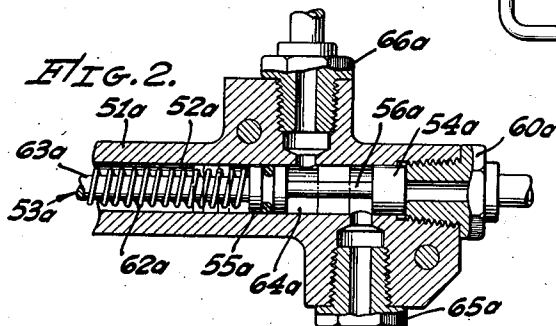
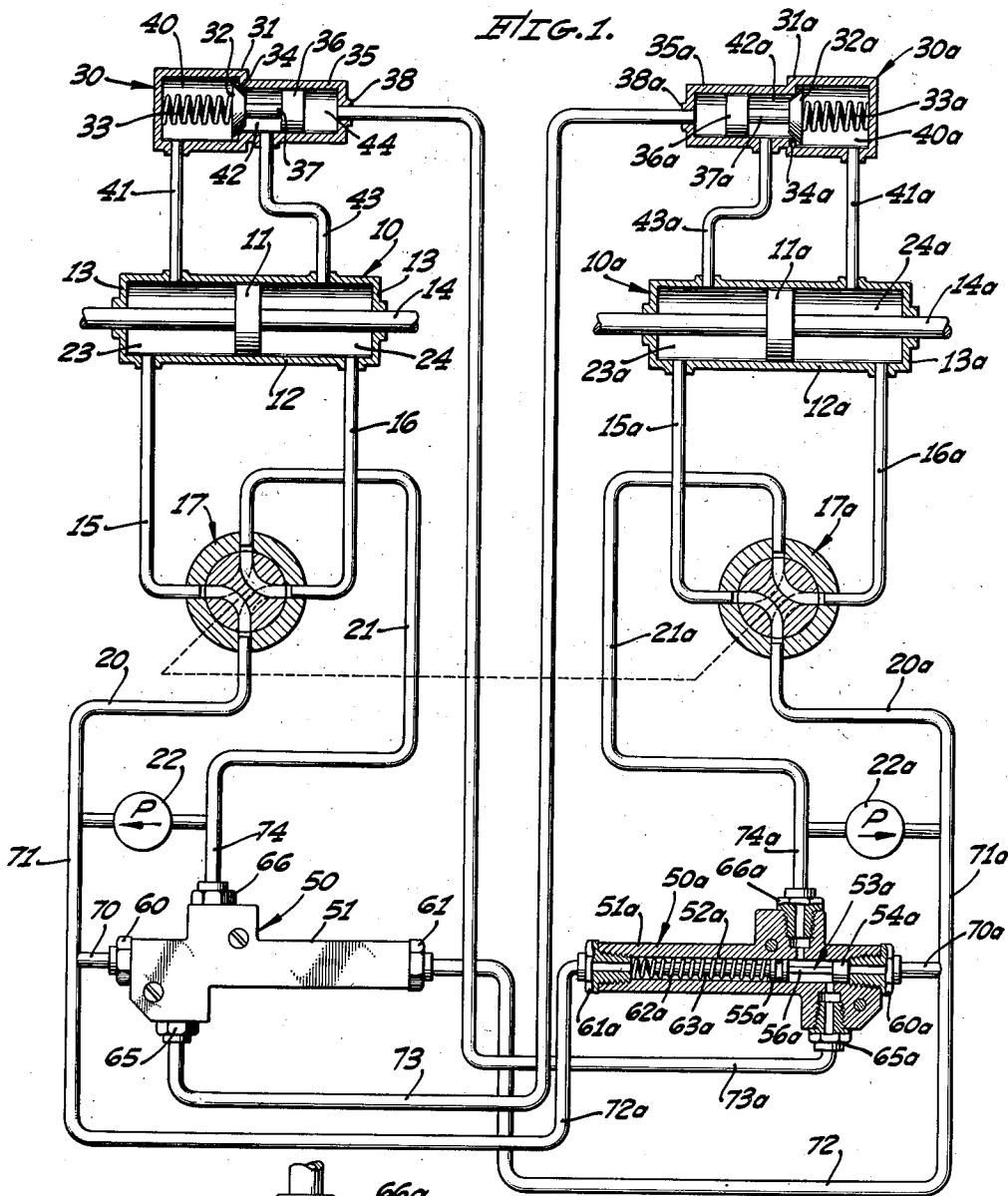


