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Kubik

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[54] **FLUID SYSTEM HAVING POSITIVE VERTICAL HOLD MEANS**

[76] Inventor: **Philip A. Kubik,** 6809 Sprice Dr., Birmingham, Mich. 48010

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Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 91,949, Nov. 23, 1970, Pat. No. 3,713,291.

[52] **U.S. Cl.** **60/444,** 60/460, 60/461, 91/420

[51] **Int. Cl.** **F15b 15/18**

[58] **Field of Search** .... 60/446, 444, 460, 461, 60/406, DIG. 2; 91/420

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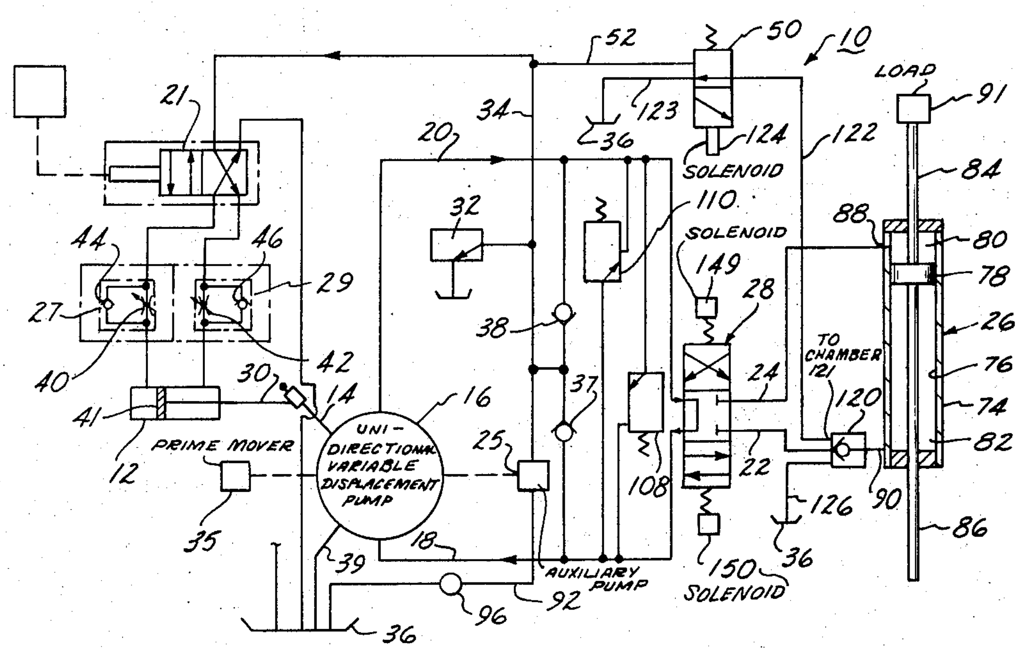
Primary Examiner—Edgar W. Geoghegan
Attorney, Agent, or Firm—Weiner, Basile and Weintraub

[57] **ABSTRACT**

A fluid system having a variable displacement fluid pump connected in a closed-loop fashion to a fluid cylinder having a piston and a pair of connecting rods extending from opposite sides of the piston and externally of the fluid cylinder with one rod supporting a vertically displacable load. A directional flow control valve connected to the inlet and outlet of the fluid pump selectively directs fluid to pressure chambers within the fluid cylinder on opposite sides of the piston to reciprocate the same within the fluid cylinder and displace the load. The lower pressure chamber of the fluid cylinder, which is exhausted during a downward stroke of the piston, is in communication with the pump via the directional flow control valve and a pilot operated check valve which, in its normally closed position, permits fluid flow from the pump outlet through the directional flow control valve to the lower pressure chamber while preventing fluid flow from the lower pressure chamber to the pump inlet and thereby maintaining the load at any desired vertical position. An independent source of fluid, maintained at a constant pressure, is selectively connected to the pilot operated check valve to open same to permit an unrestricted communication between the lower pressure chamber of the fluid cylinder and the directional flow control valve when the same is shifted to communicate high pressure fluid from the pump outlet to the upper pressure chamber of the fluid cylinder to move the load downwardly.

