July 27, 1965 W. L. CHICHESTER 3,196,755

FLOW CONTROL SYSTEM FOR LOAD-HANDLING APPARATUS

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FIG. 1

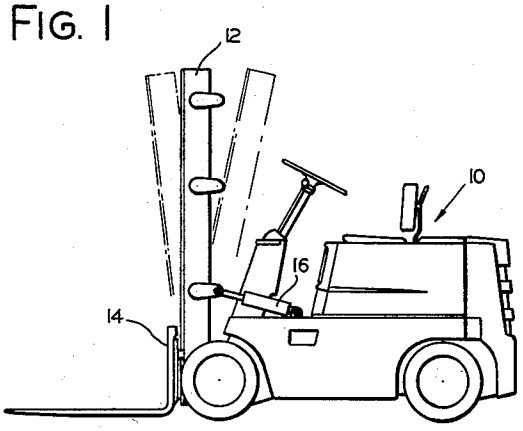
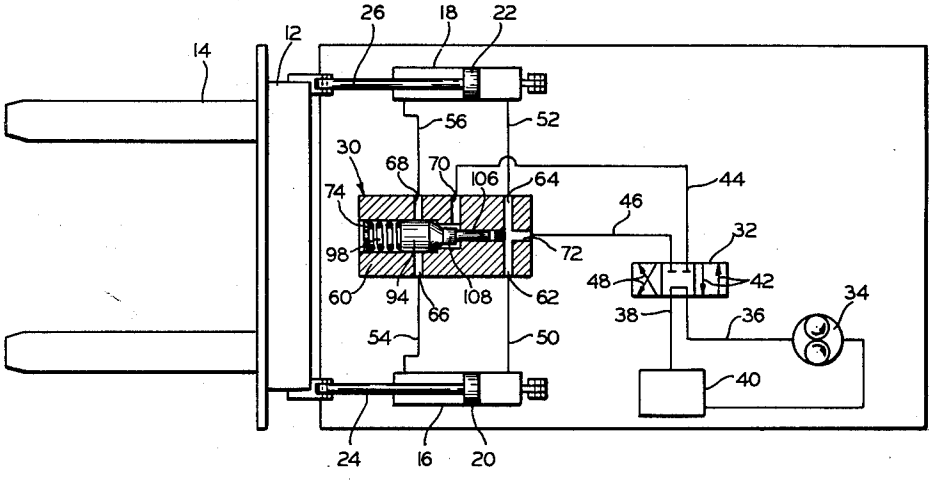


FIG. 2



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FIG. 3

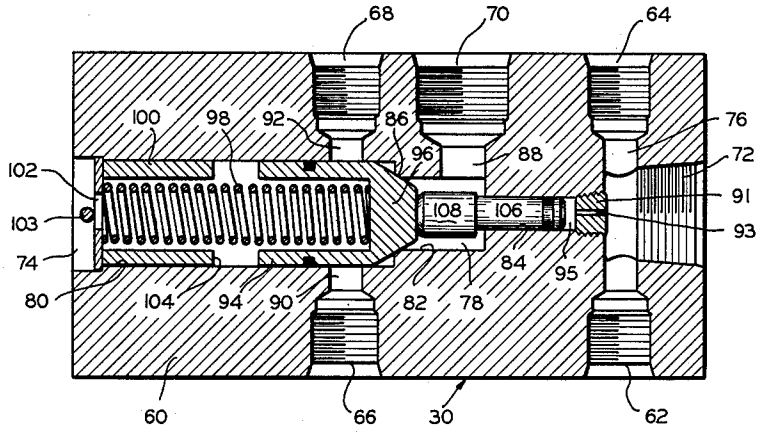
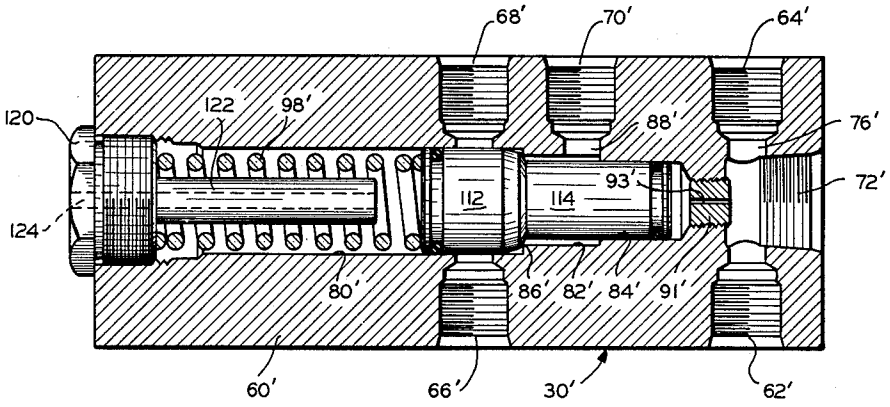


