

May 31, 1955

E. F. FULLWOOD ET AL

2,709,420

HYDRAULIC CYLINDERS HAVING BY-PASS VALVE MEANS

Filed June 27, 1951

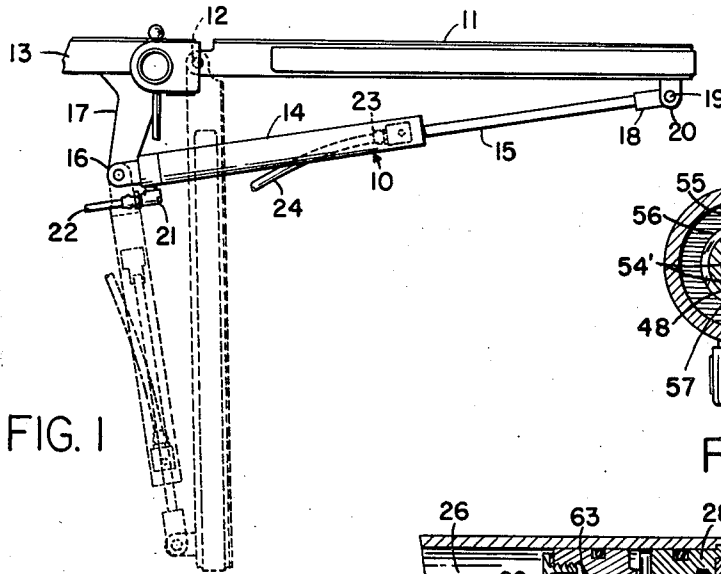


FIG. 1

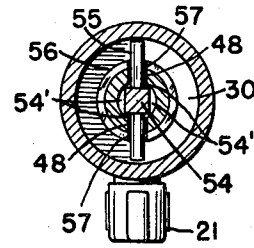


FIG. 3

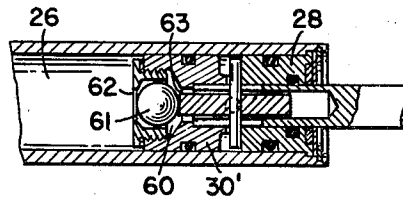


FIG. 6

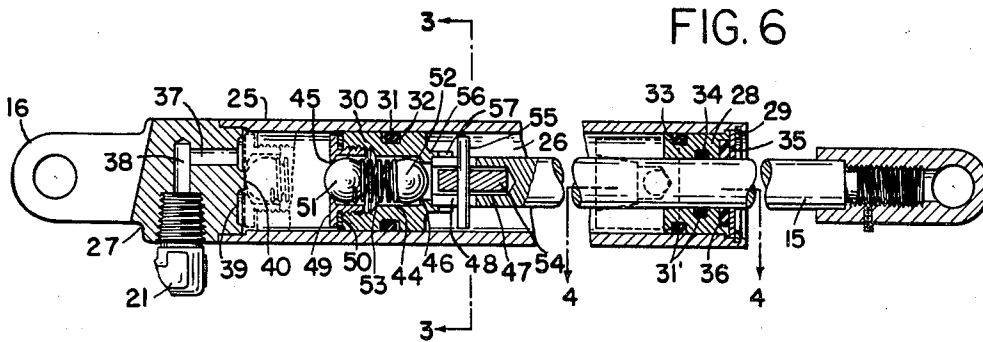


FIG. 2

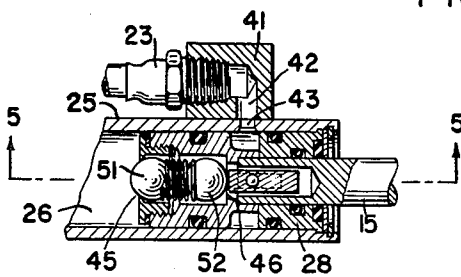


FIG. 4

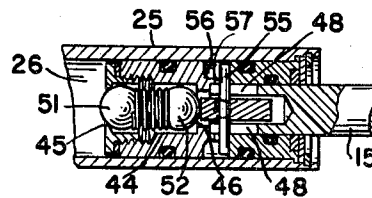


FIG. 5

INVENTORS
EDWARD F. FULLWOOD
BY JOHN PHILIPPI

H. Hume Matheson
ATTORNEY

1

2,709,420

HYDRAULIC CYLINDERS HAVING BY-PASS VALVE MEANS

Edward F. Fullwood and John Philippi, Madison, Wis.,
assignors to Air Reduction Company, Incorporated,
New York, N. Y., a corporation of New York

Application June 27, 1951, Serial No. 233,758

5 Claims. (Cl. 121—38)

This invention relates to hydraulic cylinders and particularly to overtravel or pressure relief means for such cylinders.