5 Claims, 3 Drawing Figures



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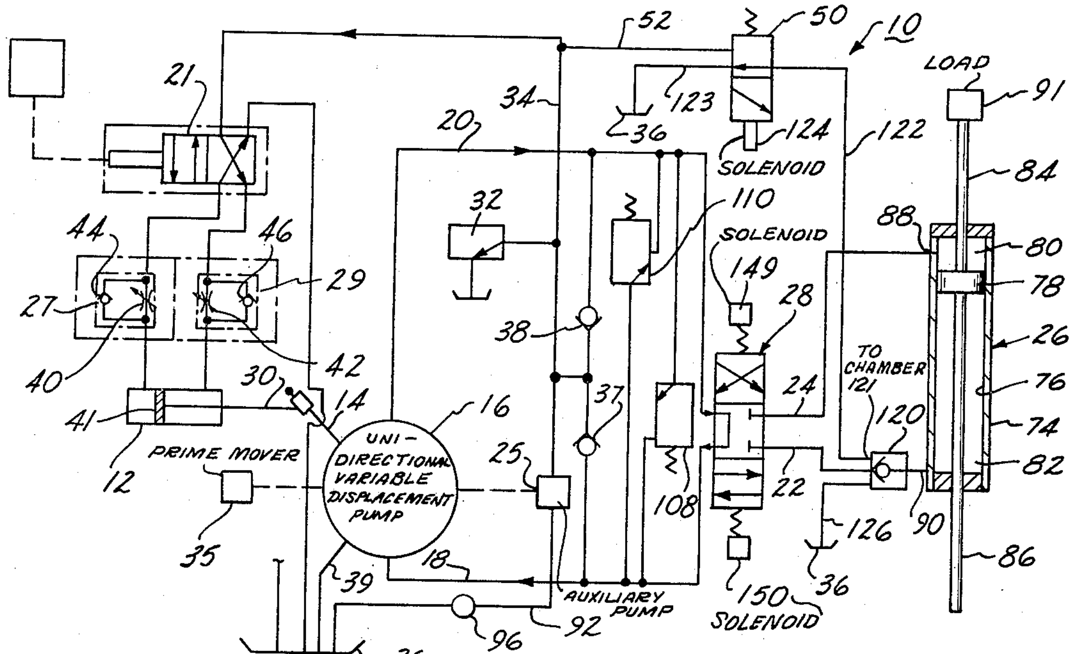

