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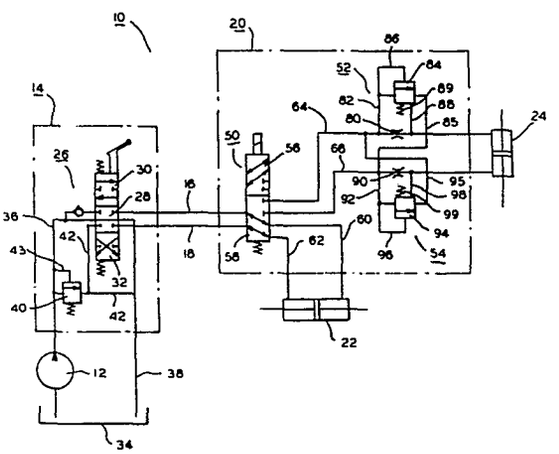
(54) Hydraulic circuit selector with flow control.

(57) A hydraulic circuit selector with flow control for selectively operating any one of a plurality of hydraulic actuators (22, 24) at a given time and for bypassing the excess flow to the sump (34) if the actuator (24) being operated requires a lower fluid flow rate than that supplied to the circuit selector (50). An orifice (80 or 90) is disposed between the circuit selector (50) and actuator (24) in each line (64 or 66) which may function as a pressure line to the actuator. A hydraulic line (82, 85 or 92, 95) is connected to the pressure line (64 or 66) upstream from the orifice (80 or 90) and to a return line (66 or 64). A bypass valve (84 or 94) is disposed in the connecting line (82, 85 or 92, 95) and detects a pressure drop across the orifice (80 or 90) to open the bypass valve (84 or 94) and bypass the excess flow from the pressure line to the return line.



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HYDRAULIC CIRCUIT SELECTOR WITH FLOW CONTROL

This invention relates to a hydraulic circuit selector with flow control.

It is common on industrial vehicles, such as fork lift trucks and the like, to provide attachments on the vehicles for performing specialized work operations. Although some attachments have only one function, and therefore only one hydraulic actuator such as a hydraulic piston-and-cylinder assembly or hydraulic motor, it is becoming increasingly common that the attachments have two or more functions with a plurality of hydraulic actuators, and pressurized hydraulic fluid must be supplied to each actuator for its operation. It is desirable to minimize the number of hydraulic lines on most industrial vehicles, and, for example, on fork lift trucks it is preferred to have only a minimum number of hose lines extending over the uprights to attachments at the front of the truck. Normally, at least two hose lines are required for a hydraulic actuator, one to function as a pressure line from the hydraulic pump on the vehicle to the actuator on the

attachment, and the other to serve as a return line from the actuator to the pump and fluid reservoir. When two or more actuators are present on the attachment, each actuator is connected to the main pressure and return lines by a hydraulic circuit selector which is operator controlled and determines which of the hydraulic actuators will be supplied with pressurized hydraulic fluid. The main lines transfer fluid to and from the circuit selector, and individual hydraulic line pairs connect each of the actuators to the circuit selector.

One of the principal problems encountered in supplying two or more actuators from one pump, through a single pair of hydraulic supply and return lines regulated by a circuit selector, is that frequently the hydraulic actuators have different fluid flow requirements for operation. Hence, the hydraulic pump must be of sufficient capacity to supply fluid to the actuator having the maximum flow requirement; and flow reduction means must be provided to reduce the fluid flow when actuators are being operated which require less fluid flow than that supplied from the hydraulic pump. In the past, the practice for reducing the fluid flow has been to provide an orifice to reduce the flow to actuators requiring less fluid flow, and a relief valve associated with the pump has been used to bypass the excess fluid flow from the pump to the reservoir. The past practices for reducing fluid flow to hydraulic actuators having a lesser fluid flow requirement than the flow supplied from the pump are inefficient and wasteful in terms of energy consumption and power utilization.

One of the principal objects of the present invention is to provide a hydraulic circuit selector having an automatic flow control which permits selectively operating one of a plurality of hydraulic actuators having different fluid flow requirements from a single pair of pressure and return lines connected to a hydraulic pump, and which automatically bypasses the excess fluid flow to the fluid reservoir when an actuator having a lesser fluid flow requirement than the flow supplied from the pump is being operated.

