Oct. 31, 1967 R. L. HOFFMAN 3,349,671

HOLDING VALVE WITH THERMAL RELIEF

Filed Oct. 21, 1965

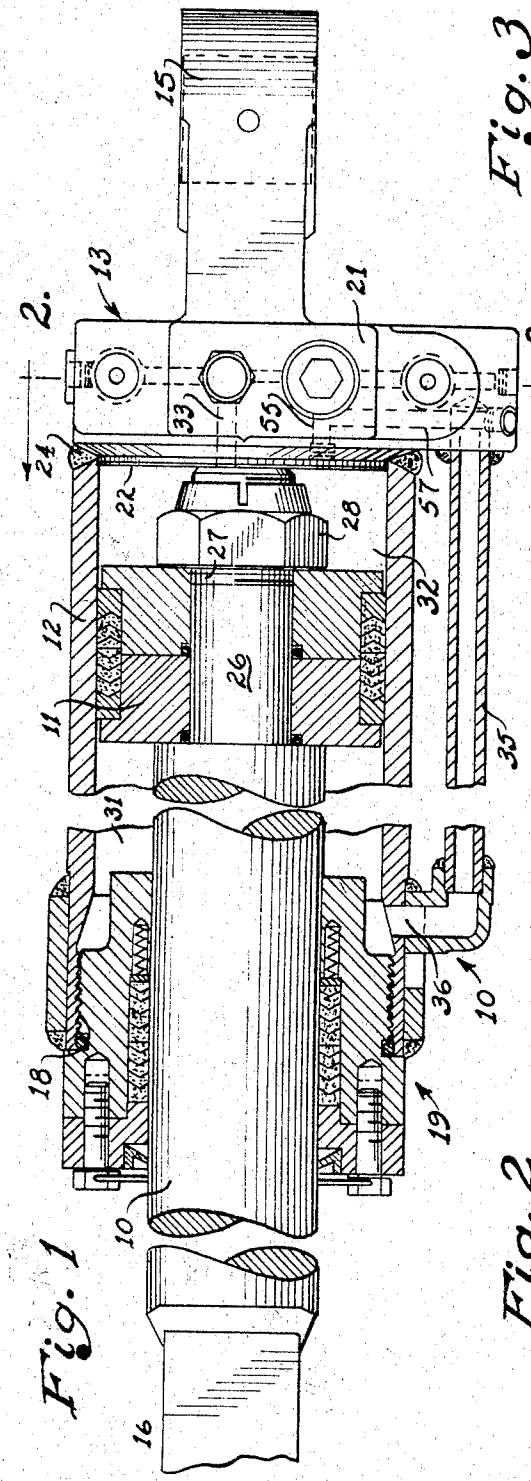


Fig. 1

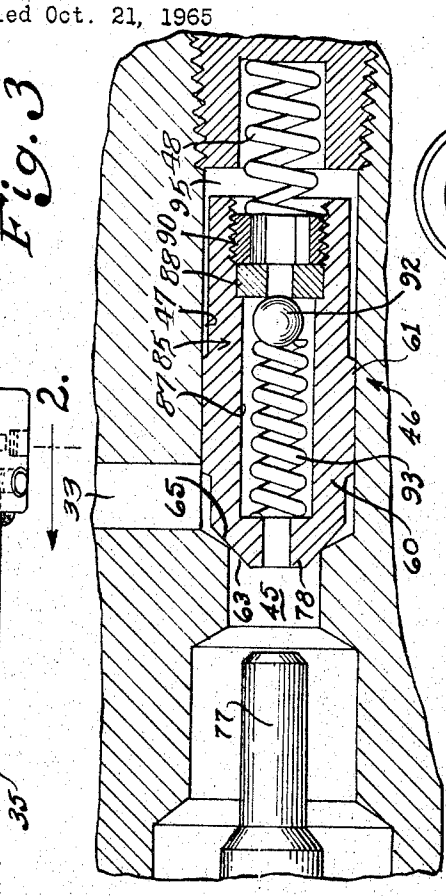


Fig. 3

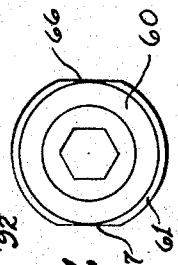


Fig. 4

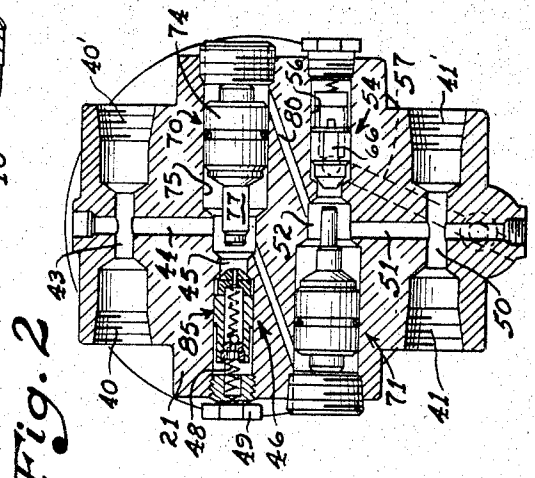


Fig. 2

Inventor
Robert L. Hoffman
By Hofgren, Wegner,
Allen, Stellman & McCord
Attys

United States Patent Office 3,349,671 Patented Oct. 31, 1967

3,349,671

HOLDING VALVE WITH THERMAL RELIEF

Robert L. Hoffman, St. Joseph, Mich., assignor to Benton Harbor Engineering Works, Incorporated, a corporation of Michigan

Filed Oct. 21, 1965, Ser. No. 499,463
9 Claims. (Cl. 91—420)

This invention relates to the control of reciprocating hydraulic actuators and, more particularly, to a holding valve assembly for controlling the flow of fluid relative to a hydraulic cylinder.

In hydraulic systems where a reciprocating hydraulic actuator is employed to raise and lower a movable load, a directional control valve is conventionally employed to selectively port fluid to the opposite sides of the hydraulic actuator. The directional control valve is, also, movable to a block position to prevent discharge flow from either side of the hydraulic actuator in an attempt to hold the load stationary. However, the hydraulic seals in the directional control valve are insufficient to prevent load creepage under the force of gravity acting thereon.

For the purpose of preventing this load creepage, and fluid leakage in the directional control valve, holding valves have been provided in the past to lock hydraulic fluid in the actuator when the control valve is in the neutral or blocking position. These prior valves have been interposed in the hydraulic circuit between the actuator and the directional control valve to selectively prevent flow from either or both sides of the actuator. To provide an operational device these holding valves are, also, capable of permitting fluid flow to one side of the cylinder and from the other side of the cylinder when the directional control valve is moved to one of its active positions. For this purpose, the holding valve is overridden usually by means of a pressure responsive actuator.

A serious disadvantage of these prior valves is that they positively lock fluid in the hydraulic actuator regardless of the pressure conditions therein. While it is desirable to provide a positive blocking function under normal operating conditions to prevent load creepage, under certain conditions excessive pressure in the hydraulic actuator cylinder may cause failure of the cylinder or certain parts associated therewith. One such abnormal condition may occur when the hydraulic actuator is brought inside after being used outside under low temperature conditions. As the temperature of hydraulic fluid in the cylinder increases, it expands and the pressure in the cylinder increases due to the positive blocking function of the holding valves. A failure may result unless some provision is made to relieve this excessive pressure condition.

In accordance with the present invention, a relief valve is provided for permitting the escape of hydraulic fluid from either side of the actuator when an excessive pressure condition exists therein.

It is, therefore, a primary object of the present invention to provide a holding valve assembly with a new and improved thermal relief valve which permits the egress of fluid from the hydraulic actuator when an excessive pressure condition exists therein.

Another object of the present invention is to provide a holding valve assembly with a new and improved thermal relief valve, of the type described above, in which the thermal relief valve is disposed within the movable holding valve member to provide a new and simplified construction heretofore unknown in prior holding valve assemblies.