Fig-1

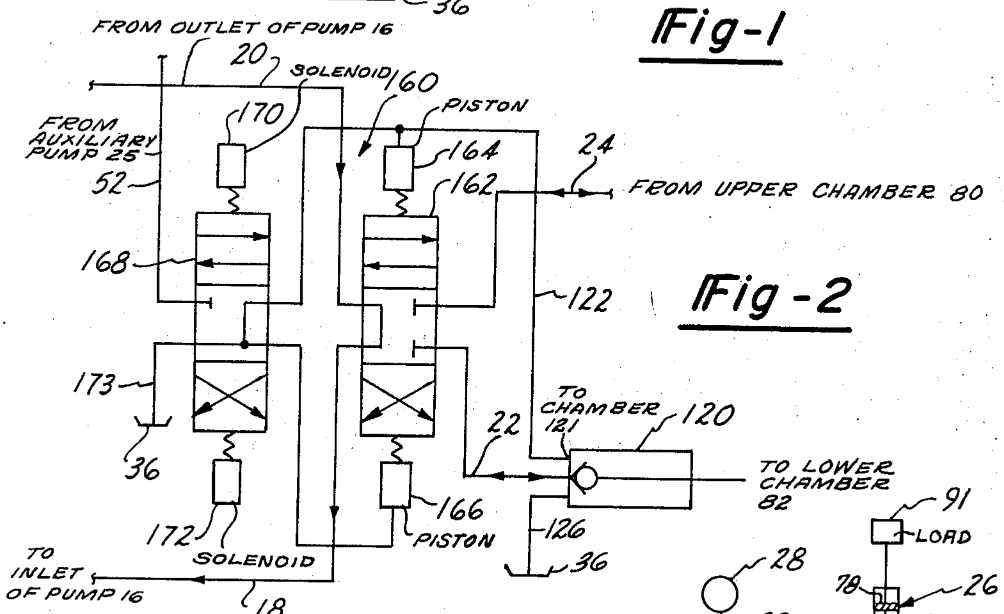

Fig-2

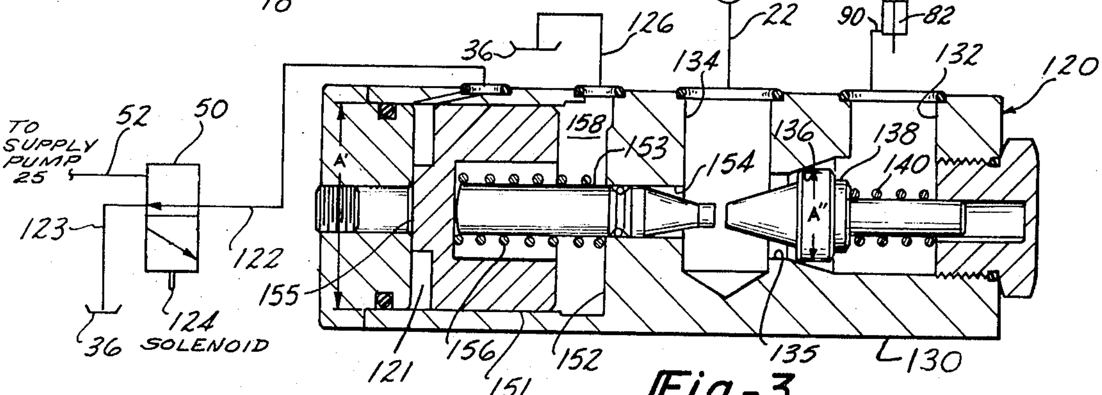

Fig-3

FLUID SYSTEM HAVING POSITIVE VERTICAL HOLD MEANS

CROSS-REFERENCE TO RELATED APPLICATIONS

The present patent application is related in substance to U.S. Pat. No. 3,653,208 and is a continuation-in-part of copending U.S. Pat. application Ser. No. 91,949, now U.S. Pat. No. 3,713,291 both of which are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to fluid systems for controlling the movement of a fluid cylinder and, in particular, the present invention relates to a positive hold system for selectively preventing movement of a fluid cylinder piston while the same is supporting a vertical load.

2. Description of the Prior Art

Heretofore, open-loop circuits have been constructed with a positive piston hold for a fluid cylinder of the type normally disposed in a vertical position and supporting a displacable load thereabove. Such open-loop circuits have included a pilot operated check valve that functions to prevent fluid from being exhausted from the lower pressure chamber of the fluid cylinder. However, the adaptation of the teachings of the open-loop circuits to a closed-loop circuit has resulted in a highly inefficient and noisy operation. In such previously used closed-loop circuits, the pilot operated check valve is adapted to become operative, that is, to move from a closed to an open position to permit the exhaust of fluid from the lower pressure chamber of the fluid cylinder by communicating the operating pressure of the system to the pilot valve, all of which has necessitated restrictive valving and flow control means in order to maintain a proper operating system pressure that results in very high pressure losses and unnecessary heat dissipation. Prior attempts which have been employed to overcome the aforementioned difficulties have resulted in elaborate and expensive circuitry employing valving and restrictive flow passages, all of which become unnecessary in light of the teachings of the present invention.