Another object of the present invention is to provide a hydraulic circuit selector with flow control which can be adjusted to provide the required fluid flow for various types of hydraulic actuators, and which requires only a single pair of lines to the circuit selector valve, each of which may operate as a fluid pressure line or as a fluid return line, with the bypassed fluid flowing from a flow control valve in the line operating as a pressure line to the line of the pair functioning as a return line.

The present invention provides a hydraulic circuit selector with an automatic flow control to bypass the excess fluid flow to the fluid reservoir when operating hydraulic actuators requiring a lesser fluid flow than the maximum supplied from a source. Two operator controlled valves are provided in a hydraulic system embodying the present invention, the first valve being for selecting the direction of operation of the hydraulic actuators, and the second valve being a circuit selector valve for determining which of a plurality of actuators is operated.

A connection is provided between the hydraulic pump and an actuator requiring the maximum flow rate. An actuator requiring less than the maximum flow supplied from the pump is connected to the pump through a bypass type flow control valve, two of which are provided if the actuator is double acting. The flow control valve includes an orifice and a bypass valve responsive to a minimal pressure drop across the orifice. The bypass valve opens when the required pressure drop is detected, and the excess fluid flow over that required to operate the actuator is bypassed from the upstream side of the orifice to the fluid return line. The orifice in each of the bypass type flow controls may be of the variable tuning type, so that the present hydraulic circuit selector with flow control can be used for various devices, and the orifice can be tuned for the flow requirements of the hydraulic actuators on the device.

The present invention will be more particularly described with reference to the accompanying drawings, in which the single figure is a schematic view of a hydraulic system having a hydraulic circuit selector with automatic flow control embodying the present invention.

Referring more specifically to the drawing, numeral 10 designates a hydraulic circuit having the automatic flow control feature embodying the present invention, for selectively operating one hydraulic actuator of a plurality of actuators, and for bypassing the excess fluid to the reservoir when an actuator requiring less than the maximum fluid flow is being operated. Circuit 10 includes a

hydraulic pump 12 and an operator controlled auxiliary valve assembly, indicated in the drawing by the box designated by numeral 14, which, on a fork lift truck, for example, normally will be on the body of the truck. Hydraulic lines 16 and 18 connect the auxiliary valve to a circuit selector assembly, represented by the box designated by the numeral 20 in the drawing. The circuit selector is connected to, for the selective operation of, hydraulic actuators 22 and 24, which may be hydraulic motors, hydraulic piston-and-cylinder assemblies or other hydraulic devices.

Auxiliary valve assembly 14 includes a valve means 26 having a neutral section 28 and fluid communicating sections 30 and 32 which are selected for the desired direction of operation for actuators 22 and 24. Pump 12 pumps fluid from a reservoir or sump 34 through a pressure line 36 to valve 26. When valve 26 is in the neutral position the fluid pumped by pump 12 flows through the neutral section to a return line 38 and back to sump 34. The fluid communicating sections 30 and 32 operate to transfer the fluid through the valve so that in one of the positions, i.e., that designated by numeral 30 in the figure, hydraulic line 16 operates as the pressure line to the circuit selector assembly, and hydraulic line 18 operates as a return line from the assembly. In the other of the positions, i.e., that indicated by numeral 32 in the figure, hydraulic line 18 operates as a pressure line to the circuit selector assembly, and hydraulic line 16 as a return line from the assembly. Hence, by selecting the position for valve 26,

either of the actuators 22 or 24 can be operated in either direction. A pressure control valve 40 is disposed between hydraulic line 36 and return lines 42 and 38 and is connected to line 36 by line 43 for sensing the pressure in line 36 and thus operating the valve to maintain a preselected fluid pressure in line 36 to valve means 26.

Circuit selector assembly 20 includes a circuit valve 50 for selectively operating either of actuators 22 or 24, and flow control valves 52 and 54 for bypassing the excess fluid to sump 34 when operating actuator 24. Circuit valve 50 has two operating positions wherein hydraulic fluid may flow therethrough to the hydraulic actuators. The positions are shown in the drawing as sections 56 and 58, one of which is in flow communication with hydraulic lines 16 and 18 when either actuator is operated. Section 58 connects hydraulic lines 16 and 18 to hydraulic lines 60 and 62 for direct flow communication with actuator 22, which, for purposes of illustration, operates at the maximum flow from valve assembly 14. Operation of actuator 22 in either direction as selected by valve 26 will occur at substantially the same pressure and displacement as that supplied from line 36, in that no flow restriction is interposed between line 36 and actuator 22. Section 56 connects hydraulic lines 16 and 18 to hydraulic lines 64 and 66, and places actuator 24 in flow communication with valve assembly 14. The hydraulic fluid passes through one or the other of flow control valves 52 and 54 when actuator 24 is operated, and the excess fluid beyond that flow required to operate

