

United States Patent Griffiths

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[54] HYDRAULIC CONTROL CIRCUIT

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[58] **Field of Search** 91/41, 45, 436; 60/53, 52,
60/52 HE, 52 HD

[56] **References Cited**

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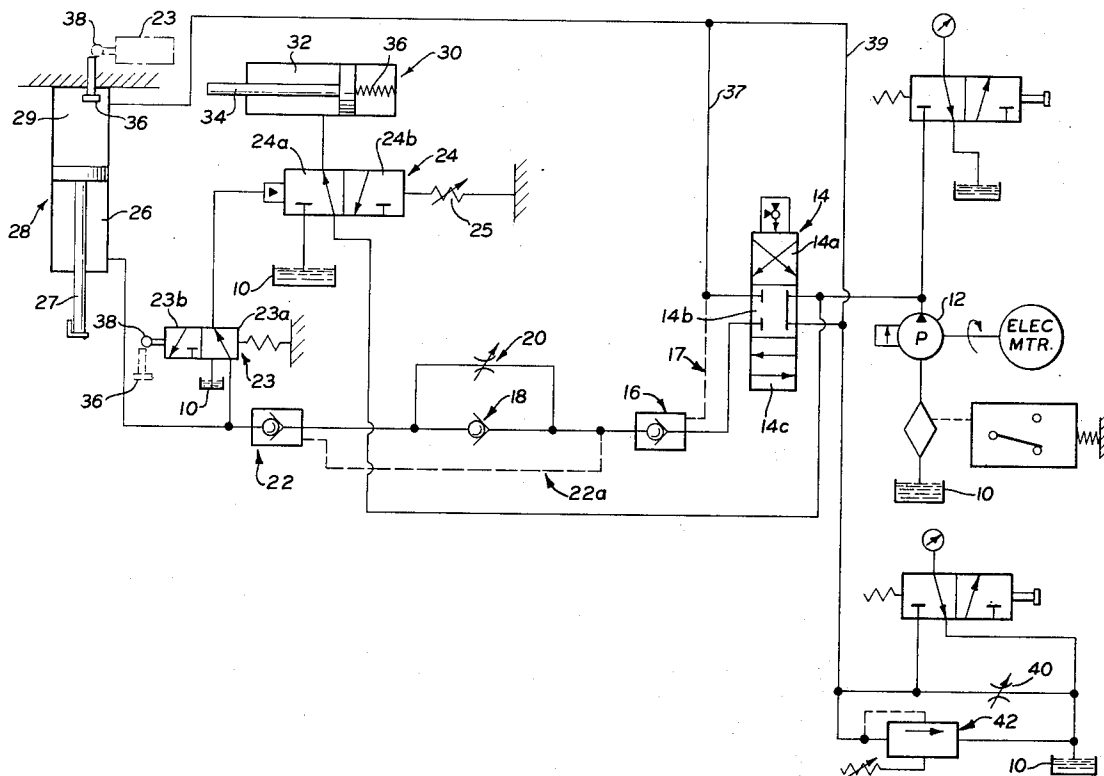
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ABSTRACT