Nov. 4, 1952

D. GRANT ET AL
HYDRAULIC BY-PASS CONTROL

2,616,264

Filed Feb. 6, 1948



DAVID GRANT,
LELAND V. HALL,
INVENTORS.

BY
Charles W. Fulwider
ATTORNEY.

UNITED STATES PATENT OFFICE

2,616,264

HYDRAULIC BY-PASS CONTROL

David Grant, Los Angeles, and Leland V. Hall,
Manhattan Beach, Calif., assignors to Hughes
Tool Company, Houston, Tex., a corporation of
Delaware

Application February 6, 1948, Serial No. 6,748

12 Claims. (Cl. 60—97)

1

Our invention relates generally to hydraulic control systems and more particularly to such systems having two separate and independent operating means with provision to disconnect, in effect, one of these means should any failure occur therein.

With the increasingly widespread use of hydraulic control and operating systems, it frequently happens that provision must be made to insure the control or operation of a certain member even though the normal hydraulic system fails. Consequently, some attempts to secure the desired reliability of operation have made use of two separate and independent control systems, one of which normally acts to produce the desired control, while the other is an alternate system which acts only when the first system fails. However, such a dual system arrangement has certain disadvantages, and consequently it has been proposed to use two separate and independent systems both of which normally operate simultaneously and independently, sharing the load between them, but each of which is fully capable of providing the desired control should the other system fail.

One of the commonly used actuating elements of a hydraulic control system is a double acting piston mounted within a cylinder adapted to have fluid under pressure injected at either end. If fluid is forced into one end of the cylinder while simultaneously being released at the other end, the piston therein will be moved toward the low pressure end of the cylinder. However, if an attempt is made to move the piston without simultaneously admitting fluid to one end of the cylinder and releasing it at the other end, the incompressibility of the fluid results in the piston's being "locked" in one position. If two separate and independent control systems are used to operate a single device, it sometimes happens that failure of one of the systems will result in the fluid therein being trapped or locked so that the piston associated with that system is effectively held against movement, even though the other system is functioning and attempts to move the member to which both pistons are connected. We have found that these objections may be overcome by using a shunting or by-pass valve connected between opposite ends of the operating cylinder so that fluid at one end of the piston may be readily transferred to the other end thereof so that the piston is freely movable. In normal operation, the by-pass valve is closed so that the piston and cylinder operate in the conventional fashion, but when a failure occurs in the

2

control system, the by-pass valve is opened so that the other, independent system may operate in the normal manner.

It is therefore a major object of our invention to provide a hydraulic system having great reliability of operation.

Another object of our invention is to provide such a system which is operable even though one-half of the complete system has entirely failed.

It is a further object of our invention to provide a hydraulic control system having means therein to insure the free movement of the non-operating elements when such a failure occurs.

Still another object of our invention is to provide a pilot or control valve to open a by-pass of the type previously mentioned.

It is a still further object of our invention to provide such a valve and system which are light in weight and simple in operation so that the advantages of this system may be had in applications where space and weight are important factors.

These and other objects and advantages of our invention will become apparent from the following description of a preferred form thereof, and from the drawing illustrating that form in which Fig. 1 is a diagram showing the complete layout and connections of our system; and

Fig. 2 is an enlarged view of a portion of the by-pass control valve used therein.