SUMMARY OF THE INVENTION

The present invention, which will be described subsequently in greater detail, comprises a fluid system having a closed loop fluid system for selectively connecting the inlet and outlet of a fluid pump to the ports of a fluid cylinder which is nor-mally disposed in a vertical position and supporting a vertical load. Control means, operable upon actuation, are adapted to communicate the pilot operated check valve to an independent source of fluid maintained at a constant pressure when the fluid pump outlet is connected to the fluid cylinder to lower the supported load.

It is therefore an object of the present invention to provide a closed-loop fluid system for raising and lowering a vertical load and having means for providing a positive hold of the vertical load.

It is also an object of the present invention to provide a closed-loop fluid system which employs a pilot operated check valve to achieve a positive hold of a vertically supported load.

Other objects, advantages and applications of the present invention will become apparent to those skilled in the art of fluid systems when the accompanying description of several modes contemplated for practicing the invention is read in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

The description herein makes reference to the accompanying drawing, wherein like reference numerals refer to like parts throughout the several views, and in which:

FIG. **1** represents a schematic illustration of one example of a fluid system constructed in accordance with the principles of the present invention;

FIG. **2** is a schematic illustration of a modification of the fluid system illustrated in FIG. **1**; and

FIG. **3** is an enlarged cross-sectional view of a pilot operated check valve employed in the fluid systems illustrated in FIGS. **1** and **2**.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to the drawing and, in particular, to FIG. **1**, there is illustrated a fluid system **10** constructed in accordance with the principles of the present invention and comprising a variable displacement fluid pump **16** connected m a closed-loop manner by conduits **18, 20, 22** and **24** to a main fluid cylinder **26.** Incorporated in the system **10** is a conventional four-way, solenoid operated, spring centered, directional flow control valve **28** which is adapted to connect the conduits **18** and **20** selectively to the conduits **22** and **24**, or be positioned tandem-center to allow communication between the conduits **18** and **20** but prevent fluid communication between conduits **22** and **24.**

The fluid pump **16** may be any suitable, variable displacement fluid pump such as the pump disclosed in the aforementioned United States patents and, as explained in greater detail therein, the amount of fluid displaced by the fluid pump **16** is controlled by an internal displacement control mechanism which may be varied between minimum and maximum flow positions by an external lever **14** operated by a control fluid cylinder **12** which will be described in greater detail hereinafter. In the schematic example of FIG. **1**, the pump **16** is considered for purposes of explanation to be at a minimum displacement or minimum flow position when the lever **14** is rotated clockwise and is considered to be in a maximum displacement or maximum flow position when the lever **14** is rotated counterclockwise by the action of the control cylinder **12.** The shifting of the lever **14** between the minimum and maximum flow positions, or any intermediate flow positions, and the rate at which the lever **14** is so shifted, controls the amount of fluid and the rate at which the fluid is displaced by the fluid pump **16** and thus controls the fluid cylinder **26**, all of which is described in greater detail in the aforementioned Letters Patents, and since the same does not form the subject matter of the present invention, a further detailed description thereof is not necessary.

An example of one means for controlling the displacement of the variable displacement fluid pump **16** comprises a directional flow control valve **21** adapted to selectively communicate a control fluid maintained at a constant pressure from a supply pump **25** via a conduit 34 to either of a pair of feed control valve 27 or 29 which, in turn, are respectively connected to the ports of the fluid cylinder 12 by any suitable conduits or the like. The fluid cylinder 12 is conventional in its construction and comprises a fluid piston 41 having a connecting rod 30 that extends therefrom for coupling with the pump lever 14. A conventional pressure relief valve 32 communicates with the supply pump conduit 34 and functions in the conventional manner to limit the pressure of the fluid being delivered from the supply pump 25. A prime mover, such as an electric motor, schematically illustrated at 35, is mechanically connected through a suitable coupling to the drive shaft of the fluid pump 16, which, in turn, drives the supply pump 25. The fluid pump 16 communicates with a fluid reservoir 36 through the charge pump 25, valving 37 and 38 on the pump inlet, and a drain conduit 39, all of which is described hereinafter.

