

[54] **PILOT OPERATED CONTROL VALVE**

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[22] Filed: **Feb. 7, 1973**

[21] Appl. No.: **330,459**

Related U.S. Application Data

[62] Division of Ser. No. 163,866, July 19, 1971, Pat. No. 3,739,690.

[52] **U.S. Cl.**..... **137/106**, 91/28, 91/447, 137/596.15

[51] **Int. Cl.**..... **F16k 11/10**

[58] **Field of Search**..... 91/28, 461, 447; 137/102, 137/106, 596.14, 596.15

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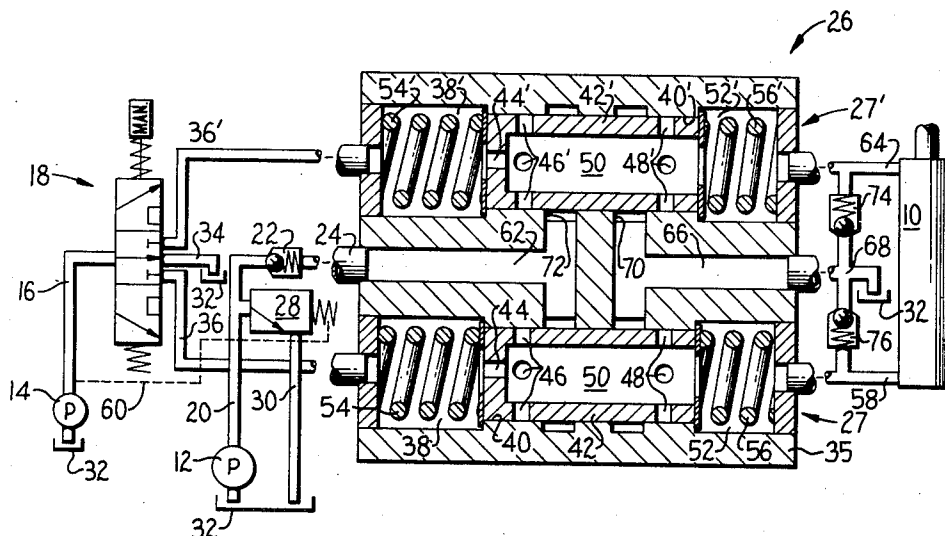
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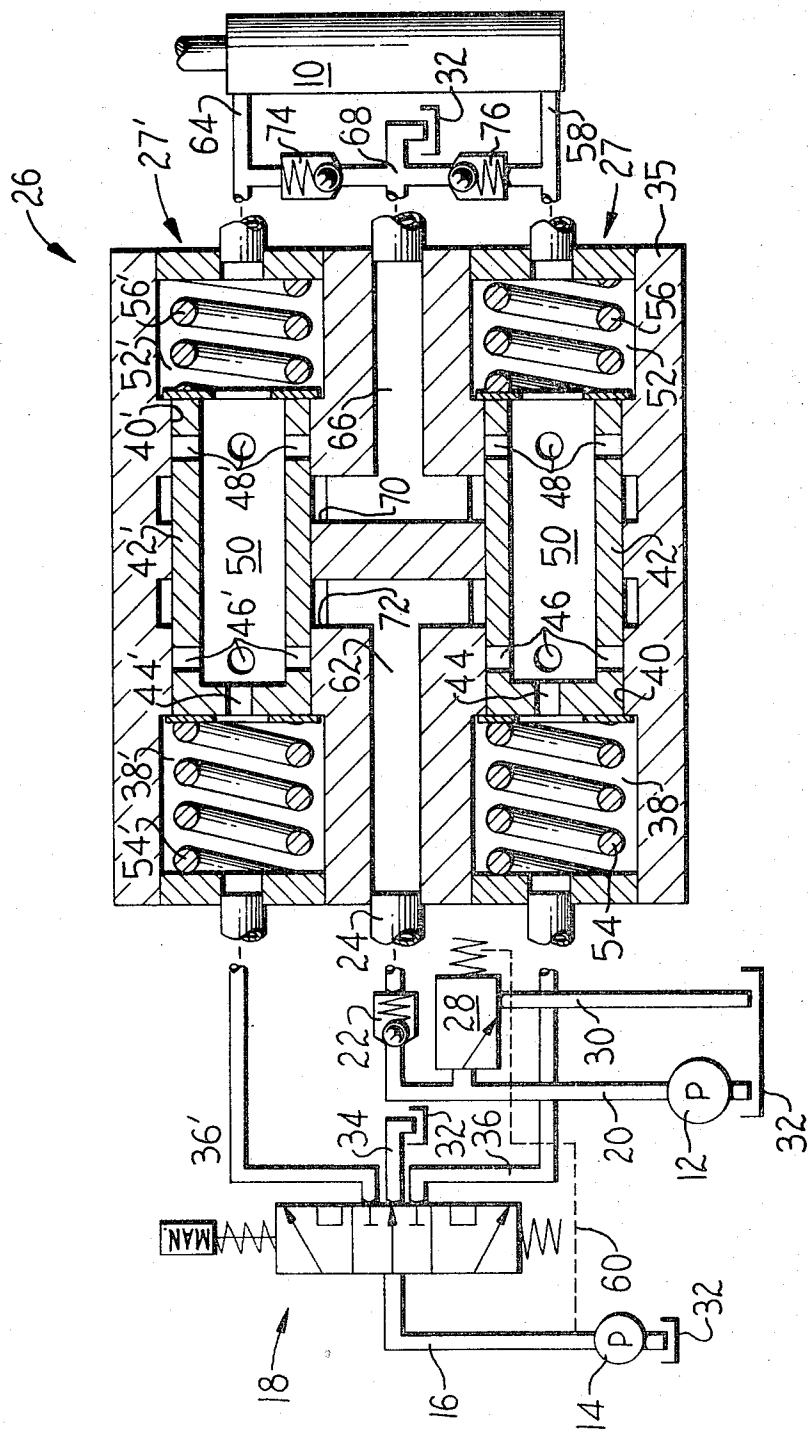
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[57] **ABSTRACT**