Referring now to the drawing and particularly to Fig. 1 thereof, the numeral 10 indicates generally a double-acting piston and cylinder of a conventional type having a piston 11 within a housing or cylinder 12. The ends of the cylinder 12 are closed by caps 13 through which a piston rod 14 extends to connect to the device to be controlled (not shown). Suitable tubing 15 is fluid connected to one end of the cylinder 12, while similar tubing 16 is likewise connected to the other end thereof, both of these tubes extending to a suitable hydraulic selector valve 17. Selector valves of this type are well known in the art and are so designed that they may be connected through suitable hydraulic tubing 20 to a source of hydraulic pressure such as a pump 22. Similarly, provision is made to connect the valve 17 through tubing 21 to a reservoir or return line of the pump 22, thereby providing a complete, operative system. By suitably operating the valve 17, a fluid connection may be established therethrough from the supply line 20 to the tubing 15, simultaneously completing a fluid connection from the tubing 16 to the

3

return line 21. Fluid will thus be forced into a chamber 23 between the piston 11 and one end of the cylinder 12, while fluid will simultaneously be removed from a chamber 24 between the opposite side of the piston and the opposite end of the cylinder. This will cause the piston 11 to be moved toward the chamber 24, to the right in Fig. 1, thereby operating the equipment to which the piston rod 14 is connected. By reversing the operation of the valve 17, the piston 11 may be moved in the opposite direction, while in intermediate positions of the valve, both of the tubes 15 and 16 are disconnected from the supply line 20 and the return line 21 and the piston does not move.

The system just described is the conventional hydraulic system used in operating many different devices, but where the utmost in reliability in operation is required, we have found it desirable to provide a duplicate system, identical to that just described, including a double acting piston 11a and cylinder 10a, a control valve 17a, and various connecting members adapted to provide a fluid connection to pump 22a or other suitable pressure supply means. The controlling members of the valves 17 and 17a are mechanically linked together so that both are simultaneously operated to cause a simultaneous movement of the piston rods 14 and 14a. Both of these piston rods are connected to the member to be controlled, and the size of the hydraulic cylinders 10 and 10a and their respective sources of fluid pressure are so correlated with the force required to move the controlled member that either cylinder acting alone may produce the required movement.

If a failure occurs in the hydraulic system receiving its pressure from pump 22 it is quite possible that fluid in cylinder 10 will be trapped, effectively locking piston 11. By connecting a valve between the chambers 23 and 24 of the cylinder 10, these difficulties may be surmounted, since the opening of this valve will permit the direct flow of fluid from one end of the cylinder, through the valve, to the opposite end of the cylinder. Under normal conditions, the valve will be closed so that conventional operation of the cylinder 10 will be had but when a failure occurs, the valve is opened. Consequently, any valve which is connected between the chambers 23 and 24 must be quickly and positively operable, and preferably this valve should be operated automatically upon the failure of the corresponding pressure supply or connections thereto. While many different types of valves in different kinds of control systems may be used, we have found that hydraulic controls and hydraulically operated valves form a very convenient method of solving the problem since no other power source is necessary for their operation.

The valve which we have developed for use as a by-pass valve is indicated generally by the numeral 30 and includes a housing 31 having a poppet valve 32 therein normally urged by a spring 33 against a valve seat 34 formed in the housing. The opposite end of the housing 31 is provided with a rather small hydraulic cylinder 35 in which is mounted a piston 36 connected by a piston rod 37 to the valve 32. Under normal circumstances, the valve 32 will bear against the valve seat 34 by reason of the urging of spring 33, but by increasing the pressure within the cylinder 35, the piston 36 will be moved toward the spring to open the valve. The space within the housing 31 which contains the spring 33,

4

designated as chamber 40, is fluid connected by tubing 41 to chamber 23 of the hydraulic cylinder 10, and in a similar manner, the compartment between the valve seat 34 and the piston 36, chamber 42, is connected by tubing 43 to chamber 24 of the hydraulic cylinder 10. The space within the hydraulic cylinder 35, chamber 44, is connected by a fluid connection 73a to a suitable source of pressure operable in a manner herein-after described to control the by-pass valve 30. Thus, when the pressure within the chamber 44 is low, spring 33 will urge the valve 32 against the valve seat 34 and thereby prevent any transfer of fluid between chambers 23 and 24 through the by-pass valve 30. However, when the pressure in chamber 44 of the latter is increased, piston 36 is moved to open the by-pass valve so that there may be a relatively free interchange of fluid between the chambers 23 and 24 of the hydraulic cylinder 10, and the piston 11 may thus be freely moved throughout its entire length of travel.