A still further object of the present invention is to provide a holding valve assembly for selectively blocking fluid flow from either side of a hydraulic actuator with a new and improved thermal relief valve for preventing excessive pressure build-up in the hydraulic cylinder, in

which the relief valve includes a ball and compression spring check valve disposed concentrically within the movable holding valve member and adapted to open in the opposite direction of the holding valve, there being provided an annular guide on the periphery of the holding valve member with axial passages therein for providing a continuous communication between the actuator cylinder chambers and the ball thermal relief valve.

A more specific object of the present invention is to provide a new and improved hydraulic actuator assembly including a reciprocating piston cylinder, a holding valve member fixed at one end of the cylinder with supply and exhaust conduits connecting the holding valve member with the fluid chambers on either side of the actuator piston, there being provided one holding valve associated with each of the conduits to control fluid therethrough; each of the holding valves including a first inlet passage in the holding valve member adapted to be connected selectively to a source of fluid under pressure or a drain, a second passage in the holding valve member is generally perpendicular to the first passage and is adapted to be connected to one of the supply or exhaust conduits, with a valve seat separating the first and second passages, a valve bore extending from the seat on the side thereof adjacent the second passage, a generally annular movable valve member slidable in the valve bore and having a generally conical valve portion selectively engageable with the valve seat, the valve member having a raised generally annular guide portion spaced from the seat, a compression spring in the bore for biasing the valve member against the seat in opposition to the fluid pressure in the first passage, with a pilot piston in the valve responsive to fluid pressure in the other supply or exhaust conduit for lifting the valve member from its seat to permit fluid flow from one side of the actuator to the drain; and relief valve means in each of the holding valves for preventing excessive pressures in the actuator that includes an axially extending stepped bore through the movable valve member, an annular valve seat releasably fixed in the stepped bore, a ball valve engageable with the seat and biased thereagainst by a compression spring in the stepped bore in a direction opposite the direction of biasing the holding valve member, and reduced axial bleed surfaces on the annular guide permitting communication between the hydraulic cylinder and the ball valve, with the ball valve compression spring having a sufficient strength so that it does not yield under normal operating conditions, but will yield under a predetermined excessive pressure in the hydraulic actuator to prevent damage thereto.

Further objects and advantages will become apparent from the following detailed desecription taken in connection with the accompanying drawings, in which:

FIG. 1 is an elevational view partially in cross section showing the hydraulic cylinder assembly;

FIG. 2 is a cross section taken generally along line 2—2 of FIG. 1 showing the holding valve assembly;

FIG. 3 is a fragmentary cross section of one of the holding valves showing the thermal relief valve construction; and

FIG. 4 is an end elevation of one of the movable holding valve members.

Referring to FIG. 1, the hydraulic actuator **10** includes a reciprocating piston **11**, a cylinder **12**, and a holding valve assembly **13**, fixed to one end of the cylinder **12**. A pivot mounting **15**, formed integrally with the holding valve assembly **13**, is adapted to be pivotally mounted on a suitable pin fixed on a relatively stationary portion of a lifting device (not shown) associated with the hydraulic cylinder **10**. Another pivot mounting **16** (broken in FIG. 1) is adapted to be connected through another pin to the load. As fluid is selectively ported to either side of the piston **11**, the mount **16** will extend and retract with

respect to the cylinder 12. More specifically, the cylinder 12 has cylindrical outside and inside surfaces with one end threaded at 18 to receive a suitable end cap and seal assembly 19 which slidably receives a piston rod 20 which carries the piston 11 at one end thereof.

The holding valve assembly 13, includes a generally rectangular valve plate 21 with an annular projection 22 on one side thereof which fits within the right end of the cylinder 12 and is welded thereto as at 24. Piston rod 20 has a reduced portion 26 which receives the piston 11 with a threaded portion 27 threadedly receiving a suitable nut 28 which functions to maintain the piston on the reduced piston rod portion.

The piston 11 divides the cylinder into chambers 31 and 32. Fluid is ported to and from chamber 32 through passage 33 (FIGS. 1 and 3) in the holding valve plate 21. Fluid is ported to and from chamber 21 through a suitable conduit 35 which communicates with a port 36 in cylinder 12 and with the holding valve plate 21 in a manner more fully described below.