Feed control valves 27 and 29 may be conventional in their construction and have restricted passages 40 and 42, respectively, which are adjustable such that the feed control valves may be pre-set to supply any desired flow rate over any desired range. The feed control valves 27 and 29 further comprise, respectively, check valves 44 and 46 which permit fluid to by-pass the restricted passages 40 and 42, respectively, in one direction of flow. Thus, when the control valve 21 is in the position indicated, fluid flow is directed from the supply pump 25 through the feed valve 29 via the check valve 46 and is communicated to one side of the fluid cylinder 12 to force the piston 41 to shift the same leftwardly to displace the pump lever 14 toward a minimum flow position. At the same time, the fluid at the opposite side of the piston is exhausted from the fluid cylinder 12 through the restricted passageway 40 in the feed valve 27 and returned to the reservoir 36 via control valve 21. When the direction of the control valve 21 is reversed to direct fluid through the check valve 44 of the feed control valve 27, fluid is communicated to the pressure chamber on the opposite side of the fluid cylinder piston 41 whereupon the fluid pressure exerts a force against the piston 41 to shift the same rightwardly as viewed in FIG. 1 to increase the displacement of the fluid pump 16, while at the same time, fluid on the opposite side of the piston 41 is exhausted through the restricted passage 42 of the feed valve 29 and back to the reservoir 36 via the directional control valve 21.

The supply pump 25 is designed to deliver fluid at a constant pressure to the feed control valves 27 and 29 and, as will be explained in greater detail, the output fluid from the supply pump 25 is communicated to a second solenoid operated directional control valve 50 via a conduit 52 that is connected to the conduit 34.

The main fluid cylinder 26 has a vertically disposed cylindrical housing 74 having an internal bore 76 in which a cylindrically shaped piston 78 is reciprocally mounted, dividing the internal bore 76 into two pressure chambers 80 and 82, respectively, opposite the upper and lower sides of the piston 78. The opposite sides of the piston 78 have cylinder rods 84 and 86 which extend through the opposite end walls and externally of the main fluid cylinder 26. The pressure chambers 80 and 82 of the fluid cylinder 26 respectively have fluid ports 88 and 90 which, in turn, are respectively connected to the fluid conduits 24 and 22. The connecting rods 84 and 86 have equal diameters and

thus the effective pressure responsive areas on the opposite sides of the piston 78 are equal. The fluid cylinder 26 operates in a well known manner to support a vertical load 91 and when the piston 78 is moved in opposite directions within the cylinder bore 76 by the action of fluid pressure in the pressure chambers 80 and 82, the load 91 may be raised, lowered or maintained at some selected position.

The supply pump 25, which may be any suitable pump, such as a gear pump, is in communication with the reservoir 36 through a supply conduit 92 and a filter 96 for supplying a replenishing fluid to the conduits 18 and 20, respectively, by means of the spring biased check valves 37 and 38, both of which function in a well known manner to replenish the system.

Upstream from the directional control valve 28, the conduits 18 and 20 are respectively connected to the inlets of high pressure relief valves 108 and 110 which, at a predetermined pressure, e.g., 3,000 PSI, will exhaust the fluid pressure from one of the conduits to the other conduit to prevent damage to the system in the event of over-pressurization.

