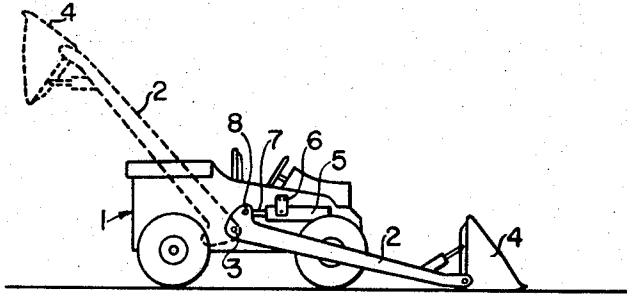


FIG 1

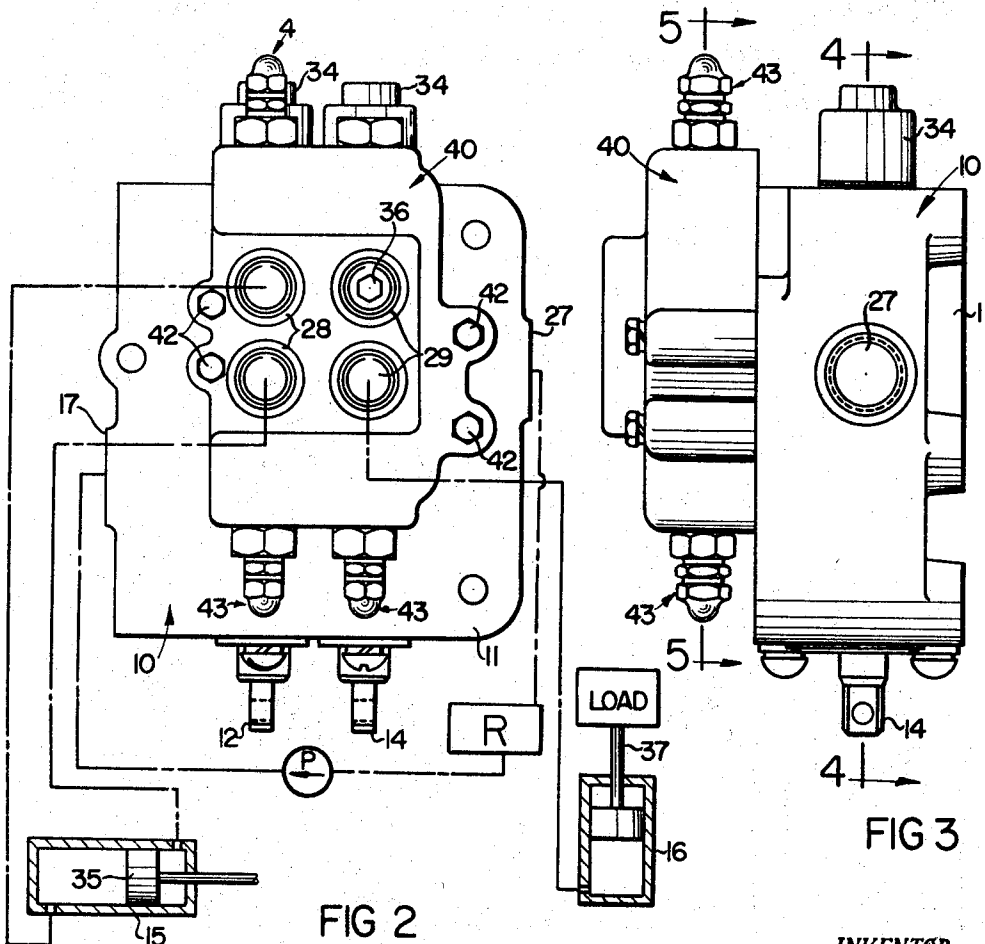


FIG 2

FIG 3

INVENTOR.

