

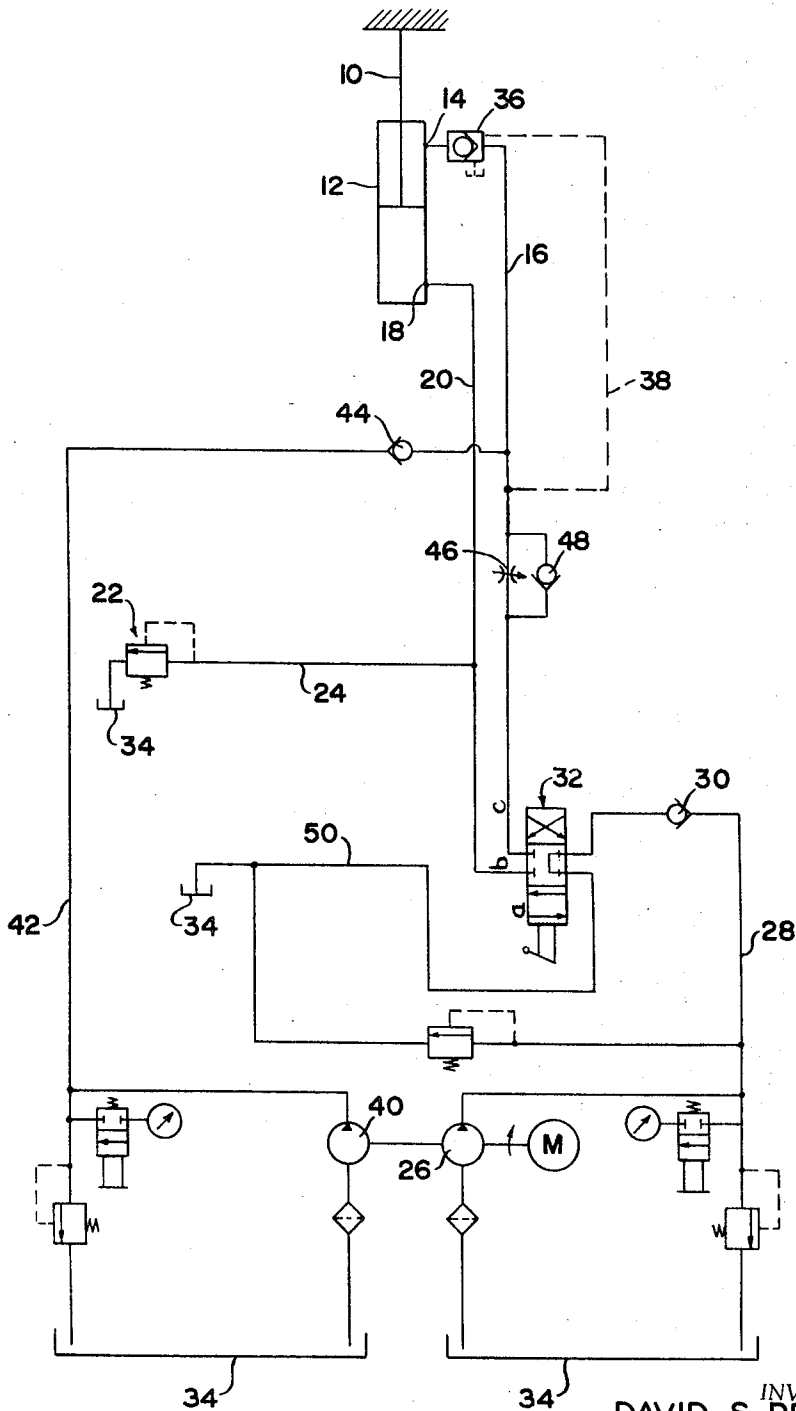
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HYDRAULIC CONTROL CIRCUIT

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HYDRAULIC CONTROL CIRCUIT

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5 Claims

ABSTRACT OF THE DISCLOSURE

A hydraulic control circuit for a hydraulic piston and cylinder which raises and lowers heavy loads having: (a) a fail safe mechanism including a pilot operated check valve at the high pressure port of the cylinder and a pilot pressure line in parallel with the high pressure line, such that failure of either line causes a loss of pilot pressure, closing the check valve; and/or (b) a low pressure fluid back fill circuit connected to the dead end of the cylinder, which keeps the cylinder always filled with fluid, reducing reservoir and heat exchange requirements.