As aforementioned, in certain applications using a fluid cylinder to support the load 91, a positive hold feature is employed to prevent the load from moving downwardly, that is, from moving the piston 78 downwardly toward the port 90. In the present invention, the positive hold feature is accomplished by having a pilot operated check valve 120 which will be described in greater detail hereinafter. The check valve 120 is disposed in the conduit 22 having one port 132 (FIG. 3) communicating with the port 90 of the fluid cylinder 26 while the other port 134 communicates with the directional flow control valve 28. A pilot conduit 122 communicates a pilot pressure chamber 121 (FIG. 3) of the check valve 120 with the directional control valve 50 which, in turn, is operative when its solenoid 124 is actuated to communicate fluid pressure from the supply pump 25 to the pilot pressure chamber 121 to open the check valve 120 in a manner which will be described. When the solenoid 124 of the valve 50 is deactivated, the pilot conduit 122 and thus the pilot pressure chamber 121 is communicated directly back to the reservoir 36 via a conduit 123.

Referring now to FIG. 3, wherein the pilot operated valve 120 is illustrated as comprising a housing 130 having spaced parallel bores defining ports 132 and 134. The port 132 communicates with the port 90 of the fluid cylinder 26 while the port 134 communicates with the directional flow control valve 28 via the conduit 22. The ports 132 and 134 are connected by a passageway 135 having a valve seat 136. A valve member 138 is biased by spring 140 into a sealing engagement with the valve seat 136, and thus during normal operation of the valve 120 when the solenoid 149 of the directional flow control valve 28 is activated to direct fluid under pressure from the pump outlet through conduit 20 to the conduit 22 and the pilot operated valve port 134, the pressure will exert a force against the valve member 138 to unseat the same and communicate with the fluid cylinder lower pressure chamber 82 wherein the pressure exerts a force against the piston 78 to raise the load 91 vertically, while at the same time, fluid from the pressure chamber 80 is exhausted through the conduit 24, the directional control valve 28, the conduit 18 and returned to the inlet of the pump 16. When the other solenoid 150 of the directional control valve 28 is energized such as to communicate pressure fluid from the pump outlet to the conduit 24 and thus to the upper pressure chamber 80, fluid pressure therein acts against the piston 78 urging the same downwardly so as to lower the load 91. However, since the check valve 120 normally will not permit free fluid communication from the lower pressure chamber 82 back to the pump inlet, via the direction control valve 28 and conduit 18, the load 91 may not be lowered.

In order to permit the lower fluid chamber 82 of the main fluid cylinder 28 to be exhausted back to the pump inlet, the pilot operated valve 120 is provided with a piston member 151 slidably mounted in the pilot pressure chamber 121 which is separated from the port 134 by a partition 152. The piston member is carried by a rod 153 slidably supported in bore 154 extending through the partition 152 and is adapted to abuttingly engage the valve member 138 to unseat the same when control pressure is communicated to the pilot chamber 121 and acts against the face 155 of piston member 151. The piston member 151 is biased to the position shown by a spring 156 while a chamber 158 behind the piston member 151 is connected to the reservoir 36 via a conduit 126. When the valve member 138 is unseated, permitting communication between the cylinder chamber 82 and the port 134, the load 91 may be lowered. Since the control pressure delivered from the supply pump 25 is usually 100 to 125 PSI and the system pressure may be as high as 4,000 to 5,000 PSI, the effective pressure responsive area A' of the piston member 151 must be substantially greater than the effective pressure responsive area A'' of the valve member 138. In the preferred embodiment the area A' is 40 times the area A''.

In operation, in order to raise the load 91, the solenoids 124 and 150, respectively, of the valves 50 and 28 are in an unactivated position while the solenoid 149 of the directional control valve 28 is activated to shift the directional control valve 28 to a position directing fluid flow from the conduit 20 into the conduit 22 through the check valve 120 and into the lower pressure chamber 82 exerting a force against the piston 78 raising the load 91 while the pressure in the upper pressure chamber 80 is exhausted through conduit 24, the directional control valve 28 and returned to the pump inlet via conduit 18. To lower the load 91, the solenoid 149 of the directional control valve 28 is deactivated and solenoids 124 and 150, respectively, of the directional control valves 50 and 28 are activated, whereby fluid from the high pressure outlet port of the pump 16 flows via conduit 20, the directional control valve 28 and the conduit 24, into the upper pressure chamber 80 of the fluid cylinder exerting a force on the piston 78 urging the same downwardly while simultaneously therewith the fluid from the supply pump 25 at a constant pressure is directed via conduit 52, the directional control valve 50 and the conduit 122 to the pilot pressure chamber 121 generating a force against the piston member 151 to unseat the valve member 138 permitting fluid to be exhausted from the fluid lower cylinder chamber 82 through the pilot operated check valve 120 and to the pump inlet via the directional control valve 28 and conduit 18.