ROBERT B. OLEN

BY

Oberlin, Maky & Donnelly

ATTORNEYS

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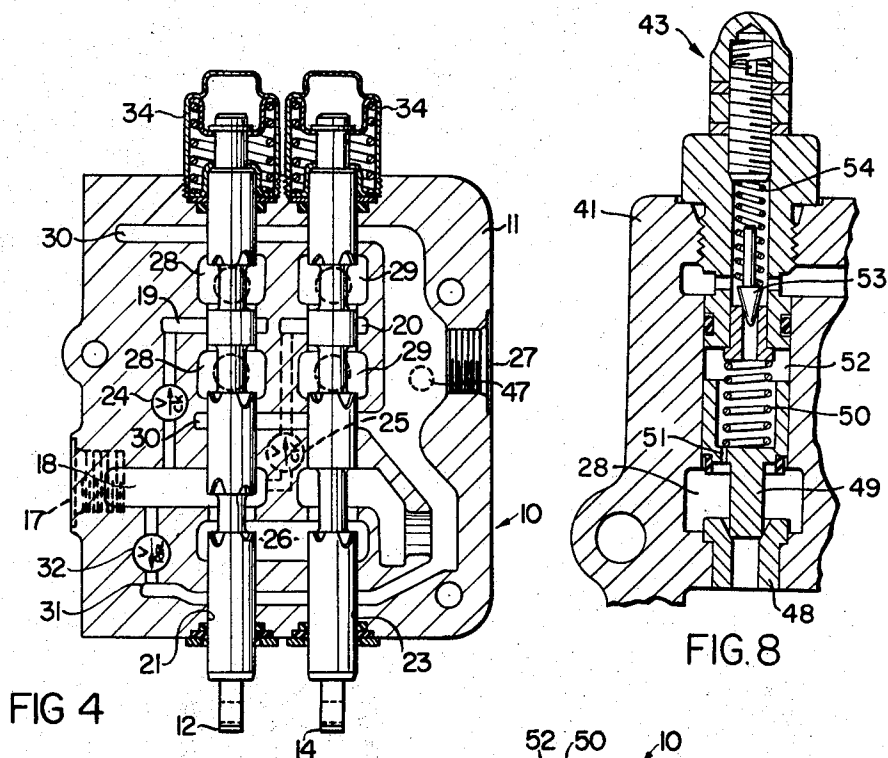
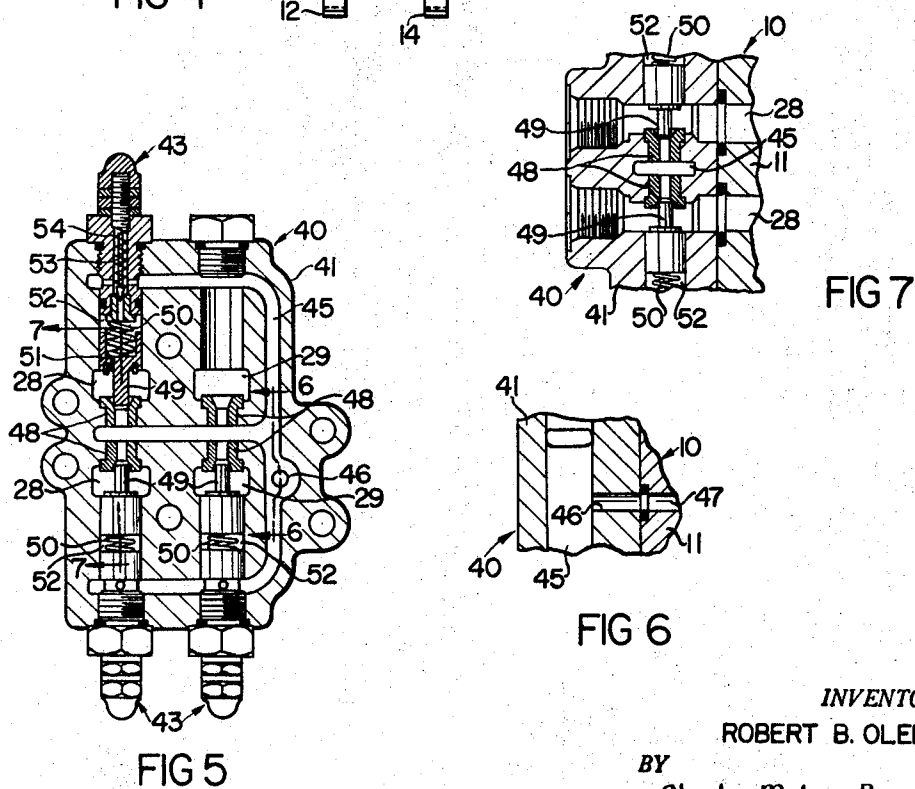