An implement hydraulic circuit including a pilot operated flow amplifier directional valve for controlling communication between a source of primary actuating fluid and a hydraulic motor. A pair of valve spools in the valve provide separate regulated flow paths for an inlet passage and an outlet passage respectively with a pair of work ports. An actuating chamber is associated with one end of each of the spools and may each be selectively communicated with a separate source of pilot fluid for actuation of either of the spools to communicate the primary source with either side of the motor. The other spool is positioned by fluid displaced from the motor to communicate the displaced fluid to the outlet passage for return to a reservoir. The configuration of the spools and their arrangement in the valve provide a capability of metering flow from motor to reservoir to prevent overrunning of the motor.

7 Claims, 1 Drawing Figure





PILOT OPERATED CONTROL VALVE

RELATED U.S. PATENTS

This is a Division of U.S. Pat. application Ser. No. 163,866 which issued June 19, 1973 as U.S. Pat. No. 3,739,690.

BACKGROUND OF THE INVENTION

Pilot operated flow amplifier valves of the type contemplated by the present invention are employed for directional control of hydraulic motors for operation of components such as implements mounted on mobile construction or material handling equipment or steering systems for vehicles. It is often necessary or desirable to actuate the hydraulic control valve by a pilot system to avoid the use of unduly complex mechanical linkages and/or to reduce the effort required by an operator for control of the implement or steering system. The pilot pressure fluid for such pilot system is often used only to position the control valve spool and is then returned to the reservoir. In systems of that type, the horsepower required for driving the pilot pump does not perform any other useful work and is therefore relatively wasted.

One presently known system borrows a small volume of fluid from the main fluid source for pilot actuation purposes and then recombines that flow with the main pump flow for actuation of the cylinders. This introduces a disturbance into the system at two separate points and can result in instability of the valve in the system.

In certain applications, the implement or tool being controlled may be affected by gravitational or other external forces which can result in an overrunning condition and cavitation on the expanding side of the motor. Presently known directional control valves do not inherently provide control of such overrunning conditions. As a result, it has been necessary to add additional valving for controlling this undesirable condition, therefore increasing cost and complexity of the system.

SUMMARY AND OBJECTS OF THE INVENTION

The present invention relates to a pilot operated flow amplifier control valve and more particularly to such a valve wherein a spool is selectively positioned by pilot flow through a restriction in the spool to condition the valve for actuation of a hydraulic motor. The restriction in the spool communicates the pilot flow to a work port associated with that particular spool so that the pilot flow is combined with the main pump flow to perform useful work in addition to its pilot control function.

As illustrated in a preferred embodiment of the invention as described below, the configuration of the spool and its arrangement in the valve assembly is also adapted to regulate exhaust fluid flow from the motor and to provide an automatic overrunning control, for example to limit or regulate operation of the motor by an external load.