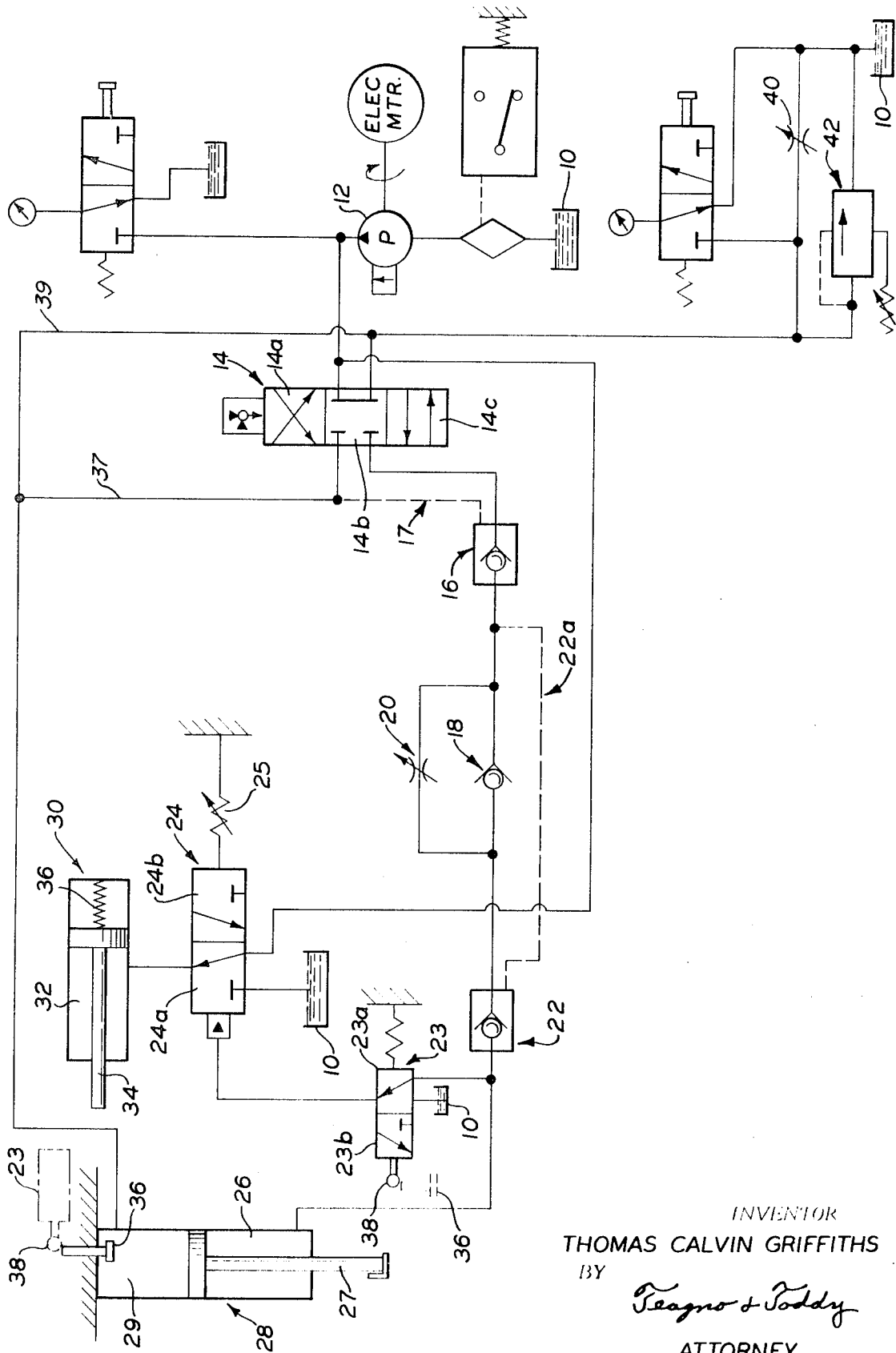
A hydraulic control circuit for raising or lowering a load includes a hydraulic ram having a movable load engaging piston therein and a pressure compensated hydraulic pump for supplying fluid thereto for raising a load. Means are provided in the circuit between the pump and the hydraulic ram for controlling the raising and lowering operations of the ram. Further means are provided for locking the position of the load in the event of mechanical or hydraulic failure of any portion of the load raising mechanism.

5 Claims, 1 Drawing Figure



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HYDRAULIC CONTROL CIRCUIT**BACKGROUND OF INVENTION****1. Field of Invention**

This invention relates to an automatic hydraulic system of the type which uses a pilot operated check valve for controlling, raising and lowering of a load lifting ram and wherein a hydraulic cylinder having hydraulic pressure on both sides of the piston is used to accomplish this purpose. More particularly, this invention relates to a new and novel means of supplying makeup fluid for this type of system. This invention also provides an automatic hydraulic circuit as described above which includes means for automatically preventing movement of the load lifting and lowering ram in the event of hydraulic or mechanical failure.

2. Discussion of the Prior Art

Prior art hydraulic circuits of the type to which this invention relates require the use of a special pump in addition to the main fluid supply pump. The purpose of this special pump is to supply hydraulic fluid pressure for pilot operation of certain check valves within the system. One example of such a prior art device is U.S. Pat. No. 3,455,209 issued July 15, 1969 to D. S. Preston et al. and assigned to the assignee of the instant invention. The Preston et al. patent discloses a hydraulic circuit for raising and lowering a load supported on the mast section of a stacker crane. The hydraulic circuit includes check valves which normally allow fluid flow in only one direction. Several of these check valves are provided with pilot operation whereby when flow is desired in the reverse direction through that portion of the circuit, the check valve can be opened by applying pressure to the pilot portion of the check valve. In the Preston device, the pressure necessary for pilot operation of these check valves is supplied by a special pump and hydraulic circuit. This is in addition to the main pump and hydraulic circuit normally used for raising and lowering the load carrying section of the stacker crane.