To operate the by-pass valves 30 and 30a, we have developed a control valve connected between the pumps 22 and 22a so that a failure of one of these pumps will cause the pressure of the other to be transmitted to the chamber 44 and thereby open the by-pass valve of the system supplied by the inoperative pump. The control valves operate automatically, and their construction is such as to render them very reliable in operation.

In Fig. 1 of the drawing, we have illustrated the control valve 50a in cross-sectional view, with an enlarged view of a portion of this valve shown in Fig. 2. Like the other parts of the two separate and independent systems, the valves 50 and 50a are identical to each other and are similarly connected to corresponding parts.

Within a housing 51a having an axially extending bore 52a therethrough, we mount a compound piston member 53a having a piston 54a at one end thereof with a spaced piston 55a connected to the end piston 54a by a reduced portion 56a acting as a connecting rod. The pistons 54a and 55a thus move as a unit, and fluid connections 60a and 61a are mounted in opposite ends of the housing 51a to admit fluid under pressure into the axial bore 52a, to act upon the pistons 54a and 55a, respectively. A spring 62a extends from the fluid coupling 61a to the adjacent end of the piston 55a to urge the latter and the piston 54a toward the fluid connection 60a, while a rod 63a within the spring prevents undesirable flexing or bending thereof.

By reference to Fig. 2, it will be seen that a chamber 64a is formed between the adjacent faces of the pistons 54a and 55a within the bore 52a. This chamber will move with the piston member 53a, and we provide a pair of fluid connections adapted to be connected to this chamber when the piston member 53a is in its normal position, indicated in Fig. 1 and shown in full or solid outline in Fig. 2. As illustrated, one coupling 65a is fluid connected to the bore 52a at a point immediately adjacent the inner surface of the piston 54a, while the other fluid connection 66a is connected to the bore at a point between the connection of connector 65a and the adjacent face of piston 55a. Consequently, while there is normally a fluid connection between the connectors 65a and 66a, movement of the piston member 53a to the position shown in dotted outline in Fig. 2 will interrupt this connection and establish a connection between the connectors 60a and

5

65a. Normally, spring 62a urges the piston member 53a against the connector 60a, but when the pressure differential between opposite ends of the piston member becomes sufficiently great, the latter will be moved to the alternate position shown in Fig. 2, with the end of the rod 63a bearing against the fluid connector 61a to limit the movement of the piston member.

The various fluid connectors are suitably attached and connected to various portions of the hydraulic control system, as indicated in Fig. 1. Thus, fluid connector 60a is connected by tubing 70a and 71a to the pressure or discharge side of pump 22a, while connector 61a is connected by tubing 72a and 71 to the pressure or discharge side of pump 22 so that these two pressures are balanced against each other within the bore 52a. Connector 65a is connected by tubing 73a to the connector 38 of the by-pass valve 30, while connector 66a is connected by tubing 74a to the return or intake connection of pump 22a.

The operation of the control valve 50a may now be understood. When the pressures supplied by the pumps 22 and 22a are substantially equal, the piston member 53a will have the outer faces of the pistons 54a and 55a subjected to substantially equal pressures, but the spring 63a, acting on the piston 55a, will urge the piston member toward the fluid connector 60a so that the member is in the position shown in Fig. 1. Under these conditions, fluid connectors 65a and 66a are fluid connected through the chamber 64a so that the intake or return connection of pump 22a is connected through tubing 74a, connector 66a, chamber 64a, connector 65a and tubing 73a to chamber 44 of the by-pass valve 30. Consequently, the pressure within chamber 44 is low, and spring 33 urges the valve 32 to closed position so that the hydraulic cylinder 10 operates in the normal manner. By similar connections to pumps 22 and 22a, and by-pass valve 30a, the hydraulic cylinder 10a is caused to operate in a similar manner.