This invention relates to the art of machine control mechanisms, and more particularly to a hydraulic control circuit.

The present invention is particularly applicable to controlling the operation of materials handling equipment, such as cranes, fork-lifts and the like, and it will be described with particular reference thereto; however, it will be appreciated that the invention has broader applications and may be used to control the operation of other types of machines.

In a class of materials handling equipment known in the trade as "stacker cranes," heavy loads, and in some designs even portions of the cranes, such as telescoping mast sections, are raised under force of hydraulic fluid, held suspended by hydraulic pressure while the loads are translocated, and then lowered by the weight of the load or the combined weight of the load of suspended crane portions.

Hydraulic control circuits for such equipment usually include a piston and a cylinder coactive for relative movement therebetween; a port in the cylinder; high pressure conduit means communicating with the port; a source of high pressure fluid; a fluid reservoir; control valve means connected to the high pressure conduit means, and operative selectively to communicate the source of high pressure fluid and the fluid reservoir with the high pressure conduit means.

Almost invariably, the hydraulic control systems for a stacker crane include flexible hose portions to permit full manipulation of the crane. These hoses deteriorate in time as a result of exposure to high pressure, heat and fatigue through flexure. Since rupture of the hoses is an ever-present danger, safety devices should be provided to protect personnel and equipment against injury and damage due to loss of hydraulic pressure through a ruptured hydraulic hose.

The present invention contemplates a fail safe mechanism which will hold the load and suspended crane portions in a fixed position in the event of a failure of hydraulic pressure.

In accordance with the present invention, a fail safe mechanism operative to stop relative movement between the piston and cylinder in the event of fluid pressure failure is provided, comprised of a pilot operated check valve positioned in line with the high pressure conduit means near the cylinder port, the check valve being operative to close upon loss of pilot pressure; and a pilot pressure line communicating the check valve with the high pressure conduit means at a point near the control

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valve means, whereby failure of pressure in the high pressure conduit means causes a loss of pressure in the pilot pressure line, closing the check valve.

Hydraulic equipment for raising and lowering heavy mass usually employs a single acting piston, the load being lowered by simple bleeding of the fluid from the pressure end of the piston. Such a system presents problems of leakage past the piston and other difficulties.

The invention also contemplates a hydraulic control circuit of the type described having improved efficiency by employing a double acting hydraulic cylinder and maintaining the blind end of the cylinder back-filled with hydraulic fluid under nominal pressure. Thus, substantially the entire volume of the cylinder is kept filled with hydraulic fluid at all times. This arrangement reduces the size of the fluid reservoir needed for a given system, and serves as a heat exchanger for hydraulic fluid, reducing or eliminating the requirement for external cooling means.

In accordance with this aspect of the invention, there is provided additionally a second port communicating with the interior of the cylinder member near the opposite end thereof for admitting low pressure fluid when the mass is lowered and withdrawing low pressure fluid when the mass is raised; a low pressure relief valve; a low pressure conduit communicating the relief valve with the second cylinder port for maintaining fluid at a predetermined low pressure head; and a multi-position control valve operative selectively to communicate the high pressure conduit with the source of high pressure fluid and with the fluid reservoir, and selectively to communicate the low pressure conduit with a source of low pressure fluid and with the fluid reservoir, the control valve having one position effective to raise the mass under force of hydraulic fluid, wherein the high pressure source is in communication with the high pressure conduit and the first cylinder port, and the second port and low pressure conduit are in communication with the fluid reservoir, the control valve having another position effective to permit the mass to be lowered, wherein the first cylinder port and the high pressure conduit are in communication with the fluid reservoir and the source of high pressure fluid is in combination with the low pressure conduit, the relief valve and the second cylinder port.

It is, therefore, an object of the invention to provide an improved hydraulic control circuit.

Another object of the invention is to provide a hydraulic control circuit with a fail safe mechanism of improved construction.

A further object of the invention is to provide a hydraulic control circuit of improved efficiency.