actuator 24 is bypassed back to sump 34. Hydraulic line 64 is connected to one side of actuator 24 and is connected by section 56 of circuit valve 50 to hydraulic line 16. Flow control valve 52 is disposed in line 64 between circuit valve 50 and actuator 24 for reducing the flow of fluid to actuator 24 when line 64 is the pressure line. Hydraulic line 66 is connected to the other side of actuator 24, and is connected by section 58 of circuit valve 50 to hydraulic line 18. Flow control valve 54 is disposed in line 64 between circuit valve 50 and actuator 24 for reducing the fluid flow to actuator 24 when line 66 is the pressure line. One or the other of the flow control valves operates whenever fluid flows to actuator 24, depending upon the direction in which the actuator is being operated and which of the lines 64 or 66 is the pressure line, as controlled by valve 26.

Flow control valve 52 includes a tuning orifice 80 which may be tuned to the flow requirements of actuator 24. A hydraulic line 82 connects hydraulic line 64 anterior to orifice 80 to a relief valve 84 which in turn is connected to hydraulic line 66 by line 85. The relief valve 84 is responsive to a pressure drop across orifice 80, sensed through pilot lines 86 and 88 connecting, respectively, relief valve 84 with hydraulic line 82 and relief valve 84 with hydraulic line 64 downstream from orifice 80. Thus, a pressure drop across orifice 80, as determined by the size of the orifice and the force of a calibrated spring 89, opens relief valve 84, and the excess fluid not required for operation of actuator 24 passes through valve 84 and

hydraulic line 85 to hydraulic line 66. The pressure drop across the orifice sufficient to open the relief valve can be relatively small, such as a 3.53kg/cm^2(50 PSI) drop.

Flow control valve 54 is similar to valve 52, and includes a tuning orifice 90 which may be tuned to the flow requirements of actuator 24. A hydraulic line 92 connects hydraulic line 66 anterior to orifice 90 to a relief valve 94 which in turn is connected to hydraulic line 64 by line 95. Relief valve 94 is responsive to a pressure drop across orifice 90, sensed through pilot lines 96 and 98 connecting, respectively, relief valve 94 with hydraulic line 92, and relief valve 94 with hydraulic line 66 downstream from orifice 90. Thus, a pressure drop across orifice 90, as determined by the size of the orifice and the force of a calibrated spring 99, opens relief valve 94, and the excess fluid not required for operation of actuator 24 passes through valve 94 and hydraulic line 95 to hydraulic line 64.

In the use and operation of a hydraulic system including the automatic flow control feature of the present invention, if actuator 22 is to be operated, circuit valve 50 is operated to place hydraulic lines 16 and 18 in flow communication with hydraulic lines 60 and 62 through valve section 58. If valve 26 is in the neutral position, hydraulic fluid from pump 12 circulates freely back to sump 34 through return line 38. If section 30 of valve 26 connects the various hydraulic lines, line 16 functions as a pressure line, line 18 functions as a return line and

actuator 22 will operate to move the piston in the actuator to the left as shown in the drawing. If section 32 is used to connect the hydraulic lines, line 18 functions as the pressure line, and line 16 functions as the return line, so that actuator 22 will sequence to the right. The fluid supplied from pump 12 to actuator 22 will be at substantially the same pressure as it is when it is in line 36 coming from the pump, the pressure being determined by the setting selected for control valve 40 by a calibrated spring therein opposing the fluid pressure transmitted through line 43.