A valve including two such pilot operated spools may also be employed to regulate a double-acting hydraulic motor, for example. One of the spools may be pilot actuated to a position communicating the primary source with one side of the motor while the other spool is actuated, in response to displaced fluid from the contracting side of the motor, to a position communicating that

side of the motor to a reservoir. This is accomplished by venting the pilot actuating chamber for that spool to the reservoir such that displaced fluid flows through the restriction in the spool and generates a pressure differential actuating that spool to the fluid return position. When the returning flow exceeds a predetermined volume, the spool is actuated to a position restricting communication between the motor and the reservoir to automatically control overrunning of the motor and thereby prevent cavitation in the expanding side of the motor.

Accordingly, it is an object of the present invention to provide a hydraulic system incorporating a pilot operated valve supplied by a pilot fluid source and combining the pilot fluid with main flow controlled by the valve so that the pilot fluid performs other useful work in conjunction with the main fluid to minimize the horsepower loss normally associated with pilot control systems.

It is a further object of the invention to provide such a system which includes automatic control of an overrunning condition in response to the fluid volume displaced from the contracting end of the cylinder.

Another object is to incorporate the above-stated features in a relatively simple valve mechanism, the design of which greatly simplifies manufacture and accordingly minimizes cost of such mechanism.

Other objects and advantages of the present invention are made apparent in the following description having reference to the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

The single drawing discloses an implement hydraulic circuit including a cross-sectional view of a pilot actuated flow amplifier valve of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A typical work implement circuit is disclosed in the drawing, wherein a main control valve is pilot actuated to control a hydraulic motor 10. Primary actuating fluid for the hydraulic motor 10 is supplied by a pump 12. Fluid for the pilot section of the circuit is supplied by a pump 14. The pump 14 is communicated, via a line 16, with a pilot control valve 18. The pump 12 is communicated, via a line 20, a check valve 22, and a line 24, with a flow amplifier valve 26. The line 20 also communicates with a pilot operated relief valve 28 that directs flow from the pump 12 to a line 30 and then to a tank 32 when the control valve 18 is in a neutral position. In neutral, the valve 18 directs pilot flow from the line 16 to a line 34 and then to the tank 32.

The valve 26 includes two separate spool or valve sections generally indicated at 27 and 27' within a housing 35.

When the pilot valve 18 is shifted from neutral (in an upward direction, for example) fluid is communicated from line 16 to a line 36 which is in communication with an actuating chamber 38 in one section 27 of valve 26.

The chamber 38 is formed in one end of a stepped bore 40 by a spool 42 which is slidably arranged therein. The spool 42 includes an axial restriction or passage 44 and two sets of axially spaced apart radial passages 46 and 48 all in communication with a chamber 50 internally formed by the spool 42 and opening into a chamber 52 formed in the bore 40 at the oppo-

site end of the spool from the chamber 38. Springs 54 and 56 are arranged respectively in the chambers 38 and 52 and tend to center the spool in the position shown in the drawing.

Pilot flow into the actuating chamber 38 flows through the orifice 44 into the chamber 50 and through the spring chamber 52 into a line 58 which connects with the head end of the hydraulic motor 10.

Fluid flow as described above causes a pressure rise in the line 16 which is in communication with the relief valve 28 by means of a pilot line 60. The relief valve is thus set in proportion to pressure in the line 16 and blocks flow of fluid from the line 20 to the line 30. Thereafter fluid from the line 20 is directed to line 24 which is in communication with an inlet passage 62 in the valve 26. Simultaneous fluid flow through the orifice 44 of spool 42 produces a pressure drop thereacross. The spool 42 is thus shifted to the right against the spring 56 so that the passage 62 is placed in communication with the chamber 50 of spool 42 through the plurality of passages 46 in the spool 42. The check valve 22 prevents pilot flow from chamber 50 through passage 46, passage 62 and line 24 from entering line 20 and passing to the tank 32 through relief valve 28 and line 30 prior to setting of the relief valve 28 by pressure from line 16.