FIG. 4



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FLOW CONTROL SYSTEM FOR LOAD-HANDLING APPARATUS

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7 Claims. (Cl. 91—411)

This invention relates to a flow control system for load-handling vehicles, such as lift trucks, and more particularly to an improved valve construction for use in such a system. It is particularly well-suited for use in industrial lift trucks having a pair of cylinders for tilting the truck mast.

When a lift truck is turned, such as when rounding a corner, the load on the fork tends to twist the mast. The two tilt cylinders, which control the position of the mast, permit such twisting when the cylinders are connected to one another, because the fluid from one cylinder can cross over to the other cylinder. That is to say, fluid from the heavily loaded cylinder can flow over to the lightly loaded cylinder. This is undesirable because of resulting undue strain on the mast and can be unsafe because at times the mast tends to sway dangerously.

My flow control system utilizes an improved tilt lock control valve for the tilt cylinders of lift trucks, for example, which are connected between the truck body and the mast of the truck for pivoting the upright forwardly and rearwardly of a vertical position whereby to aid in picking up loads (forward tilt) and in carrying loads (backward tilt). During tilting operation it is important that both the head and rod ends of the tilt cylinders be maintained full of hydraulic fluid, preferably at a positive pressure, so that no cavitation can occur in the cylinder and so that the pistons are positively locked in any given selected pivoted position of the mast. Olson et al. U.S. Patent No. 3,022,773 discloses one means which purports to accomplish this result.

My invention provides improved fluid locking valve means in flow control systems of the type contemplated, and it is a main object of the present invention to provide in certain types of load-handling apparatus an improved valve construction for preventing cross-over of fluid between cylinders in the system after actuation thereof to predetermined positions, and which valve means also permits the cylinders to be connected together for receiving fluid from a common source.

A further object of the invention is to provide in a fluid control system of the type contemplated improved valve means preventing cross-over between cylinders of the system under certain conditions while providing for the supply of pressure fluid to the cylinders from a common source, and also being adapted to positively prevent cavitation in any of the cylinders under certain conditions of operation.

Another object of the invention is to provide in a fluid control system of the type contemplated improved valve means providing a positive seal between conduits connecting a pair of oppositely disposed cylinders under certain conditions, and to generally improve the performance and dependability of such valves.

Other objects and advantages of the invention will become apparent to persons skilled in the art from the following detailed description taken in conjunction with the accompanying drawings wherein:

FIGURE 1 is a side elevational view of a lift truck which incorporates the hydraulic system of the present invention;

FIGURE 2 is a diagrammatic plan view of the truck showing the hydraulic circuit schematically;

FIGURE 3 is an enlarged cross-sectional view of one

embodiment of my improved valve means which forms a part of the hydraulic circuit illustrated in FIG. 2; and

FIGURE 4 is a cross-sectional view of a modified form of the valve means shown in FIG. 3.

Referring now to the drawings, and particularly to FIGS. 1–3, the lift truck 10 has a mast 12 at its front end pivoted from the front drive axle of the truck for tilting movement from a rearwardly inclined position, to a slightly forwardly inclined position as shown in dotted lines. A fork carriage 14 is elevatable on mast 12 by conventional hydraulic hoist and chain means, not shown. A pair of tilt cylinders 16 and 18 have pistons 20 and 22 which are pivotally connected by piston rods 24 and 26 and suitable bracket and pin means to mast 12, the head ends of the cylinders being pivotally connected by bracket and pin means to the body of the truck.