Turning now to the details of the construction of the holding valve assembly as shown in FIGS. 1 to 4, and particularly FIG. 2, inlet ports 40 and 41 are provided, both of which function to convey, supply and discharge fluid between a control valve (not shown) and the hydraulic cylinder 12. Alternate inlet ports 40' and 41' may be employed depending upon operational requirements. Port 40 supplies and returns fluid to and from the hydraulic cylinder chamber 32, while port 41 supplies and returns fluid to and from hydraulic chamber 31. Port 40 communicates with chamber 31 when pressurized by the directional control valve through passages 43, 44, 45, poppet valve 46, and passage 33.

The poppet valve 46 permits flow from passage 44 to passage 33, but prevents flow in the reverse direction. This constitutes the holding function of the poppet valve 46. A spring 48, seated against a suitable plug 49 threaded in valve bore 47, urges the poppet valve 46 to its closed position in opposition to fluid pressure in bore 45 and passage 44.

A similar inlet fluid circuit is provided in association with port 41 and includes passages 50, 51, bore 52, poppet valve 54, and passage 55. Passage 55 extends generally perpendicular to valve bore 56 in a generally axial direction with respect to the cylinder 12, and communicates with conduit 35 through a generally transversely extending passage 57 shown in FIGS. 1 and 2. The poppet valve assembly 54 is identical in construction to the poppet valve assembly 46, so that it should be understood that when reference is herein made to one, it applies equally as well to the other.

As shown in FIG. 3, the poppet valve assembly 46 is seen to include a generally cylindrical movable valve member 60 having a raised generally annular guide portion 61 which slidably engages the cylindrical valve bore 47 in valve plate 21. The forward end of the valve member 63 is conically shaped and defines a valve surface which engages a valve seat 65 defined by the intersection of bores 45 and 47. The annular guide 61 has flat portions 66 and 67 which provide communication between the passage 33 and the right end of valve member 60 as shown in FIG. 3, for a purpose more fully described below.

Pressure responsive piston assemblies 70 and 71 are provided for opening the poppet valve assemblies 46 and 54, respectively, to selectively permit the discharge of fluid from one side of the hydraulic actuator when the other side of the actuator is pressurized from fluid flowing through the directional control valve. As both of the pilot pistons are identical, the details will be discussed only with reference to piston assembly 70.

The piston 74 is provided slidable within a transverse bore 75 in plate 21, and has an axially extending projection 77 engageable with the flat end 78 on the movable valve member 60. Fluid is ported to the right end of bore 75 to actuate piston 74 through a passage 80 which communicates with the inlet port 41 associated with poppet valve 54. Thus, when port 41 is pressurized to deliver fluid under pressure to hydraulic chamber 31, a portion of this fluid will flow through passage 80 into bore 75, moving piston 74 to the left and opening poppet valve 46 to permit the discharge flow from the actuator chamber 32 through passage 55 and port 41.

The piston 11 and the mount 16, thus, move to the right under the differential pressure across the piston. If the directional control valve, controlling the flow of fluid relative to ports 40 and 41, is placed in its neutral or blocking position, a low pressure condition will exist in passages 44 and 51, and the poppet valves 46 and 54 will close, locking hydraulic fluid in the actuator chambers 31 and 32. This provides the holding function of the valve which prevents load creepage when the directional control valve is in neutral.