FIG 6

FIG 7

FIG 5

INVENTOR.
ROBERT B. OLEN
BY
Oberlin, Maky & Donnelly
ATTORNEYS

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RELIEF-CHECK ASSEMBLY FOR DIRECTIONAL CONTROL VALVE

Robert B. Olen, Akron, Ohio, assignor to Parker-Hannifin Corporation, Cleveland, Ohio, a corporation of Ohio

Continuation of application Ser. No. 426,468, Jan. 6, 1965, which is a continuation of application Ser. No. 114,471, June 2, 1961. This application July 20, 1966, Ser. No. 568,701

9 Claims. (Cl. 137—596)

The present invention is a continuation of applicant's prior copending application Ser. No. 426,468, filed Jan. 6, 1965, now abandoned, which is a continuation of application Ser. No. 114,471, filed June 2, 1961, now abandoned, and relates generally as indicated to a relief-check assembly for a directional control valve and more particularly to such assembly which may be made up as a separate unit for attachment to a conventional type of directional control valve.

In hydraulic systems wherein the hydraulic motors handle heavy loads, there are instances in which, when actuation of the motor is arrested, the inertia of the load will build up a high shock pressure in the system between the hydraulic motor and the closed directional control valve. Continued movement of the load under such conditions also causes cavitation in the fluid circuit between the hydraulic motor and the closed directional control valve. Moreover, there may be occasions in which the load changes from positive to negative whereby it may tend to move faster than the system pump can supply fluid thereto in which case cavitation may result in the inlet system and, furthermore, excessive pressure may build up in the fluid return system.

Accordingly, it is a principal object of this invention to provide a relief-check assembly which is disposed between the directional control valve and the fluid motor to preclude cavitation or excessive pressure build-up in the system, irrespective of whether such conditions may be caused by the directional control valve being shifted from an operating position to neutral position blocking the motor ports, or by load shifting while the directional control valve is in an operating position.

Other objects and advantages of the present invention will become apparent as the following description proceeds.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter fully described and particularly pointed out in the claims, the following description and the annexed drawings setting forth in detail a certain illustrative embodiment of the invention, this being indicative, however, of but one of the various ways in which the principle of the invention may be employed.

In said annexed drawings:

FIG. 1 is a side elevation view of a hydraulically operated overhead shovel loader in which the load on the boom actuating cylinder shifts from positive to negative as the boom swings from the one side of vertical position to the other side;

FIG. 2 is a front elevation view of a two-spool directional control valve having mounted thereon the relief-check assembly constituting the present invention;

FIG. 3 is a side elevation view as viewed from the right-hand side of FIG. 2;

FIG. 4 is a cross-section view through the directional control valve assembly taken substantially along the line 4—4, FIG. 3;

FIG. 5 is a cross-section view through the relief-check assembly taken substantially along the line 5—5, FIG. 3;

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FIG. 6 is a fragmentary detail cross-section view taken substantially along the line 6—6, FIG. 5;

FIG. 7 is a fragmentary cross-section view through a pair of relief-check assemblies as associated with one of the directional control valves, such section having been taken substantially along the line 7—7, FIG. 5; and

FIG. 8 is an enlarged fragmentary detailed view of the upper relief-check assembly of FIG. 5.

Referring now more particularly to the drawings, and first to FIG. 1, there is shown therein an overhead shovel loader 1 having a boom assembly 2 pivotally connected thereto at 3, there being a bucket or scoop 4 mounted at the end of said boom assembly 2. The boom assembly 2 is adapted to be swung from the full line position to the dotted line position as by means of the hydraulic cylinder 5 which is mounted on a trunnion 6 and having its piston rod 7 pivotally connected to the boom assembly at 8. It can be seen that when the bucket 4 is filled and swung upward, the center of gravity of the boom assembly 2 and the load in the bucket 4 will pass over to the left side of the boom pivot 3, whereafter the boom weight and load will change from positive to negative and thereby tend to pull the piston in the cylinder 5 toward the left and perhaps at a rate which exceeds the capacity of the engine driven pump (not shown). Similarly, the inertia of the load in shifting to negative may build up a high pressure in the return system. FIG. 1 is, of course, merely an illustrative example of a case wherein the load moved by a fluid motor may shift from positive to negative. Moreover, in FIG. 1 when the loaded bucket 4 is lowered, and the directional control valve for the cylinder 5 is moved to neutral position, the inertia of the load may build up a high shock pressure in the fluid which is then trapped between the discharge end of the cylinder 5 and the now closed directional control valve. Likewise, such inertia and continued movement of the load may cause a partial vacuum to be formed in the intake side of the cylinder 5 which also is blocked by the closed directional control valve.