Hydraulic fluid is supplied to and exhausted from the cylinders by the operation of a tilt-lock valve shown generally at numeral 30 and a manually operated directional control valve 32, the latter valve being supplied with hydraulic fluid under pressure from a pump 34 through a line 36. The directional control valve is a three-position, four-connection valve having a closed center. However, when the directional control valve is in its closed position, as illustrated, there is a return line 38 from the pressure line 36 to a sump 40. The directional control valve is actually a spool valve and the symbols shown merely simplify the disclosure of the spool valve.

When valve 32 is shifted to the left, parallel channels 42 therein connect with lines 36 and 44 and with lines 38 and 46 so that fluid under pressure is supplied from line 36 to line 44 and fluid is delivered from line 46 to the sump 40. When the directional control valve is shifted to the right, reversing channels 48 cause fluid under pressure to be delivered from line 36 to line 46, and enable fluid to be discharged from line 44 to the sump by way of line 38. Lines 50 and 52 connect the head ends of cylinders 16 and 18 to positions of tilt-lock valve 30 and are connectible upon manipulation of control valve 32 to either pump 34 or sump 40, whereas lines 54 and 56 connect the rod ends of cylinders 16 and 18 to other portions of valve 30 and are likewise connectible by manipulation of control valve 32 to either the pump or sump, as will be described in detail below.

A body 60 of control valve 30 is formed to provide a plurality of transversely spaced ports comprising a first pair of ports 62 and 64 which are connected to the head ends of the cylinders by lines 50 and 52, respectively, a second pair of spaced ports 66 and 68 which are connected to the rod ends of the cylinders by lines 54 and 56, respectively, a single transversely disposed port 70 which is connected to line 44, and a pair of longitudinally spaced ports 72 and 74 which are connected to line 46 and open to the atmosphere, respectively. Ports 62 and 64 are connected to each other by a transverse passage 76, which passage also communicates with port 72 and intersects a longitudinally extending valve bore 78 which opens into port 74. Valve bore 78 is formed of three portions of different diameters, viz, a large diameter valve chamber portion 80, an intermediate diameter portion 82, and a small diameter portion 84, said portions 80 and 82 forming in the plane of intersection thereof an annular valve seat 86. Port 70 communicates with bore portion 82 by way of passageway 88, and ports 66 and 68 are adapted to communicate with bore portion or valve chamber 80 by way of passages 90 and 92. A threaded insert plug 91 having a restricted opening 93 therein communicates passage 76 with a chamber 95 in bore portion 84.

A generally cup-shaped fluid control poppet valve 94 having a truncated conical control portion 96 which is adapted to seat on the valve seat 86 is slidably mounted in

chamber 80, being urged in a closing direction against seat 86 by a control spring 98 which abuts the valve at one end, as shown, and which is held in position by a cup-shaped spring retainer 100 having an opening 102 which vents chamber 80 to the atmosphere through port 74. Spring retainer 100 is of predetermined length and provides an annular abutment edge 104 which limits the maximum movement of valve 94 in an opening direction. A pin 103 is mounted in the housing 60 transversely of the outer end of retainer 100 holding the retainer in position. A pilot valve member is adapted to operate valve 94 under certain conditions and is composed of a guide stem 106 received in bore portion 84 and an abutment head 108 disposed in bore portion 82. O ring seals are provided on both valve portions 94 and 106 to prevent fluid leakage through opposite ends of the valve. It will be noted that valve portion 106, 108 is not integral with control valve 94, but is a separate piece which abuts the end of the conical portion of the latter valve.

It may be assumed that when pistons 20 and 22 move to the left as view in FIGS. 1 and 2, they are moving with load assistance, that is, the weight of a load on fork 14 is urging the pistons to move toward the left to advance forward tilting movement of mast 12, but when the pistons move to the right to tilt mast 12 rearwardly from any given position thereof they move with load resistance. The operation of the circuit is as follows: It may be assumed that a load is to be deposited and that the mast is in a vertical or rearwardly inclined position. To facilitate deposit of the load, pistons 20 and 22 are required to move leftwardly; however, since the pistons tend to move to the left with load assistance there is a tendency for cavitation to take place in the right-hand ends of the cylinders, which tendency is avoided as will now be explained.

