

[54] FLUID MAKEUP SYSTEM

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[22] Filed: Apr. 13, 1970

[21] Appl. No.: 27,828

[52] U.S. Cl.60/52 R, 91/420, 91/452

[51] Int. Cl.F15b 15/18, F15b 11/08, F15b 13/042

[58] Field of Search91/420, 165, 166, 452; 60/52 R

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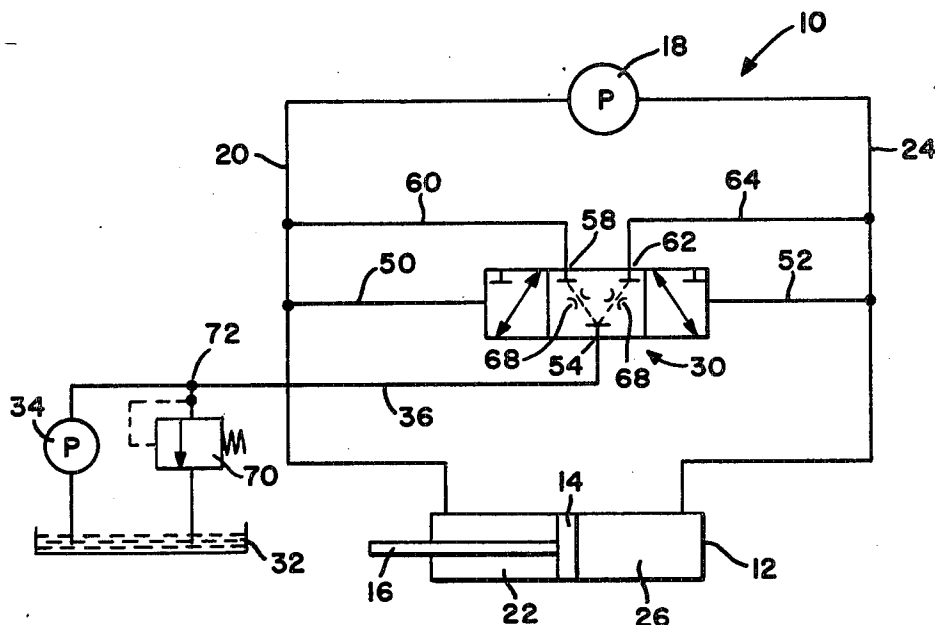
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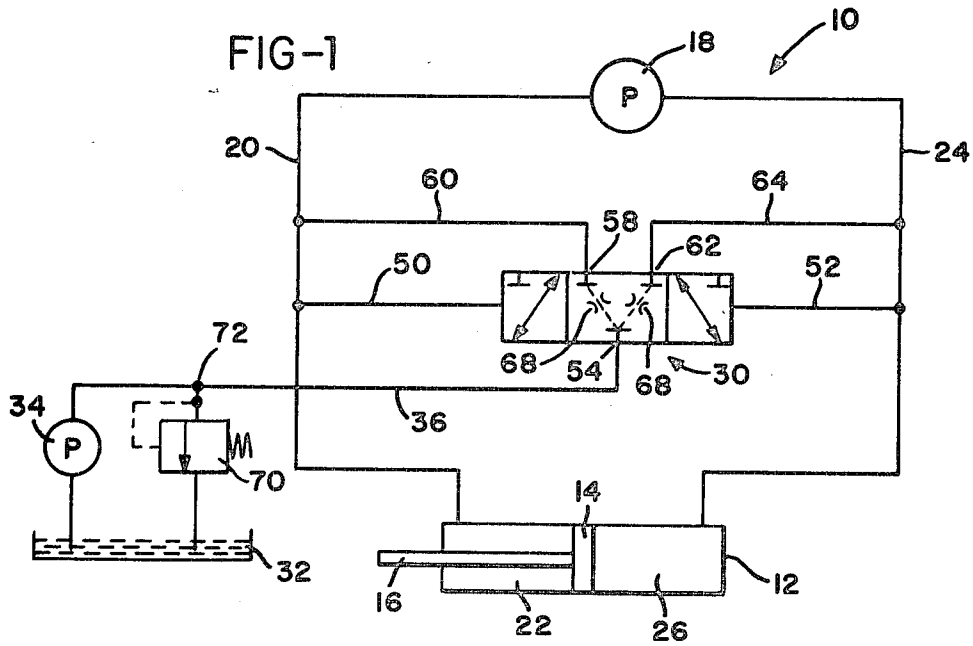
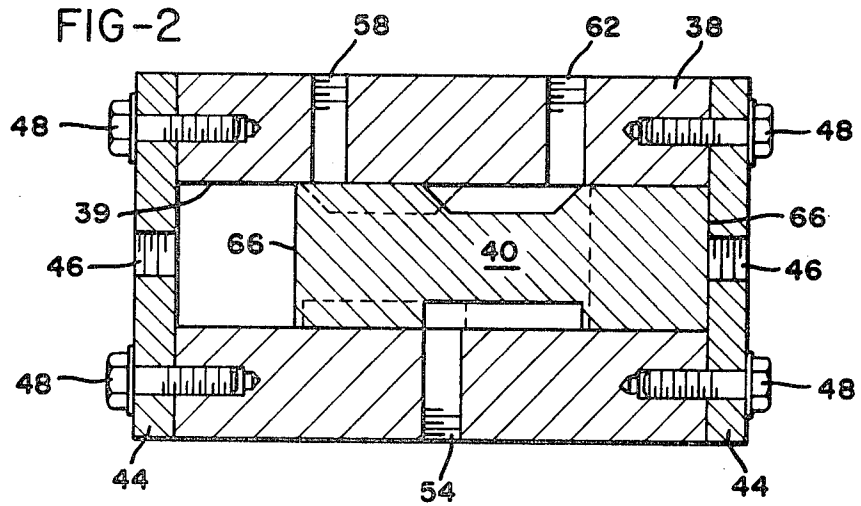
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[57] ABSTRACT