Referring now more particularly to the present invention as disclosed in FIGS. 2 to 7, the directional control valve 10 is herein shown as comprising a housing 11 in which two spool valves 12 and 14 are axially shiftable respectively to control the operation of, for example, a double acting cylinder 15 and a single acting cylinder 16.

As is known in the art, and as best shown in FIGS. 2 and 4, the housing 11 has a pressure inlet port 17 (in communication with the discharge port of pump P) and inlet chamber 18, the latter of which communicates with the feed passages 19 and 20 intersecting the bores 21 and 23 for the respective spools 12 and 14 via the check valves 24 and 25. The housing 11 is also formed with a bypass passage 26 common to the spool bores 21 and 23, said bypass passage 26 communicating with the fluid return port 27 adapted for connection with a fluid reservoir R.

Straddling the respective feed passages 19 and 20 are the pairs of service ports 28—28 and 29—29 and the return passages 30—30. Another return passage 31 is provided, there being a relief valve 32 between the inlet chamber 18 and such return passage 31.

The spool 12 is formed with alternate lands and grooves and is herein shown as being of the double acting, or four-way type, for actuation of the double acting cylinder 15 connected to the service ports 28—28. When the spool 12 is in neutral position as shown in FIG. 4, fluid in the inlet chamber 18 will freely bypass to the return port 27 via the bypass passage 26. When the spool 12 is moved upwardly, the bypass 26 is closed, and fluid under pressure in the inlet chamber 18 flows through the check valve 24 into the feed passage 19 and through the lower service port 28 into the rod end of the cylinder

15, and the fluid displaced from the head end of the cylinder 15 flows to the return port 27 by way of the upper service port 28 and return passage 30. On the other hand, when the spool 12 is shifted downwardly, the upper service port 28 becomes the pressure outlet to the head end of the cylinder 15 while the lower service port 28 becomes the return for the fluid displaced from the rod end of the cylinder 15, the bypass 26 again being closed.

One end of the spool 12 has associated therewith a spring return mechanism 34 which automatically returns the spool 12 to neutral position from either of its two operating positions. In the neutral position, fluid is trapped between the service ports 28—28 and the ends of the cylinder 15, whereby the piston 35 in the cylinder 15 is held against movement in either direction.

With reference to the other spool 14, it is herein shown as being of the single acting, or three-way type, for actuating the single acting cylinder 16 and in that case only one service port 29 is required, the upper service port 29 being closed by plug 36. In the neutral position of the single acting spool 14, the lower service port 29 is blocked, whereby fluid is trapped between the cylinder 16 and the directional control valve, i.e., the free circulation of fluid from the inlet chamber 18 to the return port 27. When the spool 14 is shifted upwardly from the FIG. 4 position, the bypass passage 26 is closed thereby and fluid under pressure in the inlet chamber 18 is delivered to the cylinder 16 to raise the load on the piston 37 via the check valve 25, the feed passage 20, and the lower service port 29. On the other hand, when the spool 14 is shifted downwardly, the bypass 26 is again opened and the piston 37 with its load is allowed to descend with the fluid being drained through the return port 27 via the lower service port 29 and return passage 30. The single acting spool 14 has associated therewith the same type of spring return mechanism 34 as used with the double acting spool 12.

It is to be understood that both spools 12 and 14 may be of the double acting type, or of the single acting type. Furthermore, there are other types of spools providing additional operating positions such as a float position, but for the purposes of the present invention such other types of spool valves need not be illustrated.

With reference to the relief-check assembly 40, the same is herein shown as comprising a separate housing 41 secured as by screws 42 to the directional control valve housing 11 and provided with ports 28—28 and 29—29 registering with the ports of housing 11 for connection with fluid motors 15 and 16 as shown in FIG. 2.