These and other objects and advantages will become apparent from the detailed description of a preferred embodiment of the invention when read in connection with the accompanying drawing, in which the sole figure is a schematic circuit diagram illustrating a preferred embodiment of the present invention.

Referring now to the drawing, wherein the showings are for purposes of illustrating a preferred embodiment of the invention only and not for purpose of limiting the same, the figure shows a hydraulic control circuit comprised of piston 10 and cylinder 12 coactive for relative movement therebetween. As shown in the preferred embodiment, piston 10 is fixed, while cylinder 12 is mounted for relative movement with respect to the piston. It will be understood however, that the arrangement can be reversed, making cylinder 12 fixed and piston 10 movable with respect to the cylinder.

In the arrangement illustrated, a mass (not shown) is suspended from cylinder 12 for movement therewith. As applied to a stacker crane, the mass may take the form of a load to be moved from one place to another, or the combination of such a load with suspended portions of

the crane. The circuit illustrated is operative to raise the mass under force of hydraulic fluid, and lower the mass under its own weight.

The hydraulic control circuit further comprises a port 14 near one end of cylinder 12 for admitting high pressure fluid when the mass is raised. High pressure conduit means such as line 16 is provided to supply high pressure fluid to cylinder 12 through port 14.

Cylinder 12 is further provided with a second port 18 positioned near the opposite end thereof for admitting low pressure fluid when the mass is lowered and withdrawing low pressure fluid when the mass is raised. Low pressure conduit means such as line 20 communicates low pressure fluid with port 18 and cylinder 12. Low pressure relief valve 22 communicates with line 20 to maintain low pressure hydraulic fluid at a predetermined head. Relief valve 22 communicates with fluid reservoir 34.

The circuit is further provided with a source of high pressure fluid, such as pump 26 driven by motor M. Hydraulic fluid from pump 26 travels through line 28, check valve 30 and into valve means for controlling relative movement between piston 10 and cylinder 12, which may take a variety of forms but in the preferred embodiment illustrated, takes the form of a multi-position control valve 32.

High pressure line 16 is provided with pilot operated check valve 36 positioned near port 14, and the valve is provided with pilot pressure line 38 which runs parallel to high pressure line 16 connecting with the latter at a point near multi-position control valve 32. Consequently, the same pressure which is present in line 16 is also present in pilot pressure line 38, to activate pilot operated check valve 36. Pilot pressure fluid is also provided by pilot pressure pump 40, communicating with line 42, check valve 44 which in turn communicates with high pressure line 16.

High pressure line 16 is also provided with adjustable needle valve 46 and check valve 48 in parallel. Check valve 48 is designed to permit hydraulic fluid to pass from multi-position control valve 32 to port 14, but not in the opposite direction. Fluid can flow through needle valve 46 in both directions.

The positions of multi-position control valve 32 are marked *a*, *b* and *c* in the drawing. Position *a* is effective to raise the mass under force of hydraulic pressure, by providing communication from pump 26 through line 28, check valve 30, high pressure line 16, pilot operated check valve 36, port 14, and cylinder 12. The force of hydraulic fluid forces cylinder 12 to raise itself against stationary piston 10. Position *a* of multi-position control valve 32 also communicates port 18 and line 20 with lines 50 and reservoir 34, and line 24 through pressure relief 22 to reservoir 34. Thus, as cylinder 12 is raised low pressure fluid is forced out of the bottom of the cylinder through port 18, line 20 and thence through lines 24, 50 to reservoir 34. The low pressure head is maintained on this part of the system by relief valve 22.

In order to stop the relative movement between cylinder 12 and piston 10 at any point, multi-position control valve 32 is moved to position B. In this position, lines 16, 20 are blocked with respect to lines 28, 50. In this manner, cylinder 12 is held in a fixed position, subject to slight movement due to leakage of high pressure fluid in the top half of the cylinder, past the head of piston 10 into the lower pressure chamber in the bottom half of the cylinder. A pressure built up in the bottom half of the cylinder is prevented by pressure relief valve 22. In position *b*, the supply of fluid from pump 26 passes through valve 32 to line 50 and thence, to reservoir 34.