The instant invention accomplishes the results of the Preston et al. patent while eliminating the special pump and associated components which were previously required for pilot operation of the check valves. In addition, the hydraulic circuit of the instant invention provides a means for locking the position of the load in the event of catastrophic hydraulic or mechanical failure.

Thus, the instant invention provides a hydraulic circuit for accomplishing the stated purpose which is much simpler in construction and more economical to manufacture than the hydraulic circuits of the prior art.

SUMMARY OF THE INVENTION

This invention overcomes the complexities and problems of the prior art by inserting an additional pilot operated check valve in the high pressure side of the hydraulic circuit for the lifting cylinder and using the hydraulic pressure from the low pressure side of the hydraulic lifting cylinder to provide for pilot operation of this check valve. A flow restricting orifice is placed in the low pressure side of the hydraulic circuit between the cylinder and drain to cause the increase in pressure necessary for pilot operation of the check valve.

Thus, by using a pilot operated check valve and a flow restrictive orifice in a hydraulic circuit, a complex segment of the prior art control circuit which included a pump, various control valves, and the associated piping for connecting these components into the system has been eliminated.

This invention also makes more efficient use of components already within the system to accomplish the same result as the prior art device. Because of the arrangement of the system, when the hydraulic system is lowering the load and make-up fluid is required to prevent cavitation within the hydraulic system, make-up fluid is supplied by the cylinder itself. The load raising end of the hydraulic cylinder is the rod end. Consequently, whenever the load is moving, in either direction, the rod end of the cylinder can be made to be the high pressure end. By utilizing the flow restrictive orifice and another

pilot operated check valve, the instant invention eliminates the need for make-up fluid pump by providing make-up fluid from the rod end of the hydraulic cylinder to the blind end.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawing is a hydraulic schematic illustrating the features of the invention of the present application.

DESCRIPTION OF A PREFERRED EMBODIMENT

Hydraulic circuits for controlling the operation of a hydraulic ram functioning to raise and lower loads are common in the art. The primary objective of hydraulic designers is to control the operation of the hydraulic lifting and lowering ram in the most efficient and safe manner possible. The present application discloses a hydraulic circuit of general application for obtaining high hydraulic efficiency coupled with failsafe operation of the hydraulic lifting and lowering ram in an effective and unique manner.

Referring now to the drawing for purposes of a description of the invention of the present application, hydraulic fluid is drawn from a reservoir or tank 10 at substantially atmospheric pressure by a pressure compensated electrically driven pump 12. Pressurized fluid from the pump 12 is supplied to a servo type proportional control valve 14. The control valve 14 includes a first cross flow position or section 14a, a second no-flow position or section 14b and a third parallel flow position or section 14c. As the valve spool is moved from position 14a to 14b the flow in the direction of the arrows shown gradually decreases to zero. Conversely, as the valve spool is moved from position 14b to 14c, the flow in the direction of the arrows gradually increases. When the control valve 14 is in the position shown in the drawing, the no-flow portion 14b prevents hydraulic fluid flow from the pump 12 therethrough. If the control valve 14 is shifted so that the portion 14a is moved downwardly to the position of 14b in the drawing, then fluid flow from the pump 12 is across the control valve 14 to a pilot operated check valve 16 where it encounters a parallel network comprising a check valve 18 and a variable orifice 20.

Beyond the check valve 18 and the variable orifice 20, the hydraulic fluid flow encounters a second pilot operated check valve 22. From the second pilot operated check valve 22 the high pressure fluid passes through a cam actuated valve 23 to a pressure actuated control valve 24. From the second pilot operated check valve 22, high pressure hydraulic fluid is also supplied to the lifting side 26 of a hydraulic lifting ram 28. The pressure actuated control valve 24 contains a first fluid control portion 24a which controls high pressure fluid flow to a ram locking cylinder 30. When in the positions shown in the drawing, the cam actuated valve 23 and the pressure actuated control valve 24 permit high pressure fluid to be supplied to the rod end 32 of the lock cylinder 30 thereby causing a retraction of the piston and rod 34 against the force of a spring 36 located in the blind end of the cylinder 30. The locking cylinder 30 operates upon the hydraulic ram 28 for the purpose of locking the hydraulic ram in a certain position upon a loss of pressure in the rod end 26 thereof in a manner to be more fully described hereinafter.