However, should the pressure in one of the two hydraulic systems, for example, the system connected to pump 22, fail while the other system, that connected to pump 22a, remains in operation, the control valve 50a will be operated to open the by-pass valve 30 so that the hydraulic cylinder 10 may be freely operated without placing an excessive load on the hydraulic cylinder 10a. When the pressure falls, the pressure in lines 71 and 72a will drop to a value much lower than the pressure supplied by pump 22a. Consequently, the pressure at connector 60a will materially exceed that at connector 61a, and the piston member 53a will be moved to the position indicated in dotted outline in Fig. 2. While this necessitates overcoming the urging of spring 62a, the strength of the latter is selected so that the pressure supplied by the pump 22a is adequate to do this.

With the piston member 53a in the position shown in dotted outline, a fluid connection is established between connector 60a and connector 65a, this pressure being substantially equal to that supplied by the pump 22a. Consequently, the pressure supplied by the pump 22a is transmitted through tubing 73a to the chamber 44 of the by-pass valve 30, moving the piston 36 in the latter to open the valve, against the urging of spring 33, to permit the free flow of hydraulic fluid between chambers 23 and 24.

Considering control valve 50, when the pressure supplied by pump 22 is materially decreased, the

6

pressure at fluid connector 60 is materially lower than that at fluid connector 61. However, since the piston member 53 of control valve 50 is already held in its normal position by spring 62, no additional movement of the piston member 53 occurs because of the failure of pump 22, and thus the by-pass valve 30a remains in its closed position.

Since the connections for each system are similar, it will be appreciated that should the system connected to pump 22a fail while the system connected to pump 22 remains operating, control valve 50 will be operated to open by-pass valve 30a so that hydraulic cylinder 10a is released to move freely while cylinder 10 performs the actual work in moving the member to be controlled.

It will thus be seen that we have provided a hydraulic control system possessing great reliability of operation. While the need for such a system is somewhat limited, in certain applications such as the operation of the control boost system of an aircraft, reliability of operation is of primary importance, and it is for just such applications that our system is designed. Preferably, the thickness of the piston 54a is made greater than the opening of the fluid connection from the connector 65a into the bore 52a so that there is no possibility of fluid passing directly from connector 60a to connector 66a as the piston moves from its normal to its operated position. In this manner, each of the two control systems operates so that customary control and operating members and design procedures may be used.

While it is obvious that the control and operating members may be varied to suit the individual requirements of the job, such changes will be apparent to those skilled in the art and need not depart from the scope of the invention as herein defined. Consequently, we do not wish to be restricted to the particular form or arrangement of parts herein described and shown, except as limited by our claims.

We claim:

1. In combination: a hydraulic cylinder, a piston within said cylinder; first and second pressure supply means; means for selectively coupling said first pressure supply means to the ends of said cylinder for moving said piston in either direction within said cylinder; a normally closed by-pass valve fluid coupled between the opposite ends of said cylinder; and means coupled between said first and second pressure supply means and responsive to the failure of said first pressure supply means for opening said by-pass valve.

2. A hydraulic control system comprising: a hydraulic cylinder; a piston positioned in said cylinder; first and second hydraulic pressure supply means; means fluid coupled between said first supply means and opposite ends of said cylinder for selectively applying pressure from said first supply means to opposite ends of said piston to move said piston in either direction; a normally closed by-pass valve fluid coupled between opposite ends of said cylinder; means coupled to said by-pass valve for opening said valve to equalize the pressures at the ends of said piston; and pressure responsive means coupled between said first and second supply means and operable upon failure of said first supply means for actuating the means coupled to said by-pass valve.

3. A hydraulic control system comprising: a hydraulic cylinder; a piston positioned in said cylinder; pressure supply means; control means for selectively applying the pressure from said pressure supply means to opposite ends of said

7

piston for moving said piston within said cylinder; a normally closed by-pass valve fluid connected between opposite ends of said cylinder; piston means mechanically coupled to said by-pass valve for selectively opening said valve; a source of auxiliary pressure; a normally closed valve fluid coupled between said auxiliary pressure source and said piston means; and pressure responsive means coupled between said pressure supply means and said auxiliary pressure source and operable upon failure of said pressure supply means to open the last-named valve, whereby said auxiliary pressure source actuates said piston means to open said by-pass valve and permit free fluid transfer between the ends of said cylinder.