A closed-loop fluid makeup circuit is provided for a hydraulic piston system. A shuttle valve has an inlet and a pair of selectable outlets and is connected in parallel with the cylinder. A source of makeup fluid under pressure connected to the shuttle valve inlet. The shuttle valve has a spool positioned intermediate the inlet and outlets which is movable in response to the reversing pressure differentials between opposite sides of the cylinder to a first position during piston rod extension connecting the inlet with an outlet for adding makeup fluid to the circuit, and then to a second position during piston rod retraction connecting the inlet with an outlet for draining fluid from the circuit. A relief valve is connected between the shuttle valve and the makeup fluid source and permits the drained fluid to be expelled back to the source of recirculation.

6 Claims, 2 Drawing Figures





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FLUID MAKEUP SYSTEM

BACKGROUND OF THE INVENTION

The present invention relates to a fluid makeup system for closed-loop fluid circuits of the type which include a double-acting cylinder with a single-end rod and a reversible fluid pump or other fluid-control arrangement for alternately conveying fluid under pressure to the open side of the cylinder and then to the rod side of the cylinder. Because the rod displaces a certain volume of fluid the circuit must be alternately replenished with and drained of a corresponding volume of fluid.

Systems for performing the alternate adding and dumping functions have been devised in the past. However, most of the systems incorporate special valves in the circuit lines themselves. Such valves are often controlled by solenoids which require external electrical power.

Besides being cumbersome, such makeup systems necessitate that the entire circuit be immobilized to repair or replace the solenoid or other externally actuated member. Also, such integrated systems have the disadvantage of requiring considerable maintenance.

It is therefore desirable to provide a means of replenishing and draining such circuits which is not positioned directly in the circuit lines but which is an external adjunct to the circuit so that if the makeup system should fail the entire circuit would not be completely immobilized for repairs. Ideally, such a system is essentially maintenance free.