For purposes of illustration, assume that actuator 24 operates by a fluid flow less than the flow supplied from pump 12. Tuning orifices 80 and 90 are adjusted to restrict the fluid flow to meet the requirements of actuator 24. To operate actuator 24, circuit valve 50 is operated to place section 56 in communication with lines 16 and 18, thereby connecting lines 16 and 18 with lines 64 and 66. If valve 26 is in a position so that line 16 is a pressure line and line 18 a return line, the hydraulic fluid will flow through line 64 and flow control valve 52 to actuator 24. As the fluid flows through orifice 80, the pressure drop across the orifice is detected by relief valve 84, and the relief valve will open to bypass the excess fluid not required for the operation of actuator 24, through hydraulic lines 82 and 85 to line 66 and return line 18 to sump 34. If valve 26 is in a position so that line 18 is a pressure line and line 16 is a return line, the hydraulic fluid will flow through line 66 and flow control valve 54 to actuator 24, and the

actuator will operate in the opposite direction from that just described. As the fluid flows through orifice 90, the pressure drop across the orifice is detected by relief valve 94, and the relief valve will open and bypass the excess fluid not required for operation of actuator 24 through hydraulic lines 92 and 95 to line 64 and return line 16 to sump 34.

Orifices 80 and 90, being tuning orifices, permit the flow control valves to be tuned for the flow requirements of the actuator being operated, and the valves can be adjusted for use with different attachments. Relief valves 84 and 94 respond to a predetermined pressure drop across the orifices to bypass the excess fluid flow to sump. The present hydraulic circuit selector with automatic flow control can be used whenever a plurality of actuators are selectively operated and have differing fluid flow requirements. The same general principals may be applied to duplicate the flow control assembly when three, four or more actuators are being operated, even if each has a different flow requirement than the others. If the hydraulic actuator is of the single acting type, so that only one of the lines to the actuator functions as a pressure line, only one flow control valve is required.

CLAIMS:-

1. A hydraulic circuit selector for operating a hydraulic actuator requiring less than the maximum fluid flow supplied to the selector, characterized in that said selector comprises a circuit valve (50) for receiving a flow of hydraulic fluid from a hydraulic fluid supply source (12) and for directing the flow of fluid to said hydraulic actuator (24), a pressure line (64 or 66) from said circuit valve to said actuator, a return line (66 or 64) from said actuator to said circuit valve, flow restriction means (80 or 90) in said pressure line for reducing the fluid flow rate in said pressure line to said actuator, and a bypass valve (84 or 94) sensing the pressures on opposite sides of said restriction means and having a first conduit means (82 or 92) connected to said pressure line upstream from said flow restriction means, and a second conduit means (85 or 95) connected to said return line for bypassing the excess fluid flow from said pressure line to said return line.

2. A hydraulic circuit selector as defined in Claim 1, characterized in that said restriction means (80 or 90) is a tuning orifice.

3. A hydraulic circuit selector as defined in Claim 1 or 2, characterized in that a first pilot line (86 or 96) connects said bypass valve (84 or 94) to said pressure line (64 or 66) upstream from said restriction means (80 or 90), and a second pilot line (88 or 98) connects said bypass valve to said pressure line downstream from said restriction means, for making said bypass valve responsive to a pressure drop

across said restriction means.

4. A hydraulic circuit selector as defined in Claim 1, 2 or 3 characterized in that first and second lines (64 and 66) are disposed between said actuator (24) and said circuit valve (50), said first line (64) being a pressure line when the actuator operates in a first direction and a return line when the actuator operates in a second direction, said second line (66) being a return line when the actuator operates in the first direction and a pressure line when the actuator operates in the second direction, a flow restriction means (80,90) disposed in each of said first and second lines, first and second bypass lines (82,85 and 92,95) each connected to said first and second lines between said circuit valve and said flow restriction means in said lines, and a bypass valve (84,94) disposed in each of said bypass lines permitting excess fluid to flow from the pressure line to the return line for each direction of operation for said actuator in response to the drop in pressure across said flow restriction means in said pressure line.