An object of the present invention is to provide an hydraulic cylinder having improved pressure relief or overtravel means.

The hydraulic cylinder and pressure relief means of the present invention is particularly useful with an hydraulic system having two or more hydraulic cylinders series-connected by fluid circuit lines wherein the invention functions effectively as an overtravel means between successive hydraulic cylinders. The fluid lines of such a circuit connecting the cylinders may be completely filled with fluid, so that displacement of fluid in the circuit causes movement of all the cylinders. When high pressure actuating fluid is delivered to the first of the hydraulic cylinders in the circuit, the displacement of the piston therein forces fluid out of the cylinder barrel into the fluid line connecting the second cylinder. The displaced fluid thus actuates the second cylinder, ejecting fluid also from this cylinder which is delivered to a third hydraulic cylinder and so on, causing all of the series-connected cylinders to be actuated simultaneously. By so connecting the hydraulic cylinders in the fluid circuit, all of the cylinders can be operated from a single source of fluid pressure. However, it is possible in this circuit for the piston stroke of one of the hydraulic cylinders to be completed before the pistons in the other cylinders have been moved to their end stroke positions; for example, if the volume displacements of the series-connected hydraulic cylinders are not equal, or in the event of fluid leakage. When this occurs, further supply of actuating fluid to and from such cylinder ceases, and further movement of the other partially-moved hydraulic cylinders is prevented. By utilizing the cylinder and overtravel means of the present invention, fluid may pass through the cylinders after they have completed their respective movements so that all of them can be operated through their full ranges of motion.

Another object of the invention is to provide an hydraulic cylinder for use in such fluid circuits which has improved overtravel means adapted to permit passage of fluid through the cylinder for flushing the fluid circuit.

One type of pressure relief device for hydraulic cylinders responds to the fluid pressure when the pressure exceeds a predetermined value. This type of pressure relief means may be unsatisfactory where it is desired to permit the passage of fluid only at the end of the piston stroke or when operation of the pressure relief means is desired substantially without any increase in fluid pressure.

Another object of the invention, therefore, is to provide an hydraulic cylinder having an improved mechanically actuated pressure relief means operable only at fixed positions of the piston.

A further object is to provide improved pressure relief means for hydraulic cylinders adapted to allow passage

2

of fluid through the cylinder with substantially little or no change in cylinder fluid pressure.

A further object of the invention is to provide an hydraulic cylinder having pressure relief or overtravel means effective at both ends of the piston stroke in double-acting hydraulic cylinders.

A still further object of the invention is to provide, in an hydraulic cylinder, pressure relief or overtravel means adapted to permit fluid to pass through the cylinder and at the same time maintain the position of the cylinder against the load applied thereto.

Hydraulic circuits having series-connected hydraulic cylinders may be advantageously applied to adjustable surgical operating tables. Such tables include several movable members, each of which may have associated therewith an hydraulic cylinder for adjusting the table members. When two or more of the cylinders are series-connected in the fluid circuit, the associated table members may be actuated simultaneously, and energized from a single source of pressure fluid thus increasing the overall efficiency of the table mechanism. The present invention, though not limited to such use, is particularly adapted for incorporation in the series-connected cylinders of such hydraulically operated surgical tables.

It is therefore an additional object of this invention to provide hydraulic cylinders particularly applicable to hydraulic surgical operating tables for facilitating the simultaneous adjustment of movable parts thereof.

Other objects and advantages of the present invention may be more fully understood by reference to the following description of a preferred embodiment of the invention, and in the accompanying drawing, in which:

Fig. 1 is a side view illustrating an hydraulic cylinder operatively mounted on a portion of a surgical operating table,

Fig. 2 is a longitudinal section through the hydraulic cylinder shown in Fig. 1,

Fig. 3 is a transverse sectional view taken along the line 3—3 of Fig. 2,

Fig. 4 is a longitudinal sectional view along the line 4—4 in Fig. 2, illustrating the piston member at the outer end of its stroke in the hydraulic cylinder,

Fig. 5 is a longitudinal section along line 5—5 in Fig. 4, and

Fig. 6 is a longitudinal sectional view through an hydraulic cylinder illustrating a modification of the construction in Figs. 1—5.