SUMMARY OF THE INVENTION

The present invention is directed to an improved system for replenishing and draining fluid from a closed-loop fluid circuit of the type described which provides unique and automatic means for replenishing and draining the loop which does not interrupt the flow through the circuit lines and is essentially maintenance free.

Generally, the makeup system includes a source of makeup fluid and a makeup pump, both of which are remote from the circuit, and a flow-control valve connected in parallel with the cylinder. The flow-control valve does not interrupt the flow through the closed-loop circuit and may also be positioned remotely therefrom.

In the preferred embodiment of the present invention, the flow-control valve is a shuttle-type valve in which a spool is responsive to the reversing pressure differentials between opposite sides of the circuit alternately to register the source of makeup fluid with the rod side of the cylinder to replenish the circuit and to register the open side of the cylinder with the source to drain the circuit.

When the open side of the cylinder is pressurized to extend the rod, the spool in the shuttle valve moves to a position permitting fluid to flow from the makeup pump into the circuit line on the rod side of the circuit. This fluid replaces the volume of fluid displaced by the rod when the piston is retracted. When the rod side of the cylinder is pressurized to retract the rod the spool moves to a position which permits fluid to be drained out of the circuit line on the open side of the cylinder. The volume of fluid drained corresponds to the volume of fluid displaced by the rod as it is retracted.

Also in the preferred embodiment, the makeup pump operates continuously. The system is provided with a relief valve which may be set at an opening pressure which will permit during extension of the rod both the continuously delivered makeup fluid rejected by the circuit and the fluid drained from the circuit to be expelled to the makeup fluid source for recirculation back through the makeup pump.

DETAILED DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic view of a closed-loop fluid circuit and showing the makeup system of the present invention; and

FIG. 2 is a cross-sectional view of a preferred type of flow-control valve for use in the makeup system of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In the embodiment of the invention illustrated in the drawings, the closed-loop fluid circuit 10 is shown in FIG. 1 as including a double-acting cylinder 12 having a piston 14 with a single rod 16 extending through an end of the cylinder 12. The circuit also includes reversible fluid supply means which may consist of a suitable flow control valve or a reversible pump 18, which may be a motor-driven oil hydraulic pump, for alternately delivering fluid under pressure through line 20 to the rod side 22 of the cylinder to retract the rod 16 in a left-to-right direction, and then delivering fluid through line 24 to the open side 26 of the cylinder to extend the rod 16 in a right-to-left direction.

The rod 16 will displace a volume of fluid in the cylinder as it is retracted, but no corresponding volume will be displaced on the opposite side of the piston, and accordingly the hydraulic system is inherently unbalanced. When the cycle is reversed and the rod 16 is extended the volume of fluid displaced must be replenished. It is therefore necessary to add fluid to the circuit as the rod is being extended to make up the fluid displaced by the rod when it is retracted, and then to drain fluid from the circuit as the rod is retracted to dump a volume of fluid displaced by the rod, which volume corresponds to that added in the preceding cycle.

In accordance with the preferred embodiment of the present invention, the makeup system includes a directional flow valve 30 connected effectively in parallel with the cylinder 12, a source 32 of the makeup fluid, such as a sump, tank or the like, and a makeup pump 34 for conveying makeup fluid under pressure from the source 32 through a line 36 to the valve 30.

FIG. 2 is a simplified diagram of a suitable directional flow valve 30. It is a shuttle valve which has a body 38 formed with a cylindrical bore 39 and a partial shuttle spool 40 therein. A pair of end plates 44 having threaded holes 46 aligned with the bore 39 are fastened to the valve body 38 by means of screws 48 are adapted to communicate each end of spool 40 with one side of the circuit 10. The line 50 connects the rod side 22 of the circuit with the left end of the spool 40 and the line 52 connects the open side 26 of the circuit with the right end of the spool 40, so that different pressures operating on opposite sides of the circuit will establish pressure differentials across the spool 40.