Fluid flow into the head end of the hydraulic motor 10 causes it to extend and expel fluid from its rod end. Exhaust fluid flow from the motor is controlled by the other section of the valve 26, for example, the section 27' when the pilot valve 18 is shifted upwardly to extend the motor 10. The section 27' is constructed similarly as the section 27 and its various elements are identified by similar primed numerals. The exhaust fluid from the rod end of the motor 10 enters a line 64 which is in communication with the spring chamber 52'. That flow is directed through the chamber 50', the orifice 44' in the spool 42', into the actuating chamber 38', a line 36', through valve 18, and into tank line 34. Fluid flow through the orifice 44' produces a pressure drop thereacross which shifts the spool 42' against the spring 54' and communicates the chamber 50' with a branched passage 66 through the plurality of radial passages 48' in the spool 42'. The passage 66 communicates with a line 68 which directs a major portion of the expelled fluid to the tank 32.

As long as the rate of motor movement is established by the pump volume directed to the head end of the motor through the spool 42, exhaust flow from the rod end of the motor is relatively unrestricted by the spool 42'. Should gravitational or other external forces cause the motor to extend at a rate greater than that established by the pump volume, the increased flow through the orifice 44' increases the pressure differential acting on the spool 42'. This increased pressure moves the spool 42' further to the left so that the radial passages 48' are progressively closed by an annular groove 70 in the stepped bore 40'. The flow of exhaust fluid to the tank 32 is thus restricted or metered to control or prevent overrunning of motor 10. In this way, cavitation of the motor is prevented and the damaging effects of such cavitation on the components of the circuit, and particularly the motor 10, are avoided.

An important feature of this invention resides in a provision for combining the pilot flow with the primary actuating fluid for direction to the motor 10. In order to accomplish this, the pilot flow is metered through

one of the orifices, 44 or 44' to the chamber 50 or 50' as previously stated. The pilot flow combines with the main pump flow in that chamber. Thus horsepower required to drive the pilot pump 14 performs useful work other than the mere pilot function of positioning the spool in the directional control valve.

It may also be noted that pilot flow from line 16 may be modulated by the control valve 18. Fluid flow through the orifice 44 of 44' of either spool is thus regulated together with the rate of fluid flow from the passage 54 and the contracting end of motor 10 through the valve sections 27 and 27' to provide a flow amplifying function.

When the pilot control valve 18 is shifted downwardly, line 16 is communicated with the line 36'. In that instance, pilot fluid flows into the chamber 38' through the orifice 44' into the chamber 50' of the spool 42' then into chamber 52', line 64 and the rod end of hydraulic motor 10. The pressure drop created across the orifice 44' causes the spool 42' to shift to the right against the spring 56' to communicate the main flow in passage 62 with the chamber 50' by the passages 46' in the spool 42'. The main flow from passage 62 joins pilot flow from the orifice 44' in the chamber 50'. Fluid flow between the passage 62 and chamber 50' is proportional to pilot flow through the orifice 44 because of metering action between the passages 46' and an annular groove 72 along the bore 40'.

Fluid flow into the rod end of motor 10 retracts the motor and expels fluid from the head end of the motor. The exhaust fluid enters through the line 58 into the spring chamber 52 and chamber 50 in the spool 42 and crosses the orifice 44 into the spring chamber 38 which communicates with the line 36. Since the control valve 18 is moved downwardly, the line 36 is in communication with the line 34 and the tank 32 to receive fluid flow from the chamber 38. A pressure differential produced by fluid flow across the orifice 44 causes the spool 42 to move to the left against the spring 54 until the passages 48 register with the passage 66 to direct the exhaust fluid to tank 32 through the passage 66 and line 68.

Overrunning of motor 10 is also controlled in this mode of operation by the valve 42 in a manner identical to that described above with reference to valve 42'. Automatic overrunning control is inherently provided by integral features of the valve or spool design in a very simple and relatively inexpensive manner and eliminates the need for additional complicated and expensive valve mechanisms commonly employed to prevent this undesirable condition.

With the pilot control valve 18 in the neutral position shown in the drawing, the spools 42 and 42' are centered in the positions shown in the drawing by the springs 54, 56 and 54', 56'. The neutral position of valve 18 blocks lines 36 and 36' so that any fluid pressure generated in lines 58 and 64, for example by external forces acting on the motor 10, will be equalized across the orifices 44 and 44' so that the spools will remain centered (as shown) by their respective springs. The motor is then isolated from the primary pump, pilot pump and tank, providing a "neutral" or "hold" position for the motor 10.

The particular design of the spools 42 and 42' as related to simplicity of manufacture, cost and performance is also important. As previously described, the flow paths controlled by the spools is established by the

central chambers 50 and 50' and radial ports 46, 48 and 46', 48'. The orifices 44 and 44' which position the spools, communicate directly between the pilot chambers 38, 38' and the central chambers 50, 50' of the spools. Spools are relatively simple to manufacture and in cooperation with the radial ports 46, 48 and 46', 48' provide the desired pressure modulation characteristics of the fluid directed to and returning from motor 10.