In order to stop the movement of the load 91, the solenoids 124, 150 and 149, respectively, of the directional control valves 50 and 28 are all deactivated, whereupon the fluid pressure is not communicated to either chamber 80 or 82 and at the same time fluid in the lower pressure chamber 82 is prevented from being exhausted therefrom, maintaining the load in the desired level.

The solenoid operated directional flow control valve 28 is well suited for low volume operations. However, when very high volume operation is being employed, a pilot operated directional control valve may be utilized in the system 10. Referring to FIG. 2, a pilot operated directional control valve 160 is illustrated and is adapted to replace the directional control valve 28 and the directional control valve 50 illustrated in FIG. 1 with all other components of the system remaining the same and functioning in the same manner, and thus are not illustrated in FIG. 2. However, it is to be understood that a system using the directional control valve 160 illustrated in FIG. 2 employs all the other components illustrated in FIG. 1. The directional control valve 160, which is conventional in its construction, comprises a main valve section 162 having a spring centered spool (not shown) which is actuated to perform the desired fluid connections by hydraulic pistons 164 and 166 disposed at the opposite ends thereof. Control pressure from the supply pump 25 is selectively directed to the pistons 164 and 165 on the opposite sides of the valve section 162 by a solenoid operated pilot section 168. In addition to communicating fluid pressure to the opposite sides of the valve section 162, the pilot pressure is communicated via line 122 to the pilot pressure chamber 121 of the check valve 120 to operate the same in the manner hereinbefore described. In operation, to raise the load 91 carried by the fluid cylinder 26, a solenoid 170 of the pilot section 168 is deactivated while the solenoid 172 of the valve 164 is energized to shift the valve 168 to communicate fluid pressure from the supply pump 25 to the piston 166 causing the valve section 162 to be shifted in such a manner as to direct fluid from the high pressure conduit 20 through the pilot operated check valve 120 into the fluid lower pressure chamber 82 exerting a force against the piston 78 to raise the vertical load 91 while fluid in the pressure chamber 80 is exhausted through the conduit 24, valve section 162, to the inlet of the pump 16 via conduit 18. During this mode of operation, the piston 164 and the pilot pressure chamber 121 are connected to the reservoir 36 via pilot valve section 168 and a conduit 173. In order to lower the load 91, the solenoid 170 of the pilot section 168 is energized while the solenoid 172 is deactivated, whereby control pressure from the supply pump 25 is communicated to the piston 164 shifting the valve section 162 so as to communicate fluid pressure from the outlet of pump 16 to the conduit 24 and thus to the upper pressure chamber 82 exerting a force on the piston 78 to lower the load 91. Simultaneously, control pressure from the valve section 168 is directed via conduit 122 to the pilot operated check valve 120 to cause the same to open in the manner aforementioned whereby fluid in the lower chamber 82 of the fluid cylinder 26 is exhausted therefrom through the pilot operated check valve 120, the valve section 162 and to the pump inlet via conduit 18. In order to stop movement of the load 91 at any desired position and maintain a positive hold, both the solenoids 170 and 172 of the pilot section 168 are de-energized, causing the spring centered spool of the pilot section 168 to close communication between the supply pressure and the pilot valve **120** and the valve section **162**, thereby preventing the exhausting of fluid from the lower chamber **82** of the fluid cylinder **26**.