To lower the mass suspended from cylinder 12, multi-position control valve 32 is moved to position *c*. Under the weight of the mass suspended from cylinder 12, high pressure fluid travels out of the cylinder through port

14, pilot operated check valve 36, high pressure line 16, needle valve 46, through line 50 and into reservoir 34. Due to the positioning of check valve 48, all of the high pressure fluid travels through needle valve 46, which limits the rate of descent of the mass suspended from cylinder 12.

The lowering of the mass permits the entry of additional low pressure fluid through line 20, port 18 and into the interior of the lower portion of cylinder 12. This fluid comes from the high pressure line 28, through check valve 30, where the high pressure fluid is vented by relief valve 22, providing a source of low pressure fluid into line 20, port 18 and the interior of cylinder 12. Excess hydraulic fluid traveling through line 24, relief valve 22 enters reservoir 34.

As previously described, pilot operated check valve 36 will remain open only so long as pilot pressure of a predetermined minimum head is present on line 38. During raising of the mass, when high pressure fluid communicates with line 16, and port 14, the same high pressure fluid is present in pilot pressure line 38. However, when the mass is lowered, the pressure in line 16 may drop to a level below the predetermined minimum required to maintain pilot operated check valve 36 open. In this event, supplemental pilot pressure generated by pump 40 travels through line 42, check valve 44 and into high pressure line 16. Due to the interconnection of high pressure line 16 and pilot pressure line 38, this auxiliary pressure will maintain a minimum predetermined pilot pressure in line 38.

In the event that high pressure line 16 ruptures, due to a failure of a flexible portion thereof, pilot pressure in line 38 will immediately be lost, due to the parallel arrangement of line 38 with line 16. With a loss of pilot pressure, pilot operated check valve 36 will close, sealing high pressure fluid within the upper portion of cylinder 12. This in turn will cause a stoppage of relative movement between cylinder 12 and piston 10. This fail safe mechanism will prevent an uncontrolled descent of the mass suspended from cylinder 12, preventing injury to personnel and damage to equipment.

As will be noted, substantially the entire volume of cylinder 12 is maintained filled with hydraulic fluid, by keeping the dead end of the cylinder back filled with low pressure hydraulic fluid through line 20 and port 18. In this way, the size of the reservoir required for the system is substantially reduced. In addition, the travel of hydraulic fluid through the low pressure lines and into the lower half of the cylinder, permits some of the heat in the fluid to transfer to the lines and the cylinder, thus, reducing or eliminating the requirement for external cooling means.

Having thus described our invention, we claim:

1. A hydraulic control circuit comprised of a piston and a cylinder coactive for relative movement therebetween; a port in said cylinder; a source of high pressure fluid; a fluid reservoir; control valve means remote from said piston and cylinder; a first high pressure conduit means communicating said source and said reservoir with said control valve means; a second high pressure conduit communicating with said port and said control valve means; said control valve means being operative selectively to communicate said source of high pressure fluid and said fluid reservoir with said second high pressure conduit means; and a fail safe mechanism operative to stop relative movement between said piston and said cylinder in the event of fluid pressure failure; comprised of a pilot operated check valve positioned in line with said high pressure conduit means near said cylinder port, said check valve being operative to close upon loss of pilot pressure; and an independent pilot pressure line in parallel with and communicating said check valve with said second high pressure conduit means at a point near said control valve means, whereby failure of pressure in said second high pressure conduit means causes a loss of pressure in said pilot pressure line, closing said check valve.

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2. The hydraulic control circuit as defined in claim 1, further comprising a source of low pressure fluid, of a head great enough to actuate said pilot operated check valve; low pressure conduit means communicating said source of low pressure fluid with said second high pressure conduit means, and via the last mentioned means, with said pilot pressure line; and a check valve in said low pressure line and operative to permit fluid flow only in a direction from said low pressure source to said second high pressure conduit, whereby during normal operation of said control circuit a head of pressure great enough to actuate said pilot operated check valve is always present in said pilot pressure line.