The cam actuated valve 23 and the locking control valve 24 are normally maintained in the positions 23a and 24a respectively as shown in the drawing. However, if a hydraulic failure occurs resulting in a loss of hydraulic pressure in the rod end 26 of the hydraulic ram 28, the locking control valve 24 will be moved (toward the left in the drawing) by a compression spring 25 and thereby connect portion 24b of the locking control valve 24 into the hydraulic circuit in place of portion 24a.

Conversely, if a mechanical failure occurs resulting in loss of the load on the hydraulic ram 28, the hydraulic ram 28 will surge upward and engage link 36 which will move cam 38 of cam actuated valve 23. This movement will shift valve 23 from position 23a in which high pressure fluid acts on pressure actuated control valve 24 to position 23b in which cam actuated valve 23 vents pressure actuated control valve 24 to drain 10,

thereby allowing spring 25 to move control valve 24 from position 24a to 24b.

When control valve 24 is in position 24b, the rod end 32 of the cylinder 30 is vented to tank 10 which permits the compression spring 36 to move the rod and piston 34 of cylinder 30 into locking engagement with the hydraulic ram assembly 28.

From the foregoing it can be seen that when the servo type proportional control valve 14 is operated so that the portion 14a is moved to the position of 14b in the drawing, pressurized hydraulic fluid will be supplied by the pump through the pilot operated check valve 16, the parallel arrangement of check valve 18 and variable orifice 20 and then pilot operated check valve 22 to the rod end 26 of the hydraulic ram assembly 28. The flow of pressurized hydraulic fluid into the rod end 26 of the hydraulic ram assembly 28 will, of course, result in an upward movement of the piston and rod 27 thereof. The piston and rod 27 is adapted to be attached to a load lifting and lowering mechanism of any suitable type. The pressurized hydraulic fluid also operates on the locking control valve 24 to maintain the locking control valve in the position of 24a thereof against the force of the spring 25. With the locking control valve 24 in the position 24a, pressurized hydraulic fluid is also supplied across the portion 24a to the rod end 32 of the locking cylinder 30 in a manner which maintains the piston and rod 34 retracted against the force of the spring 36. As pressurized hydraulic fluid is being supplied to the rod end 26 of the hydraulic ram assembly 28, fluid must, of course, be exhausted from the blind end 29 of the hydraulic ram assembly 28. Fluid being exhausted from the blind end 29 passes through parallel conduits 37 and 39 and through a pressure control orifice 40 to the tank 10. Also located in the exhaust line and hydraulically in parallel with the adjustable pressure control orifice 40 is a pressure relief valve 42 which serves to vent the exhaust line to tank 10 if the pressure in the exhaust line becomes excessive. If the servo type proportional control valve 14 is moved toward the position where portion 14c thereof would be in communication with the pump 12, the hydraulic control system would operate in the following manner. Pressurized fluid would be supplied across the control valve 14 to the blind end 29 of the hydraulic ram assembly 28 thereby causing the piston and rod 27 to be moved downwardly therein. High pressure hydraulic fluid would also be supplied to the pilot portion 17 of the pilot operated check valve 16 thereby causing the check valve 16 to open and permit the flow of hydraulic fluid thereacross in a direction from left to right in the drawing. Since hydraulic fluid is incompressible as is well known in the art, the piston cannot move and fluid cannot actually flow into the blind end of the cylinder until fluid is taken from the rod end of the cylinder.

Consequently, some of the excess pressurized fluid from the pump 12 will pass through conduit 39 and across orifice 40 to drain. Orifice 40 due to flow thereacross will create a back pressure signal on the fluid flowing through the conduit 39. This back pressure signal passes along conduit 39 through the lowermost port in valve 14, across the now open check valve 16 to conduit 22a, to thereby open pilot operated check valve 22.

As will be evident to those skilled in the art, the pressure supplied by the pump 12 will be the same throughout all portions of the hydraulic circuit exposed thereto. Thus, this pressure acting alone would be ineffective to lower the ram. However, as is also well known in the art, and as shown in the drawing, the rod end area of the piston is inherently smaller than the blind end area, consequently a resultant force equal to pressure times (blind end area minus rod end area) will exist on the ram. This force will cause fluid to flow from the rod end 27, of the hydraulic cylinder 28 to thereby lower the load attached thereto.