4. A hydraulic control system including: a hydraulic cylinder; a piston positioned in said cylinder; pressure supply means; control means for selectively directing the pressure from said pressure supply means to opposite ends of said piston for moving said piston within said cylinder; a by-pass valve fluid coupled between opposite ends of said cylinder, said valve having a movable valve element positioned therein, a spring coupled to said valve element urging said element to normally close said valve, and a piston mechanically coupled to said valve element for selectively moving said valve element against the urging of said spring to open said by-pass valve; an auxiliary pressure source; a normally closed fluid connection between said auxiliary pressure source and the piston of said by-pass valve; and means fluid coupled between said pressure supply means and said auxiliary pressure source and responsive to the failure of said pressure supply means for opening said normally closed fluid connection whereby said auxiliary pressure source actuates the piston of said valve, said piston moving said valve element to open said by-pass valve and permit free transfer of fluid between the ends of said cylinder.

5. A hydraulic control system comprising: a hydraulic cylinder; a piston positioned in said cylinder; first and second pressure supply means; control means fluid connected between said first pressure supply means and opposite ends of said cylinder, said control means selectively applying pressure to opposite ends of said piston for moving said piston; a normally closed by-pass valve fluid coupled between opposite ends of said cylinder; piston means coupled to said by-pass valve for selectively opening said valve to fluid connect the ends of said cylinder; a control valve, said valve comprising a housing having a chamber therein; a first fluid path communicating between one end of said chamber and said first pressure supply means; a second fluid path communicating between the other end of said chamber and second pressure supply means; a third fluid path communicating between said chamber at a point intermediate the ends thereof and said piston means; and a piston positioned in the chamber of said control valve, said piston being maintained in a first position within said chamber by the differential pressure between the first and second supply means, said piston being responsive to the failure of said first pressure supply means for movement in said chamber to a second position, said piston, in both positions, fluid separating said first and second fluid paths, and fluid separating said first and third fluid paths, said second and third fluid paths being fluid separated by said piston in the first position thereof, and fluid coupled in the second po-

8

sition thereof whereby said second pressure supply actuates said piston means to open said by-pass valve and allow free movement of the piston within said cylinder.

6. In a hydraulic control system, the combination comprising a hydraulic cylinder, a piston positioned within said cylinder for movement in either direction along the axis of said cylinder, a source of fluid pressure, control means fluid coupled between said source and said piston for selectively applying the pressure from said source to opposite ends of said piston to move said piston in either direction, a fluid conduit coupled between opposite ends of said piston, a normally closed by-pass valve within said conduit, an auxiliary fluid pressure supply, fluid pressure responsive means coupled between said auxiliary supply and said by-pass valve for opening said by-pass valve to permit fluid to flow freely through said conduit from one end of said piston to the other, and means fluid coupled between said fluid pressure responsive means and said auxiliary supply for applying pressure from said auxiliary supply to said fluid pressure responsive means to actuate said fluid pressure responsive means, the last-named means being fluid coupled between said source and said auxiliary supply and operable in response to failure of said source.

7. A hydraulic device for moving a movable member in either of two opposite directions, said device including differential pressure responsive means for moving the member in either direction, means fluid coupled to said differential pressure responsive means for selectively applying differential pressures to said responsive means to actuate said responsive means, pressure responsive means fluid coupled to said differential pressure responsive means for equalizing the differential pressure across said differential responsive means, the last-named pressure responsive means being normally inoperative, an auxiliary pressure supply, and control means fluid coupled between said auxiliary pressure supply and said last-named pressure responsive means for applying the pressure from said auxiliary pressure supply to said last-named pressure responsive means to operate said last-named pressure responsive means, said control means being operable upon failure of said differential pressure applying means.