3. A hydraulic control circuit operative to raise a mass under force of hydraulic fluid and lower a mass under its own weight comprising: a cylinder member; a piston member mounted therein, wherein one of said members is fixed, and the other of said members is movable along a reciprocative path, said movable member being adapted to support a mass whereby movement in one direction along said reciprocative path raises said mass, and movement in the opposite direction along said reciprocative path lowers said mass; a first port communicating with the interior of said cylinder member near one end thereof, for admitting high pressure fluid when said mass is raised and withdrawing high pressure when said mass is lowered; a high pressure conduit connected to said first port; a second port communicating with the interior of said cylinder member near the opposite end thereof for admitting low pressure fluid when said mass is lowered and withdrawing low pressure fluid when said mass is raised; a low pressure relief valve; a low pressure conduit communicating said relief valve with said second port for maintaining said low pressure fluid at a predetermined head; a source of high pressure fluid; a fluid reservoir; a multi-position control valve operative selectively to communicate said high pressure conduit with said source of high pressure fluid and with said fluid reservoir, and selectively to communicate said low pressure conduit with said source of high pressure fluid and with said fluid reservoir, said control valve having one position effective to raise said mass under force of hydraulic fluid, wherein said high pressure source is in communication with said high pressure conduit and said first cylinder port, and said second cylinder port and low pressure conduit are in communication with said fluid reservoir, said control valve having another position effective to permit said mass to be lowered under its own weight, wherein said first cylinder port and said high pressure conduit are in communication with said fluid reservoir and said source of high pressure fluid is in communication with said low pressure conduit, said relief valve and said second cylinder port; and a fail safe mechanism operative to stop relative movement between said piston member and said cylinder member in the event of fluid pressure failure, comprising a pilot operated check valve interposed between said first port and said three position control valve in said high pressure conduit means, said check valve being operative to close upon loss of pilot pressure; and an independent pilot pressure line in parallel with and communicating said check valve with said high pressure conduit means, whereby failure of pressure in the latter causes a loss of pilot pressure closing said check valve.

4. The hydraulic control circuit as defined in claim 3, wherein said high pressure conduit is provided with an adjustable needle valve and a check valve in parallel, said check valve permitting fluid flow only in a direction from said control valve to said first cylinder port, whereby fluid withdrawn from said cylinder through said first port upon lowering said mass passes only through said needle valve

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at a rate controlled thereby, while fluid entering said cylinder through said first cylinder port, upon raising said mass, passes through both said needle valve and said check valve in parallel therewith.

5. A hydraulic control circuit including a cylinder member; a piston member mounted therein, wherein one of said members is fixed, and the other of said members is movable along a reciprocative path; work producing means suspended from and movable with said movable member for movement between a position of higher potential energy and a position of lower potential energy, a first port communicating with the interior of said cylinder member near one end thereof for admitting and withdrawing high pressure fluid; a second port communicating with the interior of said cylinder member for admitting and withdrawing low pressure fluid, a relief valve communicating with said second port for maintaining said low pressure fluid at a predetermined head; a source of high pressure fluid; a fluid reservoir; valve means for controlling relative movement between said piston member and said cylinder member, comprising a three position control valve, having (1) a first position operative to communicate said source of high pressure fluid via high pressure conduit means with said first port, and communicate said fluid reservoir via low pressure conduit means with said second port, causing said movable member to move in one direction along its reciprocative path and said work producing means suspended therefrom to move from a position of lower potential energy to a position of higher potential energy; (2) a second position operative to block communication between said source of high pressure fluid and said first port, and to block direct communication between said fluid reservoir and said second port, whereby said movable member and said work producing means suspended therefrom are held in fixed positions; and (3) a third position operative to communicate said fluid reservoir with said first port and to communicate said source of high pressure fluid with said relief valve and said second port, causing said movable member to move in an opposite direction along its reciprocative path, under the urging of said work producing means suspended therefrom, moving from a position of higher potential energy to a position of lower potential energy; and a fail safe mechanism operative to stop relative movement between said piston member and said cylinder member in the event of fluid pressure failure, comprising a pilot operated check valve interposed between said first port and said three position control valve in said high pressure conduit means, said check valve being operative to close upon loss of pilot pressure; and an independent pilot pressure line in parallel with and communicating said check valve with said high pressure conduit means, whereby failure of pressure in the latter causes a loss of pilot pressure closing said check valve.

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