The shuttle valve 30 is provided with an inlet passage 54 for connecting with line 36 from the makeup pump 34. The inlet passage 54 is preferably located approximately centrally of the valve 30 on one side thereof. A first outlet passage 58 connects line 60 (FIG. 1) communicating with the piston rod side 22 of the cylinder and a second outlet passage 62 connects line 64 communicating with the open or back side 26 of the cylinder. The shuttle valve 30 is provided with means for controlling the extent of the reciprocal movement of the spool 40 in response to varying pressure differentials, and one such means may embody flat end surfaces 66 against which the fluid pressure on opposite sides of the circuit may act and which will contact the end plates 44 to define the limits of movement of the spool 40 and register the inlet passage 54 selectively with either the first outlet passage 58 (dotted-line position) or the second outlet passage 62 (solid-line position).

It is desirable to provide a bleed crossover path through the valve 30 between the port 54 and the ports 58 and 62, and this is diagrammatically illustrated at 68 in FIG. 1, and may be accomplished in production by suitably grooving or porting the spool 40, or by taper-grinding the spool. The bleed path 68 in the center position permits ease of initial system filling and venting, and prevents lockup which might otherwise occur in the absence of such a bleed path.

A relief valve 70 is connected to line 36 (FIG. 1) and is positioned between makeup pump 34 and shuttle valve 30. The valve 70 is adapted to open upon receipt of the fluid drained from the circuit and to permit this fluid to flow into the makeup source 32.

In operation, the pump 18 or other reversible flow-control device delivers fluid to the piston rod side 22 of the cylinder 12, and as the rod 16 begins to retract, creates a pressure on the rod side 22 of the circuit in line 20 greater than the pressure on the open side 26 of the circuit in line 24. The pressure differential across the spool 40 will move it from its central flow blocking position in a left-to-right direction to communicate passage 54 with passage 62 (solid-line position in FIG. 2). As the rod 16 retracts into the cylinder it displaces a volume of fluid corresponding to its displacement in the cylinder which will flow through line 64 to valve 30. From valve 30 the fluid will drain through the line 36 and be returned to the makeup source 32 through relief valve 70. When the pressures in the respective sides of the circuit equalize, the pressure differential across the spool 40 will disappear and the spool 40 will center and isolate line 36 from lines 60 and 64. For this purpose it may be desirable to employ a combination of centering springs (not shown) to assure a self-centering action of the valve spool 40.

During the return stroke, the pump 18 or other source reverses and begins to convey fluid through line 24 to the open side 26 of the cylinder 12, causing the pressure differential across spool 40 to act in the opposite direction. The spool 40 accordingly moves from right to left to communicate inlet passage 54 with outlet passage 58. The makeup pump 34 then delivers makeup fluid through line 36, valve 30, and line 60 to the rod side 22 of the circuit 10. When the pressures in the respective sides of the circuit equalize, the pressure differential will again disappear and the spool 40 will again assume its central flow-blocking position and isolate line 36 from lines 60 and 64. The cycles previously described will be repeated for each stroke of the piston.

It is preferred that makeup fluid be delivered to line 36 continuously so that the system will operate continuously without the necessity of using an expensive reversible makeup pump which would have to be synchronized with the reversible pump 18 in the main circuit. When pump 34 operates continuously and pump 18 is delivering fluid to the rod side 22 of the cylinder, then the makeup fluid being delivered by makeup pump 34 will be rejected by valve 30 and will converge at point 72 with the fluid being drained from the circuit through valve 30 and be expelled through relief valve 70 to the source 32 for recirculation.

Accordingly, the makeup system of the present invention automatically supplies fluid to the circuit and automatically drains fluid from the circuit without the necessity of in-line valving, and is therefore essentially an external adjunct to a closed-loop, hydraulic system. The system operates automatically in response to pressures created on opposite sides of the loop, and thus requires no external electrical-switching mechanisms. Because it is remote from the circuit, the system can be maintained without interrupting or disturbing the main loop, and its simple construction is very economical.