In accordance with the present invention, a thermal relief valve assembly 85 is provided in each of the poppet valve assemblies 46 and 54 for relieving excessive pressure in the chambers 31 and 32; as shown more clearly in FIG. 3. The thermal relief valve assembly 85 is seen to include a stepped centrally disposed bore 87 extending completely through valve member 60. A generally annular valve seat 88 engages a shoulder within the bore 87 and is releasably fixed therein by a suitable threaded plug 90 having a central opening therethrough. A movable ball valve member 92 selectively engages seat 88 to prevent flow through the bore 87. Ball 92 is biased to its closed position against seat 88 by coil spring 93 seated within bore 87. Spring 93 is sufficiently strong so that it will not yield under normal operating pressures in the working chambers 31 or 32, so that under such conditions the holding valve member 60 will positively block flow from the chambers and prevent any load creepage. The spring 93, however, is designed to yield upon a predetermined excessive pressure in chambers 31 or 32 to prevent damage to the hydraulic actuator or holding valve. In one exemplary construction, the spring 93 was designed to permit the ball valve 92 to lift off the valve seat 88 from 2,500 p.s.i. to 3,000 p.s.i.

The flat surfaces 66 and 67 on the sides of the annular guide land 61, provide communication between the fluid chambers 31 and 32 and the rear ends 95 of the valve bores 47 and 56. These flat portions 66 and 67 are in effect bleed passages which provide communication between passages 33, 55 and the ball members 92 without interfering with the guiding and supporting functions of the annular lands 61.

If for some reason the hydraulic fluid pressure in chamber 32 increases to an excessive value e.g., 2,500 p.s.i. fluid pressure acting on the exposed surface of ball member 92, as shown in FIG. 3, will overcome the biasing force of spring 93 and permit fluid in chamber 32 to flow through passage 33, along the axial passages defined by flat portions 66 and 67 into the rear chamber 95 of bore 47, around the ball valve member 92, and into bore 45 which is at a relatively low pressure when the actuator is not pressurized. After the pressure in chamber 32 has fallen below a predetermined maximum limit, ball valve 92 will close and the holding valve member 60 will perform its normal holding function.

As noted above, the poppet valve member 54 is identical to poppet valve 46 and has an identical relief valve 85 therein which responds to excessive pressure in passage 55 to permit fluid flow from chamber 31 into bore 52.

Having described my invention as related to the embodiments shown in the accompanying drawings, it is my intention that the invention be not limited by any of the details of description, unless otherwise specified, but rather be construed broadly within its spirit and scope as set out in the accompanying claims.

I claim:

1. In a holding valve assembly for a fluid actuator,

the combination comprising: a valve member having first passage means adapted to be connected to a fluid return line, second passage means in said valve member adapted to be connected to one side of the actuator, a movable valve member responsive to pressure in said first passage means for providing communication between said first and second passage means, said movable valve member normally blocking communication between said first and second passage means in response to a relatively lower pressure in said first passage means, means for selectively opening said valve member to permit fluid flow from said second passage means to said first passage means, and relief valve means in said movable valve member responsive to excessive pressure in said second passage means for providing communication between said second and first passage means.

2. A holding valve assembly as defined in claim 1, wherein said relief valve means includes a second movable valve member slidable in said first movable valve member, spring means in said first movable valve member for biasing said second movable valve member to a closed position blocking communication through said first movable valve member between said second passage and said first passage, said spring means biasing said second valve member in opposition to fluid pressure in said second passage means.

3. A holding valve assembly as defined in claim 2, wherein said first movable valve member has an axial passage therethrough, a valve seat in said axial passage, said second valve member being a ball member selectively engageable with said seat in the axial passage, said spring being a compression spring seated within said axial passage and engaging said ball member.

4. In a hydraulic actuator device having first and second supply conduits adapted to deliver fluid under pressure to the opposite sides of the actuator, a holding valve assembly comprising: a relatively stationary valve member having a valve bore therein, a valve seat in said bore, first passage means in said valve member communicating with one side of said seat and adapted to be connected to one of said conduits, second passage means in said valve member communicating with the other side of said seat and adapted to be connected to one side of said actuator, a generally cylindrical movable valve member slidable in said bore and selectively engageable with said seat to block communication between said first and second passages, means biasing said movable valve member to its closed position in opposition to the force of fluid pressure in said first passage, said biasing means being constructed to yield upon a predetermined pressure in said first passage to permit fluid flow from said first passage to said second passage, a fluid operated pilot piston responsive to pressure in the other of said conduits for moving said movable valve member to its open position permitting fluid flow from said second passage to said first passage; and pressure relief valve means for providing communication between said second passage and said first passage upon the occurrence of excessive pressures in said second passage when the valve member is closed including an axial bore extending through said movable valve member, a second movable valve member shiftable in said bore and adapted to normally block flow through said bore, biasing means for urging said second valve member to the blocking position, said second valve member biasing means being of sufficient strength not to yield under normal operating pressures in said second passage means, and bleed passage means in the periphery of said first movable valve member for providing communication between said second passage means and said second movable valve member, whereby upon a predetermined excess pressure in said second passage means the second movable relief valve will open permitting fluid from said second passage to said first passage.