The check valves 74 and 76 are conventional makeup valves to aid in preventing cavitation in the hydraulic motor 10 if and when external forces cause the motor to extend or retract faster than dictated by the main pump flow to the motor 10.

What is claimed is:

1. In a hydraulic valve for directional control of a hydraulic motor,
 - a valve body, the body defining a pair of axial bores each reciprocally housing a spool therein, the body further defining an inlet passage and an outlet passage, each intersecting the bores in axially spaced apart relation, and a pair of work ports for communication with the opposite sides of the hydraulic motor;
 - the spools being movable between a normal spring biased position blocking communication of the inlet and outlet passages with the work ports and first and second positions for respectively communicating the supply passage to one of the work ports and communicating the other work port with the outlet passage,
 - a first actuating means for moving one of the spools to its first position,
 - a second actuating means associated with the other spool responsive to displaced fluid flow from the motor to move the other of the spools to a position for unrestricted communication of the other work port with the outlet passage, the second actuating means being further responsive to flow of displaced fluid from the motor in excess of a predetermined amount to move the other spool out of its second position and progressively restrict communication between the work port and the outlet passage.
2. The valve of claim 1 wherein the first actuating means comprises a pilot actuating chamber associated with each spool, metering means being associated with the actuating chambers for metering pilot fluid thereinto at a rate proportional to the desired rate of flow of the pressure fluid from the supply passage to one of the work ports.
3. The valve of claim 2 wherein the metering means of each actuating chamber is in communication with the respective work port to combine the metered pilot fluid with the pressure fluid communicated from the supply passage for delivery to the respective work port.
4. The valve of claim 1 wherein each of the spools is cylindrical and is of substantially constant outer diameter throughout its axial length,
 - each spool also having a central axial chamber opening unrestrictedly to one end thereof for communication with the respective work port, and
 - each spool also having axially spaced apart radial ports for communication between the chamber and the spool bore, the axial spacing of the radial ports being different than the axial spacing for the intersections of the inlet and outlet passages with the bore so that when the spool is in its normal spring

biased position, communication between the chamber and the passages is blocked.

5. The valve of claim 4 wherein the actuating means for each spool includes a restrictive orifice arranged at the other end of the spool from its unrestricted opening to the respective work port.

6. A pilot operable control valve for regulating a double-acting fluid motor comprising

a valve body forming two axial bores, the valve body also forming inlet and outlet passages in axially spaced apart communication with the bores, a pilot fluid inlet port being formed in one end of each bore and a work port being formed in the other end of each bore for respective communication with the motor,

a spool reciprocally arranged in each bore, each spool having an axially formed chamber opening at one end into its bore adjacent the respective work port, each spool also forming a restrictive orifice at the other end thereof for communicating its axial chamber with its bore adjacent the respective pilot fluid inlet port, each spool also forming axially spaced apart radial ports for communicating the axial chamber with the spool bore, the axial spacing for the radial ports being less than the axial spacing between the inlet and outlet passages along the bore, and

means for normally urging each spool into a centered position where its radial ports are between and out of communication with the inlet and outlet passages,

the outlet passage being in communication with each bore between the inlet passage and the work port, each spool being movable toward the respective pilot fluid inlet port from its centered position to place one of its radial ports in communication with the outlet passage, each spool being further movable toward the pilot fluid inlet port to place its one radial port out of communication with the outlet passage.

7. A pilot operable control valve for regulating an extendible and retractable fluid motor, comprising

a valve body forming an axial bore, inlet and outlet passages in axially spaced apart communication with the bore, a pilot fluid inlet port in one end of the bore and a work port in the other end of the bore for communication with the motor,

a spool reciprocally arranged in the bore, the spool having an axially formed chamber opening at one end into the bore adjacent the work port and a restrictive orifice at the other end of the spool in communication between the axial chamber and the pilot fluid inlet port, the spool also having axially spaced apart radial ports situated between the inlet and outlet passages when the spool is in a centered position in the bore, and

means for normally urging the spool into its centered position,

the outlet passage being in communication with the bore between the inlet passage and the work port, the spool being movable from its centered position to initially position one of the radial ports in communication with the outlet passage and then to move the one port out of communication with the outlet passage.

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