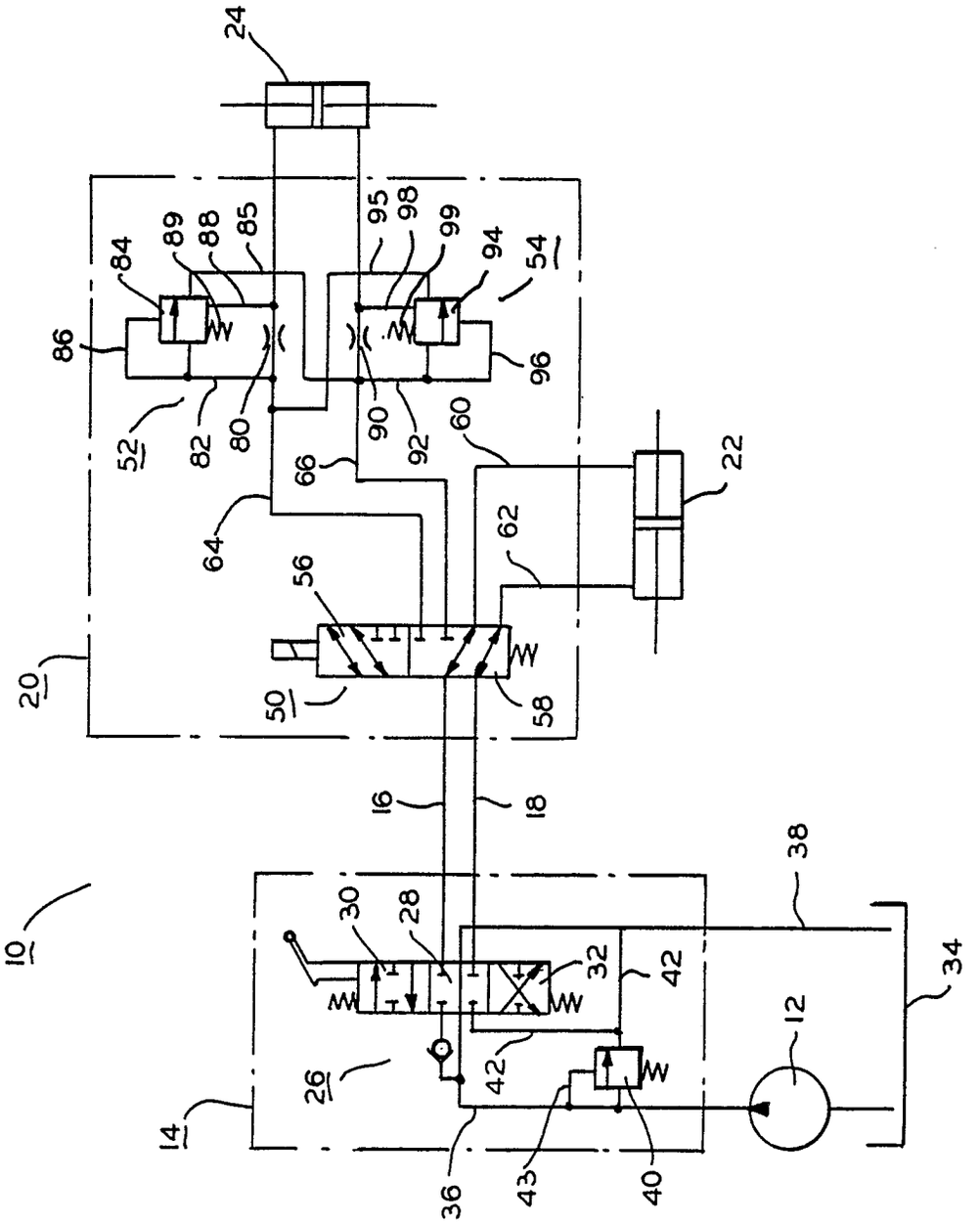
5. A hydraulic circuit selector as defined in Claim 4, characterized in that a first pair of pilot lines (86 and 88) connect one of said bypass valves (84) to said first line (64) on opposite sides of said flow restriction means (80) therein, and a second pair of pilot lines (96 and 98) connect the other of said bypass valves (94) to said second line (66) on opposite sides of said flow restriction means (90) therein for making the operation of said bypass valves responsive to predetermined pressure drops across said flow

restriction means.

6. A hydraulic circuit selector as defined in any one of the preceding claims, characterized in that an auxiliary valve assembly (14) is disposed between the fluid supply source (12) and said circuit valve (50) and includes flow communicating sections (30 and 32) for selectively connecting the circuit valve to the fluid supply source for determining the direction of operation of the actuator (24).

7. A hydraulic circuit selector as defined in any one of the preceding claims, characterized in that said circuit valve (50) has flow communicating sections (56,58) for selectively supplying fluid from said supply source (12) either to said hydraulic actuator (24) by way of said bypass valve (84,94) or to a second hydraulic actuator (22).

8. A hydraulic circuit selector as defined in Claim 7, insofar as this is dependent upon claim 6, characterized in that said auxiliary valve assembly (14) and said circuit valve (50) are manually operable to select the required flow communicating sections thereof.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