5. A holding valve assembly as defined in claim 4 wherein said second passage means is generally perpendicular to said first passage means, said first movable valve member having a generally annular guide portion spaced from said valve seat and slidably engaging said valve bore, said bleed passage including an axial groove in said annular guide.

6. A holding valve assembly as defined in claim 4 wherein said second movable valve member includes a ball member, and said second member biasing means includes a compression spring in said first valve member bore engaging said ball member and urging said ball member in a direction opposite from said first valve member biasing means.

7. A holding valve assembly as defined in claim 6 wherein said bore in the first valve member has a stepped portion therein, a generally annular removable valve seat in said stepped portion engageable by said ball member, and a threaded plug for maintaining said removable valve seat in position.

8. An actuator assembly, comprising: a cylinder; a piston slidable in said cylinder; a holding valve assembly fixed to one end of said cylinder, first conduit means connecting said holding valve assembly to one side of said piston, second conduit means connecting said holding valve assembly to the other side of said piston; said holding valve member including a plate, two holding valve means in the plate each adapted to control fluid flow through one of said conduits, each of said holding valve means including a first inlet passage in said plate adapted to be connected selectively to a source of fluid under pressure or a drain, second passage means in said holding valve plate generally perpendicular to said first passage means and connected to one of said conduits, a valve seat separating said first and second passage means, said valve plate having a main valve bore extending from said valve seat on the side thereof adjacent said second passage means, said second passage means intersecting said bore, a generally annular movable valve member slidable in said bore and having a generally conical valve portion selectively engageable with said valve seat, said valve member having a raised, generally annular guide portion spaced from said seat, a compression spring in said bore for biasing said valve member against said seat in opposition to fluid pressure in said first passage means, a pilot piston responsive to fluid pressure in the other of said conduits for lifting said valve member from its seat and permitting fluid flow from said second passage means to said first passage means; and relief valve means for preventing excessive pressures in said cylinder including an axially extending stepped bore through said movable valve member, an annular valve seat releasably fixed in said stepped bore, a ball valve engageable with said annular valve seat, a compression spring in said stepped bore for urging said ball member against said seat in a direction opposite said first valve member biasing means, and reduced axial bleed surfaces on said annular guide permitting communication between said second passage means and said ball member, said ball compression spring having sufficient strength so that it will not yield under normal operating conditions.

9. In a holding valve assembly for a double acting fluid actuator, comprising: a valve member having first passage means adapted to be connected to a fluid return line, second passage means in said valve member adapted to be connected to one side of the actuator, a movable valve member responsive to pressure fluid being delivered to the other side of said actuator for providing communication from said second passage means to said first passage means thereby permitting fluid discharge from said one side of the actuator, means responsive to said pressure fluid for selectively opening said valve member to provide said communication from said second passage means to said first passage means, said movable valve member normally blocking communication between said second passage means and said first passage means, means responsive to pressure in said first passage means for providing communication between said first and second passage

means, and relief valve means in said movable valve member responsive to excessive pressure in said second passage means for providing communication between said second and first passage means.

References Cited

UNITED STATES PATENTS

3,164,959	1/1965	Gondek	91—420
3,198,088	8/1965	Johnson et al.	91—420
3,274,902	9/1966	Kleckner	91—420

FOREIGN PATENTS

957,851	5/1964	Great Britain.

MARTIN P. SCHWADRON, *Primary Examiner.*

P. E. MASLOUSKY, *Assistant Examiner.*