Furthermore, since a load is attached to the rod 27, that additional downward force will further aid in causing fluid to flow from the rod end 27, of cylinder 28.

In lowering of the ram, fluid flows from the rod end 27 of cylinder 28, across pilot operated check valve 22, orifice 20, now open pilot operated check valve 16, control valve 14 and conduit 39 to mix with fluid from pump 12 at the juncture of conduits 37 and 39 to be used as makeup fluid for blind end 29 of cylinder 28.

The fluid necessary to prevent cavitation during operation of the system passes to the blind end of the cylinder, the excess passes across variable orifice 40 to drain thereby creating the back pressure necessary for keeping the pilot operated check valves in the system open.

The predetermined minimum pressure being maintained by the pressure control orifice 40 is also sufficient to maintain the locking control valve 24 in the position shown in the drawing so that the portion 24a thereof remains in communication with the pump pressure and supplies pressurized fluid to the rod end 32 of the locking cylinder 30 thereby maintaining the locking cylinder 30 in a retracted position and ineffective to prevent movement of the hydraulic ram assembly 28.

Further to be considered as an important feature of this invention is the fact that during exhaust of fluid from the rod end 26 of the hydraulic ram assembly 28 during lowering of the piston and rod 27 is that the pressure control orifice 40 generates a sufficient pressure in the exhaust line of the circuit so as to cause a recirculation of the hydraulic fluid being exhausted into the blind end 29 of the hydraulic ram assembly 28 thereby effecting an increase in the efficiency of operation of the hydraulic circuit. In other words, the exhausted fluid from a rod end 26 of the hydraulic ram assembly 28 supplies make-up fluid to the blind end 29 as the piston as rod 27 moves downwardly. The hydraulic control circuit of the present invention therefore eliminates the need for a secondary or make-up pump prevalent in the prior art devices.

I now claim:

1. A hydraulic control circuit for operating a hydraulic ram comprising:

- a source of hydraulic fluid;
- a pump operatively connected to the source of fluid for drawing fluid therefrom;
- a hydraulic ram including a piston and rod adapted to be extensibly and retractably driven by pressurized fluid from the pump;
- a control valve operatively associated with the output of the pump for selectively controlling fluid flow from the pump to the hydraulic ram and from the ram to the source of fluid;
- a first flow restricting means for generating a back pressure in the fluid between the hydraulic ram and the source of fluid in response to operation of said pump;
- a first pilot operated check valve disposed to normally prevent flow from the rod end of said ram to said source, the pilot of said first check valve being operated to open said first check valve in response to a pretermined fluid pressure between said pump and the blind end of said ram;
- a second check valve disposed to normally prevent flow from the rod end of said ram to said source;
- a second flow restricting means disposed in parallel with said second check valve to regulate flow from the rod end of said ram to said source; and
- a third pilot operated check valve disposed to normally prevent flow from the rod end of said ram to said source, the pilot of said third check valve being operated to open said third check valve in response to a pretermined back pressure being generated by said first flow restricting means which is located between said ram and said source of fluid.

2. The hydraulic control circuit as defined in claim 1 wherein a connecting means extends between an exhaust line from the rod end of the hydraulic ram and the blind end of the hydraulic ram during extension of the hydraulic ram, whereby fluid from the rod end may be mixed with pump pressurized fluid for supply to the blind end of said ram.

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3. The hydraulic control circuit defined in claim 2 further comprising a locking cylinder operatively associated with the hydraulic ram for preventing movement thereof upon loss of hydraulic pressure at the rod end of the hydraulic ram.

4. The hydraulic control circuit defined in claim 3 further comprising a pressure actuated control valve connected to the exhaust line from the rod end of the hydraulic ram for normally supplying pump pressure to the locking cylinder to prevent locking operation thereof on the hydraulic ram.

5. The hydraulic control circuit defined in claim 4 further comprising resilient means biasing the pressure actuated control valve toward a position relieving hydraulic pressure in the locking cylinder and permitting operation of the locking cylinder upon the hydraulic ram to prevent movement thereof upon a loss of hydraulic pressure in the exhaust line from the rod end of the hydraulic ram.

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