In the case of the double acting spool 12, there are provided two relief-check assemblies 43 and in the case of the single acting spool 14 only one relief-check assembly 43 is required, but space is provided for another one in the event that a spool 14 of the double-acting type is substituted. The relief-check housing 41 is provided with a three-branch return 45 which communicates with the return port 27 of the directional control valve housing 11 by way of the aligned passages 46 and 47 (see FIGS. 5 and 6).

Referring to the pair of relief-check assemblies 43 used in connection with the double acting spool 12, the center branch of the return passage 45 communicates with service ports 28—28 by way of the passages in seat bushings 48. A valve member 49 is urged by spring 50 into engagement with each seat bushing 48 whereby fluid will be admitted into either service port 28 if the pressure therein is less than in the return passage 45, as when there is a case of cavitation with the double acting cylinder demanding fluid that is either not available, or demanding more fluid than can be provided by the system pump.

Each valve member 49, however, in addition to functioning as a check valve, also constitutes a pilot-operated

relief valve. As perhaps best seen in FIG. 8, valve member 49 has an orifice 51 therethrough to equalize the fluid pressures in the chamber 52 and in the associated service port 28, whereby the valve member 49 will be seated by fluid under pressure in chamber 52 and by the spring 50. Closing the chamber 52 is a pilot relief valve 53 which is held in seated position by the adjustable spring 54. It can be seen that when the pressure in the chamber 52 exceeds the seating force on the pilot valve member 53, the chamber 52 will be vented to the return passage 45 more rapidly than fluid can be replenished into the chamber 52 through the orifice 51. This, therefore, creates a pressure differential such that the valve member 49 will be moved away from its seat thereby to relieve excess pressure in the associated service port 28 to the return passage 45.

In the case of the relief-check assembly 43 used in conjunction with the single acting spool 14, it is of the same construction as the pair of assemblies 43 used with the double acting spool 12 and operates in the same way, that is, as a check valve when the pressure in the lower cylinder port 29 is less than in the return passage 45 and as a relief valve when the pressure in the lower cylinder port 29 is greater than that for which the pilot relief valve member 53 is set by the adjustable spring 54.

Referring now more particularly to the operation of the present invention, it can be seen that should the double acting spool 12 be allowed to shift to neutral position from one operating position fluid will be trapped between the cylinder 15 and the service ports 28—28 and should the load on the piston 35 tend to continue to move by reason of its inertia, the pressure will build up in what was the return circuit sufficient to unseat the pilot relief valve 53 and thereby open the valve member 49 to communicate the service port 28 to return passage 45. At the same time, cavitation in the other end of the cylinder 15 is prevented by opening of the other valve member 49 by lower pressure in the associated service port 28 than in the return passage 45. Moreover, in the case of the double acting arrangement as shown in FIG. 5, the relieved fluid shooting across the return passage 45 will assist in the opening of said other valve member 49. Thus the latter is subjected to impingement or dynamic fluid pressure as well as the static fluid pressures acting on the lower end thereof to aid in rapid opening of such member 49. Arrangement of the two valve members 49 of an associated pair of the same in opposed relation with a straight passage therebetween further facilitates maximum utilization of such dynamic fluid pressures.

With reference to the operation of the relief-check assembly 43 associated with the single acting spool 14, if the spool is allowed to move from the position whereat the piston 37 is descending under load to neutral position, the inertia of the downwardly descending load on the piston 37 will build up a substantial pressure in the fluid that is now blocked by the single acting spool 14. However, the relief-check assembly 43 herein acts as a pilot operated relief valve to allow excess pressure thus built up to pass into the return passage 45. If, on the other hand, the installation is such that the load on the piston 37 is moved upwardly at a rapid rate, and the single acting spool 14 is allowed at that time, to move from operating position to neutral position, then the tendency of the load to continue to move by inertia will decrease the pressure in the fluid trapped between the spool 14 and the cylinder 16 and at that time the pressure in the lower service port 29 may become low enough with respect to the pressure in the return passage 45 as to cause opening of the valve member 49 functioning as a check valve.

The relief-check assemblies 43 herein also function to relieve partial vacuum and/or excessive pressure due to load shift from positive to negative, or negative to positive, as exemplarily shown in FIG. 1. The pilot relief

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valves 53 should be set to open at pressures at least as great as the main relief valve 32 so that the valve members 49 do not open prematurely when heavy loads are handled on the pistons 35 and 37.