To cause the pistons to move to the left, the directional control valve 32 is shifted to the right to locate the cross-over portion 48 in the center of the valve in order to supply pressure fluid from pump 34 to the head ends of cylinders 16 and 18 by way of lines 36, 46, 50 and 52, the valve ports 62, 64 and 72. Pressure fluid increases in the head ends of the cylinders, but because valve 94 is held in pressure contact with valve seat 86 by spring 98, fluid cannot flow from the rod ends of the cylinders prior to opening movement of valve 94, which then permits the cylinder rod ends to communicate with sump 40 by way of lines 54, 56, ports 66, 68, the valve opening at seat 86, bore portion 82, port 70, and lines 44 and 38 by way of the return cross-over channel portion 48. However, as long as poppet valve 94 is maintained by spring 98 in positive sealing relation to seat 86, no communication between the rod ends of the cylinders and the sump can occur through the aforementioned circuit. In closed position, valve 94 blocks completely any flow of fluid from the rod ends of the cylinders and the pistons remain in locked positions. Forward tilting movement of mast 12 can therefore only occure subsequent to a build-up in pressure in the head ends of the cylinders and in passage 76 sufficient to actuate pilot member 108 to the left to open poppet valve 96 against the force of spring 98 and toward a maximum open position established when valve 94 abuts edge 104 of spring retainer 100.

During the period of pressure build-up prior to opening movement of valve 94, it is apparent that equal pressure build-up occurs in the rod ends of the cylinders, and that not until valve 94 opens lines 54 and 56 to line 44 through the valve and connecting passageways in the valve housing does the mast begin to tilt forwardly. Throughout forward tilting movement of the mast, positive pressure is maintained in the head ends of the cylinders by valve 94 irrespective of the angle of forward tilt of the mast or the load on fork 14 which tends to actuate the mast with load assistance under such conditions. Valve 30 operates to prevent any action which would tend to cause cavitation in the head ends of the cylinders, since valve member 94 will in operation open and close as required to maintain the predetermined pressure level in the head ends of the cylinders as fixed by spring 98. Thus, the pistons 20 and 22 are driven to the left always under positive pressure in the head ends of the cylinders even though they have a tendency to move to the left with load assistance.

Now it may be asumed that the load has been deposited or placed on the fork and that the fork and mast is to be actuated in a reverse or rearward tilt direction. To accomplish this, valve 32 is shifted to the extreme left so as to place parallel channels 42 in the center of the valve thereby supplying pressure fluid to line 44 from the pump, while line 46 is connected to the sump. Pressure fluid in line 44 is directed into valve bore portion 82 and acts upon the exposed conical valve portion 96 whereby to actuate valve 94 to the left against spring 98. Pressure fluid then flows through ports 66 and 68 into the rod ends of the cylinders to pivot mast 12 to the right against the resistance thereof to movement in said direction, while ejecting fluid from the head ends of the cylinders to the sump through ports 62 and 64 and through lines 46 and 38. When a desired rearward tilt position of the mast is established, direction control valve 32 is returned to its closed center position, as shown in FIG. 2, whereupon spring 98 closes valve 94 and pistons 20 and 22 are sealably locked in said selected position.

In this regard, it will be noted that if the lift truck is being maneuvered around corners and the like, the load would tend to twist the mast one way or the other if lines 54 and 56 were connected to each other. For instance, if the latter lines were interconnected, a twisting force on the mast tending to move the piston 20 to the left and the piston 22 to the right would cause fluid to flow from the rod end of cylinder 16 to the rod end of cylinder 18, thus enabling the mast to sway or twist. However, upon fixing the rearward tilt position of the mast, valve 94 returns immediately to its closed position and prevents communication betwen lines 54 and 56, thus fixing the tilted position of the mast without any tendency thereof to sway or twist regardless of the subsequent maneuvers of the truck.

Small opening 93 in plug 91 functions as a dashpot during closing movement of valve 94 and restricts the rate of opening movement of valve 94, thereby preventing valve chatter and effecting a smooth and controlled rate of valve opening and closing movements. This construction permits the valve 94 to engage seat 86 with a "soft" action, thus permitting the use of relatively soft material in the valve body and valve.