In accordance with the invention, there is provided an hydraulic cylinder comprising a cylinder barrel, a piston slidably disposed therein and adapted to be reciprocated by alternate introduction of fluid at opposite ends of said cylinder barrel, and valve means contained in said piston operable by means associated with at least one end of said cylinder barrel for permitting the passage of fluid through said piston when the piston reaches a predetermined position in its stroke at the corresponding end of the cylinder. In its preferred form, the hydraulic cylinder is double-acting, said valve means comprising double-acting, ball check-valve means contained in a valve cavity in the cylinder piston, having valve seat openings in opposite faces of the piston against which the ball check-valve means is alternately seated, and means engageable with the ball check-valve means at opposite ends of the piston stroke for unseating said check-valve means. There is housed in the connecting rod, in a chamber at the piston end thereof, a thrust pin axially movable therein for engagement with said ball check-valve means, said pin being adapted for such engagement at a fixed position of said piston. Openings from said chamber are provided by radial slot passages.

Referring now to the drawings, an hydraulic cylinder 10 is shown in Fig. 1 operatively connected to a swinging

member 11 hinged at 12. The member 11 may represent the leg-supporting member or section of a surgical operating table which is hinged to the seat section of the table, only the end of which is shown at 13. The surgical table may be one such as hereinbefore mentioned having an hydraulic circuit including one or more hydraulic cylinders in series-connection with the cylinder 10 for simultaneous adjustment of said corresponding table members. The hydraulic cylinder 10 comprises a cylinder barrel 14 and a piston rod 15, which is adapted to move in and out of said barrel. The hydraulic cylinder is provided at its head end with lugs 16 which are pin-connected to a bracket 17 extending downwardly from the table seat section 13. The outer end of the piston rod assembly 15 carries an adjustable knuckle element 18 which is hinged by means of a pin 19 to lugs 20 on the under side of the table leg section. Fluid fitting 21, in the head end of the cylinder barrel 14, receives a fluid line 22 and a fitting 23 at the rod end of the barrel on the rear side thereof, as seen in Fig. 1, receives a fluid line 24. The piston rod is adapted to be extended from the barrel 14 or withdrawn into it by delivering fluid at a relatively high pressure to one end of the barrel and discharging the displaced fluid at some lower pressure from the other end thereof. By alternatively delivering the fluid under pressure through one or the other of the fluid lines 22 or 24, the direction in which the cylinder is motivated may be controlled. In this manner the swinging member, or leg section, 11 may be rotated to any desired position between the horizontally extended position shown, and a lowered position substantially represented in dotted lines.

The cylinder barrel 14, shown in longitudinal section in Fig. 2, comprises a cylindrical portion 25 having a displacement chamber 26 which is closed at the head end by a head-block 27 and at the rod end by a plug 28 which is retained in the open end of the cylindrical portion 25 by an expansion ring 29. A piston 30, carried at the inner end of piston rod 15, is slidable in the chamber 26 and is provided with fluid sealing means cooperating with the bore of the barrel, comprising annular gaskets of circular cross section, or O-rings, 31 which are seated in an annular groove 32 in the circumferential face of the piston. The end plug 28 carries O-ring sealing members 31' seated in recesses 33 and 34 which cooperate with the bore of the barrel 25 and the surface of piston rod 15, respectively, to create a fluid-tight seal at the rod end of the cylinder. A flat disc 35 is held against the outer face of the end plug 28 by the retaining ring behind which a suitable material 36, such as felt, is held so as to be in frictional contact with the surface of piston rod 15. The felt material 36 provides a wiping device which effectively removes dust or other foreign material which may be deposited on the piston rod when it is in its extended position.

The head-block 27 contains passages 37 and 38 communicating with fluid fitting 21 and terminating in an annular groove 39. A protrusion 40, formed thereon, extends inwardly of the barrel into the displacement chamber 26 and is effective for actuation of the overtravel means, as will be described hereinafter. The rod end fluid fitting 23 is shown in Fig. 4. This fitting is received in a block 41 mounted on the cylinder barrel in which passages 42 and 43 extend inwardly therethrough and through the wall of the cylindrical portion 25 to form a communication with the displacement chamber 26.

A valve cavity 44 is formed in the piston head 30 having a valve seat opening 45 terminating in the head-end face of the piston and an opening 46 which opens through the rod end of the piston. The valve opening 46 is in confronting relation to a drilling 47 in the end of piston rod 15 which is provided with radial slots 48 that open out from the drilling 47 to the displacement chamber 26. Valve seat opening 45 is formed in a bushing member 49 threadably received in the head end of

the valve cavity and sealed therein by a compression gasket 50. Ball valve elements 51 and 52 are contained in the valve cavity wherein they are adapted to be seated against the valve seat openings 45 and 46, respectively. A spring 53 is interposed between the ball elements urging them oppositely toward their respective valve seat openings. The spring 53 is a light compression spring which positions the ball elements with respect to the corresponding valve seat openings, but is not adapted to retain the ball elements in seated position against fluid pressure exerted oppositely thereon.