8. A hydraulic device for moving a movable member in either of two opposite directions, said device including differential pressure responsive means for moving the member in either direction, means fluid coupled to said differential pressure responsive means for selectively applying differential pressures to said differential pressure responsive means to actuate said differential pressure responsive means, valve means fluid coupled to said differential pressure responsive means for equalizing the differential pressure across said differential pressure responsive means, said valve means being normally inoperative, an auxiliary pressure supply, and pressure responsive means fluid coupled between said auxiliary pressure supply and said differential pressure applying means for operating said valve means upon failure of said differential pressure applying means.

9. A hydraulic device for moving a movable member, said device including pressure responsive means for moving the member; means fluid coupled to said pressure responsive means for applying pressure to said pressure responsive means to actuate said pressure responsive

means, normally inoperative means fluid coupled to said pressure responsive means for rendering said pressure responsive means ineffective to impede the movement of the movable member, an auxiliary pressure supply, and differential pressure responsive means fluid coupled between said auxiliary pressure supply and the pressure applying means and responsive to a predetermined differential pressure between said pressure applying means and said auxiliary pressure supply to operate said normally inoperative means.

10. In combination: first and second hydraulic devices, each of said devices comprising a cylinder, a movable piston positioned within said cylinder, pressure supply means fluid coupled to opposite ends of said cylinder for selectively applying pressure to opposite ends of said piston to move said piston, and a normally closed by-pass valve fluid coupled between opposite ends of said cylinder; and differential pressure responsive means fluid coupled between the pressure supply means of said first and second hydraulic devices and operable upon failure of said pressure supply means of said first device for opening the by-pass valve of said first device, said pressure responsive means being further operable upon failure of the pressure supply means of said second device for opening the by-pass valve of said second device, the opening of either of said by-pass valves permitting free movement of the piston of the hydraulic device associated with the open by-pass valve.

11. In combination: a first hydraulic system comprising a first hydraulic cylinder, a first piston positioned within said cylinder, first pressure supply means, means fluid coupling said first supply means to opposite ends of said first cylinder for selectively applying pressure to the ends of said first piston for moving said piston, and a normally closed first by-pass valve fluid coupled between opposite ends of said first cylinder; a second hydraulic system comprising a second hydraulic cylinder, a second piston positioned within said second cylinder, second pressure supply means, means fluid coupling said second pressure supply means to opposite ends of said second cylinder for selectively applying pressure to the ends of said second piston for moving said piston, and a normally closed second by-pass valve fluid coupled between opposite ends of said second cylinder; first control means coupled between said second supply means and said first by-pass valve for selectively opening said first by-pass valve to equalize the pressure at each end of said first piston for permitting movement thereof; second control means coupled between said first

supply means and said second by-pass valve for selectively opening said second by-pass valve to equalize the pressure at each end of said second piston for permitting movement thereof; and means coupled between said first and second supply means and responsive to the failure of said first supply means for actuating said first control means, the last-named means being responsive to the failure of said second supply means for actuating said second control means.

12. A hydraulic control system for actuating a movable member, said system comprising: first and second hydraulic cylinders; first and second pistons positioned in said first and second cylinders, respectively, said first and second pistons being connectable to the movable member; first and second fluid pressure supply means; a first control means for selectively applying pressure from said first pressure supply means to opposite ends of said first piston for moving said first piston; second control means for selectively applying pressure from said second pressure supply means to opposite ends of said second piston for moving said second piston, said first and second control means being mechanically coupled for moving said first and second pistons simultaneously to jointly actuate the movable member; a normally closed by-pass valve fluid coupled between opposite ends of said first cylinder; piston means coupled to said by-pass valve for selectively opening said valve and allowing a fluid connection between the ends of said first cylinder to permit free movement of said first piston; normally closed valve means fluid connected between said piston means and said second fluid pressure supply means; and means coupled between said first and second pressure supply means and responsive to the failure of said first pressure supply means for opening said normally closed valve means whereby said second pressure supply means actuates said piston means to open said normally closed by-pass valve and permit free movement of said first piston within said first cylinder.

DAVID GRANT.
LELAND V. HALL.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
446,799	Thorpe	Feb. 17, 1891
2,316,926	Willett	Apr. 20, 1943
2,354,791	Boldt	Aug. 1, 1944
2,360,839	Barksdale	Oct. 24, 1944