Other modes of applying the principle of the invention may be employed, change being made as regards the details described, provided the features stated in any of the following claims, or the equivalent of such, be employed.

I therefore particularly point out and distinctly claim as my invention:

1. In combination, a directional control valve comprising a housing having an inlet port for fluid under pressure, a return port, and a pair of service ports, and a valve member movable in said housing from neutral position blocking fluid communication between said inlet port and both service ports to either of two operating positions selectively communicating said service ports with said inlet and return ports; and a pair of combination relief-check valve assemblies normally closing communication between the respective service ports and said return port and including spring-biased valve members arranged to be moved as check valve members by fluid under pressure in said return port of magnitude exceeding that in the respective service ports to positions establishing fluid communication between said return port and the respective service ports, and to be moved as relief valve members by fluid under pressure in the respective service ports of magnitude exceeding that in said return port to a position similarly establishing fluid communication between the respective service ports and said return port; said valve assemblies being oppositely disposed so that fluid under pressure relieved by one spring-biased valve member from one service port to said return port impinges on the other spring-biased valve member tending to move the latter to establish fluid communication between said return port and the other service port.

2. In combination, a directional control valve comprising a housing having an inlet port for fluid under pressure, a return port, and a pair of service ports, and a valve member movable in said housing from neutral position blocking fluid communication between said inlet port and both service ports to either of two operating positions selectively communicating said service ports with said inlet port and return port; conduits for establishing fluid communication between said inlet port and a discharge port of a pump and between said service ports and the respective ports of a double acting fluid motor; and a pair of combination relief-check assemblies normally closing communication between the respective service ports and said return port and including spring-biased valve members arranged to be moved as check valve members by fluid under pressure in said return port of magnitude exceeding that in the respective service ports to positions establishing fluid communication between said return port and the respective service ports, and to be moved as relief valve members by fluid under pressure in the respective service ports of magnitude exceeding that in said return port to a position similarly establishing fluid communication between the respective service ports and said return port, said valve assemblies being oppositely disposed so that fluid under pressure relieved by one spring-biased valve member from one service port to said return port impinges on the other spring-biased valve member tending to move the latter to establish fluid communication between said return port and the other service port.

3. In combination, a directional control valve comprising a housing having an inlet port for fluid under pressure, a return port, and a pair of service ports, and a valve member movable in said housing from neutral position blocking fluid communication between said inlet port and both service ports to either of two operating positions selectively communicating said service ports with said inlet and return ports; and a pair of combination relief-check valve assemblies normally closing communication between the respective service ports and said return port and in-

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cluding spring-biased valve members arranged to be moved as check valve members by fluid under pressure in said return port of magnitude exceeding that in the respective service ports to positions establishing fluid communication between said return port and the respective service ports, and to be moved as relief valve members by fluid under pressure in the respective service ports of magnitude exceeding that in said return port to a position similarly establishing fluid communication between the respective service ports and said return port; said valve assemblies being oppositely acting and communicated with each other by a straight passage therebetween which is connected to said return port so that fluid under pressure relieved by one spring-biased valve member from one service port to said return port passes through said straight passage to impinge on the other spring-biased valve member tending to move the latter to establish fluid communication between said return port and the other service port.

4. In combination, a directional control valve comprising a housing having an inlet port for fluid under pressure, a return port, and at least one service port, and a valve member movable in said housing from neutral position blocking fluid communication between said inlet and service ports to either of two operating positions selectively communicating said service port with said inlet and return ports; and a combination relief-check valve assembly including a main valve member normally closing communication between said return and service ports, spring means for yieldably maintaining said main valve member in such closed position, said spring means being operative to permit said main valve member to be moved as a check valve member by fluid under pressure in said return port of magnitude exceeding that in said service port to a position establishing fluid communication between said ports, and means operative to permit said main valve member to be moved as a relief valve member by fluid under pressure in said service port of magnitude exceeding that in said return port to a position similarly establishing fluid communication between said ports; said assembly comprising a body detachably secured to said housing and having a service port for connection with a fluid motor in register with the service port of said housing and a return passage in said body that registers with an opening in said housing leading to said return port.