A thrust pin 54 is disposed in drilling 47 carrying a pin 55 having transversely extending end portions which project through the radial slots 48. The pin 55 is adapted to be moved longitudinally in the slot openings 48 to cause axial displacement of the thrust pin. A collar portion 56 on the rod-end face of the piston, wherein the piston rod 15 is received, has slots 57 that are in register with the slots 48 as best shown in Fig. 3. It will also be seen in this figure that thrust pin 54 is square in cross section affording thereby spaces 54' between the longitudinal faces of the thrust pin and the bore of the drilling 47 through which fluid may pass. The longitudinal edge corners of the pin are received substantially by the bore of drilling 47 wherein the thrust pin is guided and maintained in axial alignment with the valve seat opening 46.

In the operation of the hydraulic cylinder, high pressure fluid may be introduced, for example, at the rod end of the cylinder through the fitting 23. Such fluid acting against the ball element 52 may unseat this ball from the opening 46 against the force of spring 53. Ball element 51, however, is urged toward closed position against valve opening 45 and the fluid acting against the total exposed area of the piston forces the piston and piston rod toward the head end of the cylinder barrel, causing fluid to be forced out the chamber 26 through the fluid fitting 21. When the piston rod is at its fully retracted piston, the piston head is in a position corresponding to that shown in dotted lines in Fig. 2. In this position, the protrusion 40 engages ball element 51, unseating this member from valve seat opening 45. Ball element 52 is also unseated by fluid pressure action thereon and fluid is enabled to pass through radial slots 48, drilling 47, and valve cavity 44. Such fluid is discharged into annular groove 39 and thence through passages 37 and 38 and fluid fitting 21. It will be seen that ball element 51 is unseated mechanically at the head end position of the piston and that substantially no rise in fluid pressure is necessary to effect such opening of the overtravel valve means to allow passage of the fluid through the cylinder.

While the fluid is thus metered through the piston, a force sufficient to support the load applied to the hydraulic cylinder device is provided by a metering action inherent in the overtravel valve mechanism. This works as follows.

When the valve ball 51 is first opened, a reduction in the effective differential pressure across the piston occurs, as a result of which the piston may be moved by the load a very small distance in the opposite direction. In so doing, the ball element 51 moves toward seated position reducing the effective area of the valve opening 45 and creating, as a result, a greater differential pressure. The required load-supporting force is produced when a suitable throttling effect of the fluid being passed through the piston creates the necessary pressure differential to balance the piston force against the load. When the flow of fluid is terminated, the piston head may recede a slight amount, whereupon the valve ball element 51 is seated firmly against valve opening 45, sustaining the position of the piston and piston rod.

The overtravel mechanism operates in substantially the same manner when relatively high pressure fluid is introduced through the fluid fitting 21, causing the piston to move toward the rod end of the cylinder and extending the piston rod to its maximum protracted position. The

5

piston head is shown at the extreme rod-end position in Figs. 4 and 5. As the piston rod is moved longitudinally out of the rod end of the cylinder, the projecting ends of the pin 55 engage the inner face of end plug 28. Thereafter, the additional movement of the piston and piston rod causes the thrust pin 54 to be brought against the ball valve element 52. When the piston is at its extreme position, the thrust pin is moved sufficiently to unseat the ball valve element against the force of spring 53 and the fluid pressure acting thereon, and permits the discharge of actuating fluid through the valve seat opening 46. Fluid flows thence into drilling 47 and into chamber 26 through the radial slots 48 from where the fluid is discharged by means of the fluid fitting 23. It will be noted that the slots 57, formed in the collar portion 56, are recessed inwardly from the end of the collar a greater distance than the diameter of the pin 53, thus preventing the blockage of slot passages 54 by the pin 55 and insuring an opening from drilling 47 and radial slots 48 when the collar portion 56 is flush against the end plug 28, as seen in Fig. 5.

A regulating effect is also produced when the piston is moved to its rod-end position as was before described in connection with its head-end position whereby a differential pressure is created across the piston sufficient to support the load applied to the cylinder. In this case, the axially movable thrust pin 54, together with the transverse pin 55, which bears against the inner face of the cylinder end plug, provide an interference for unseating ball element 52 with relation to which the piston assumes a position corresponding to the required opening of the valve port 46. When the thrust pin is not in positive engagement with the end plug 28, the ball valve element 52 is seated by the force of the valve spring and the fluid pressure acting thereon. Thus, when the flow of actuating fluid ceases, the piston recedes slightly until the thrust pin is not in engagement with the end closure 28, and the ball element 52 is permitted to seat.