While the system herein described, and the form of apparatus for carrying the system into effect, constitute preferred embodiments of the invention, it is to be understood that the invention is not limited to this precise system and form of apparatus, and that changes may be made in either without departing from the scope of the invention.

What is claimed is:

1. In a closed-loop fluid-control circuit of the type which includes a double-acting cylinder having a piston and a piston rod extending therefrom operable from a reversible fluid supply source which alternately conveys fluid under pressure to a back side of the piston and then to the rod side of the piston to effect extension and retraction movement of said rod, the improved makeup system comprising, a source of makeup fluid under pressure, a flow-control valve having an inlet passage and a pair of selectable outlet passages and hav-

ing a directional flow valve member therein movable from a central flow-blocking position to a pair of flow-permitting positions selectably connecting said inlet passage with one of said outlet passages, means connecting said valve in the fluid circuit across said cylinder with said movable member being responsive to fluid pressures applied to said cylinder, and means connecting said makeup fluid source to said inlet passage so that during extension of the rod the valve member will move in one of said directions and apply makeup fluid from said source through one of said outlet passages to the rod side of said circuit and during retraction of the rod the valve member will move in the other direction and drain makeup fluid from the back side of said circuit through the other outlet passage.

2. In a closed-loop fluid-control circuit of the type which includes a double-acting cylinder having a piston with a single-actuating rod and a reversible fluid supply source which alternately conveys fluid to a back side of said cylinder and then to the rod side of said cylinder to effect extension and retraction movement of said rod, the improved makeup system comprising, a source of makeup fluid remote from said circuit, a makeup pump remote from said circuit for conveying fluid from said source to said circuit, a directional flow valve having an inlet passage and selectable first and second outlet passages, said passages being interrupted by a cylindrical bore, means at the ends of said bore connecting said valve in the circuit across said cylinder, a spool in said bore responsive to pressures acting at opposite ends thereof to move from a central flow-blocking position to a first position when said rod is extended to communicate said inlet passage with said first outlet passage and receive makeup fluid and replenish the circuit and then to move to a second position when said rod is retracted to communicate said inlet passage with said second outlet passage to drain makeup fluid from the circuit.

3. The makeup system of claim 2 including a relief valve connected between said makeup pump and the flow-control valve for allowing makeup fluid drained from the circuit to be expelled to said source for recirculation through said makeup pump.

4. The makeup system of claim 2 wherein said makeup pump operates continuously and the makeup fluid conveyed thereby is blocked by the flow-control valve when fluid is delivered to the rod side of the cylinder by the reversible fluid-supply source.

5. The makeup system of claim 2 wherein said directional flow valve is remote from said closed circuit.

6. In a closed-loop fluid circuit of the type which includes a double acting cylinder having a piston with a single actuating rod and a reversible fluid supply source for alternately conveying fluid to a back side of the cylinder and then to the rod side of the cylinder to effect extension and retraction movement of said rod, the improved makeup system which comprises, a source of makeup fluid remote from said circuit, a continuous makeup pump remote from said circuit for conveying fluid from said source to said circuit, a shuttle valve having an inlet passage connected to said makeup pump, a first outlet passage connected to the rod side of the cylinder, and a second outlet passage connected to the back side of the cylinder, means connecting said shuttle valve in the circuit across said cylinder, said shuttle valve having a cylindrical bore interrupting said passages and having a movable spool therein responsive to fluid pressures applied to said cylinder to selectively register said inlet passage alternately with the first and then the second outlet passage to first add makeup fluid to the circuit and then block makeup fluid and dump fluid from the circuit, and a relief valve connected between said makeup pump and said inlet passage and adapted to return makeup fluid blocked by the shuttle valve and fluid drained from the circuit to the source for recirculation through the makeup pump.

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