5. In combination, a directional control valve comprising a housing having an inlet port for fluid under pressure, a return port, and a pair of service ports, and a valve member movable in said housing from neutral position blocking fluid communication between said inlet port and both service ports to either of two operating positions selectively communicating said service ports with said inlet and return ports; a passage directly communicating said service ports with each other, and a pair of combination relief-check valve assemblies normally closing communication between the respective service ports, through said passage, said combination relief-check valve assemblies including spring-biased valve members arranged to be moved as check valve members by fluid under pressure in said passage of magnitude exceeding that in the respective service ports to positions establishing fluid communication between said passage and the respective service ports, and to be moved as relief valve members by fluid under pressure in the respective service ports of magnitude exceeding that in said passage to a position similarly establishing fluid communication between the respective service ports and said passage; said valve assemblies being oppositely disposed so that fluid under pressure relieved by one spring-biased valve member from one service port to said passage impinges on the other spring-biased valve member tending to move the latter to establish fluid communication between said passage and the other service port.

6. The combination of claim 5 wherein said return port is also in communication with said passage between said

combination relief-check valve assemblies, whereby said combination relief-check valve assemblies also normally close fluid communication between the respective service ports and said return port, and said spring-biased valve members are also adapted to be moved as check valve members by fluid under pressure in both said passage and said return port of magnitude exceeding that in the respective service ports to positions establishing fluid communication between said passage and return port and the respective service ports, and to be moved as relief valve members by fluid under pressure in the respective service ports of magnitude exceeding that in said passage and return port to a position similarly establishing fluid communication between the respective service ports and said passage and return port.

7. The combination of claim 5 wherein said means operative to permit said main valve member to be moved as a relief valve member comprises a chamber in which said main valve member is slidably received, an orifice extending through a portion of said main valve member for establishing restricted fluid communication between said chamber and said service port, the portion of said main valve member normally closing communication between said passage and service ports being solid, and a spring-biased pilot relief valve means operative to vent said chamber to said return passage more rapidly than fluid can be replenished into said chamber through said orifice when fluid under pressure in said service port is of a magnitude exceeding that in said passage as aforesaid.

8. In combination, a directional control valve comprising a housing having an inlet port for fluid under pressure, a return port, and a pair of service ports, and a valve member movable in said housing from neutral position blocking fluid communication between said inlet port and both service ports to either of two operating positions selectively communicating said service ports with said inlet port and return port; conduits for establishing fluid communication between said inlet port and a discharge port of a pump and between said service ports and the respective ports of a double acting fluid motor; a passageway directly interconnecting said service ports; and a pair of combination relief-check assemblies normally closing communication between the respective service ports and said passageway and including spring-biased valve members arranged to be moved as check valve members by fluid under pressure in said passageway of magnitude exceeding that in the respective service ports

to positions establishing fluid communication between said passageway and the respective service ports, and to be moved as relief valve members by fluid under pressure in the respective service ports of magnitude exceeding that in said passageway to a position similarly establishing fluid communication between the respective service ports and said passageway, said valve assemblies being oppositely disposed so that fluid under pressure relieved by one spring-biased valve member from one service port to said passageway impinges on the other spring-biased valve member tending to move the latter to establish fluid communication between said passageway and the other service port.

9. In combination, a directional control valve comprising a housing having an inlet port for fluid under pressure, a return port, and a pair of service ports, and a valve member movable in said housing from neutral position blocking fluid communication between said inlet port and both service ports to either of two operating positions selectively communicating said service ports with said inlet and return ports; a passage between said service ports, and a pair of combination relief-check valve assemblies normally closing each end of said passage and including spring-biased valve members arranged to be moved as check valve members by fluid under pressure in said passage of magnitude exceeding that in the respective service ports to positions establishing fluid communication between said passage and the respective service ports, and to be moved as relief valve members by fluid under pressure in the respective service ports of magnitude exceeding that in said passage to a position similarly establishing fluid communication between the respective service ports and said passage, said valve assemblies being oppositely disposed, whereby the fluid relieved by one spring-biased valve member increases the pressure in said passage tending to open the other spring-biased valve member.

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45 HENRY T. KLINSIEK, *Primary Examiner*.
M. CARY NELSON, *Examiner*.