It can thus be seen that the present invention has provided a fluid system which has a very simple and effective means for providing a positive hold to a fluid cylinder which is supporting a vertical load, the same being accomplished without the necessity of a complicated circuitry, not requiring the use of flow control valves and other similar restrictive means to establish pressure drops between the inlet and outlet of the pump as has been the required need of circuits heretofore employing a check valve on the closed-loop circuit.

It can also be seen that the present invention has provided a positive hold for a fluid system which is extremely simple in its operation and construction and thus inexpensive to manufacture and one which is highly reliable and of long life.

It can also be seen that the present invention permits the employment of a closed-loop circuit that provides for the controlled raising and lowering of the vertically supported load at any desired rate of acceleration or deceleration while at the same time providing a positive braking of the load when desired.

Although only two forms of the present invention have been disclosed, it is to be understood by those skilled in the art of fluid systems that other forms may be adopted, all coming within the spirit of the invention and scope of the appended claims.

What is claimed is as follows:

1. A fluid system comprising:

a fluid pump having inlet and outlet means;

a fluid cylinder having reciprocating piston means and first and second port means respectively communicating within said fluid cylinder on the opposite sides of said piston means;

directional flow control valve means selectively operable to connect said pump inlet and outlet means to said first and second port means, in a closed loop fashion for reciprocating said piston means within said cylinder;

pilot operated check valve means disposed between said directional flow control valve means and one of said cylinder port means, said check valve means being normally operable to permit fluid flow from said directional flow control valve means to said one port means and prevent a reverse flow of fluid from said one port means to said directional flow control valve means;

an independent source of fluid pressure;

control valve means operable upon actuation for communicating said independent source of fluid pressure to said pilot operated check valve to open same and permit fluid flow from said one port means to said directional flow control valve means; and

means for actuating said control valve means when said directional control valve means communicates said pump outlet to said other cylinder port means.

2. The fluid system defined in claim **1**, wherein said fluid pump is a variable displacement pump; and further comprising pressure responsive means for varying displacement of said pump; said independent source of pressure being adapted to be selectively communicated to said pressure responsive means for varying displacement of said variable displacement pump.

3. The fluid system defined in claim **2**, wherein said directional flow control valve means comprises a pilot operated directional flow control valve having a first spool means movable when pressure is selectively communicated to the opposite ends thereof, and a pilot valve having a spool means for selectively communicating said control pressure to the opposite sides of said first mentioned spool means, said pilot valve spool being adapted to communicate said control pressure to said pilot operated check valve when in a selected position.

4. The fluid system defined in claim **1**, wherein said pilot operated check valve comprises a passageway having a valve seat and a valve member engagable thereto, said valve member being movable in one direction to permit flow thereacross, said valve member having rod means extending therefrom and engaging a piston member, said piston member being exposable to said control pressure and adapted to cause said valve member to unseat from said valve seat or permit fluid communication in an opposite direction through said check valve, the effective pressure responsive area of said piston member of said pilot operated valve tending to open said pilot operated valve being 40 times greater than the effective pressure responsive area of said valve member tending to close said pilot operated valve.

5. A fluid system comprising:

a fluid pump having inlet and outlet means;

a fluid cylinder having reciprocating piston means and first and second port means respectively communicating within said fluid cylinder on the opposite sides of said piston means;

means selectively operable to connect said pump inlet and outlet means to said first and second port means, in a closed loop fashion for reciprocating said piston means within said cylinder;

pilot operated check valve means disposed between said pump and one of said cylinder port means, said check valve means being normally operable to permit fluid flow from said pump to said one port means and prevent a reverse flow of fluid from said one port means to said pump;

an independent source of fluid pressure;

control valve means operable upon actuation for communicating said independent source of fluid pressure to said pilot operated check valve to open same and permit fluid flow from said one port means to said pump; and

means for actuating said control valve means when said pump outlet is communicated to said other cylinder port means.

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