A modified form of the hydraulic cylinder 10 is shown in Fig. 6. In this construction the piston 30' has a valve cavity 60 in which is disposed a single ball check element 61. The ball element 61 is movable in the cavity 60 toward opposing valve seat openings 62 and 63 in the head-end face and rod-end face of the piston respectively. The piston rod assembly 15 is identical to that illustrated in Figs. 1-5 having drilling 47 in confronting relation to valve seat opening 63, and radial slots 48 opening therefrom into the piston displacement chamber 26. Thrust pin 54 is axially movable in the drilling 47 toward or away from valve seat opening 63. In this modification, embodying only a single ball element, the ball 61 is seated against opening 62 when fluid is introduced at the rod end of the cylinder and is seated against valve seat opening 63 when the fluid is introduced at the head end of the cylinder. The ball element is unseated by engagement of the protrusion 40, Fig. 2, when the piston is at the head end of the cylinder and by the thrust pin 54 when the piston is at the rod end, as hereinbefore described in connection with the preferred embodiment.

It will now be seen that the hydraulic cylinder described, constituting a preferred embodiment of the invention, and an alternate form thereof, is adapted to provide continuous passage of actuating fluid at either end of the piston stroke after the stroke is completed, and to maintain the position of the cylinder under the applied load. Hence, the apparatus has particular utility in fluid circuits including two or more such hydraulic devices connected in series therein.

The fluid utilized in connection with the invention is preferably an oil, such as the type conventionally used for actuation of hydraulic cylinders.

6

The invention is not limited to the specific embodiments herein illustrated and described, but may be used in other ways without departure from its spirit as defined by the following claims.

We claim:

1. An hydraulic cylinder comprising a cylinder barrel having fluid inlet and outlet openings at longitudinally spaced points therein, a piston slidable in said cylinder barrel between said fluid openings, a piston rod extending outwardly of said cylinder barrel, means receiving the inner end of said piston rod in one face of said piston forming a connection therewith, a valve cavity in said piston having valve seat openings centrally disposed in opposite faces of said piston, double-acting check-valve means in said cavity adapted to be seated by the cylinder fluid pressure against one of said valve seats in the direction of the fluid pressure acting thereon, an end bore in the inner end of said piston rod in confronting relation to one of said valve seat openings, a thrust pin guided by and axially movable in said bore having transversely extending portions, longitudinally elongated radial slots in said piston rod registering with said end bore, said transverse portions projecting through said slots and adapted to be longitudinally displaced therein, a stop means engageable with said transversely extending portions causing relative movement of said thrust pin and said check-valve means to unseat said valve means from said confronting valve seat at a fixed position of said piston, abutment means associated with said piston adapted to engage said stop means independently of said transverse portions of said thrust pin thereby limiting the movement of said piston and the relative displacement of said transverse portions in said radial slots, and interference means effective at a longitudinally spaced position of the piston to engage said check-valve means and unseat said valve means from the other valve seat.

2. An hydraulic cylinder as set forth in claim 1, in which said thrust pin is of rectangular cross-section, at least two diagonally opposite edge-corners of which are received in said bore whereby said pin is guided axially, and fluid passages are provided in the space between said pin and said bore.

3. An hydraulic cylinder as set forth in claim 1, in which said interference means comprises a protrusion extending inwardly from the terminal end of said cylinder barrel at the head end thereof.

4. A hydraulic cylinder device as set forth in claim 1 wherein said double-acting check-valve means comprises a pair of ball elements and spring means interposed between them, urging said elements toward the respective valve seat openings.

5. A hydraulic cylinder device as set forth in claim 1 wherein said double-acting check-valve means comprises a ball element adapted to be seated against either of said valve seat openings in the direction of the fluid pressure-acting thereon.

References Cited in the file of this patent

UNITED STATES PATENTS

561,747	Worthington	June 9, 1896
1,880,627	Wilson	Oct. 4, 1932
1,983,051	Smith	Dec. 4, 1934
2,233,521	Ernst et al.	Mar. 4, 1941
2,403,325	Armington	July 2, 1946

FOREIGN PATENTS

489,663	Great Britain	Aug. 2, 1938
517,314	Great Britain	Jan. 26, 1940