In FIG. 4 there is illustrated a modification of the structure of valve 30 in which similar parts have been numbered the same as in FIG. 3, but with a prime designation. Valve 30' of FIG. 4 is operable in a manner similar to that of valve 30 and is substitutable for valve 30 in the hydraulic circuit shown in FIG. 2. In the valve construction shown in FIG. 4, a poppet valve 112 has a pilot extension 114 which is integral therewith and which extends into bore portions 82' and 84' in a manner similar to the mounting of corresponding valves 94, 106 of valve assembly 30. As will be observed, the various ports and passageways in valve housing 60' are located similarly to the location thereof in valve housing 60 and are adapted to be connected to the same lines of the hydraulic circuit as are the corresponding ports of valve housing 60. Passageway 76' is connected to the bore portion 84' by the threaded plug insert 91' having a small passageway 93' therein. Insert member 91' performs the same dashpot function in the FIG. 4 construction as described above in FIG. 3. Opposite end portions of valve member 112, 114 include circumferential grooves in which O rings are located, as shown, to seal the valve from leakage flow through the ends thereof into spring chamber 80' or passage 76'. Spring 98' abuts valve 112 at its one end and abuts a spring retainer and vent plug

120 at its other end, plug 120 having a spring guide and retainer member 122 and a vent opening 124 extending therethrough to the atmosphere. The embodiment of the valve construction shown in FIG. 4 functions in the hydraulic circuit of FIG. 2 in the same way as does the valve of FIG. 3, but is somewhat less expensive to manufacture, and for that reason is preferred.

Although only only two embodiments of the present invention have been disclosd herein, modifications in the structure and relative arrangement of parts will be apparent to persons skilled in the art, and I do not intend that the invention be limited otherwise than by the scope and spirit of the claims appended.

I claim:

1. In a flow control system for a load-handling apparatus having a plurality of piston and cylinder units, the pistons of which are actuated away from one set of ends of the cylinders with load assistance and actuated away from the opposite set of ends of said cylinders against load resistance, means for connecting either set of ends of said cylinders with a source of fluid under pressure and for exhausting fluid from either set of ends of said cylinders in correlated in-one-end-out-the-other-end manner, said means including a single valve, a valve seat, means biasing said valve into fluid sealing relation with said valve seat, said valve in said sealing relation blocking exhaust from said other set of ends and being responsive to the pressure in said one set of ends to allow the exhaust of fluid from said other set of ends only after build up of a predetermined pressure in said one set of ends to prevent cavitation in said one set of ends.

2. A flow control system as claimed in claim 1 wherein said single valve comprises two separate axially aligned elements, one of which is a poppet valve element for seating on said valve seat, and the other of which is a pilot element in abutment with said poppet valve element and subjected to pressure in said one set of ends for opening said poppet valve element against said resilient means.

3. A flow control system as claimed in claim 1 wherein said single valve comprises a poppet element adapted to abut said valve seat in sealing relation and an element extending from said poppet element responsive to fluid pressure in said one set of ends of said cylinders for actuating said poppet element in an opening direction against said resilient means.

4. In a lift truck having a tiltable load handling upright and a pair of cylinder and piston units connected

to the upright for tilting the upright forwardly and rearwardly such that the pistons tend to tilt the upright forwardly with load assistance and tend to tilt the upright rearwardly with load resistance, a flow control system including conduit and valve means for directing pressure fluid simultaneously to either the head or rod ends of said cylinders, the head and rod ends of said cylinders having respective cross-over conduit connections, a poppet valve in the rod end cross-over connection for preventing communication between said rod ends of said cylinders, a valve seat normally engaged by said poppet valve in fluid sealing relation, means biasing said poppet valve into said sealing relation, and a pilot extension of said poppet valve responsive to pressure in the head ends of said cylinders for opening said poppet valve under predetermined fluid pressure in said head ends, said poppet valve and extension thereof comprising the sole cylinder pressure responsive control valve in the system.

5. In a lift truck as claimed in claim 4, dashpot means operable for controlling the rate of opening and closing movements of the poppet valve relative to the valve seat.

6. A flow control system as claimed in claim 1, wherein said valve constitutes the only cylinder-pressure-responsive control valve in the system.

7. A flow control system as claimed in claim 1, wherein said plurality of piston and cylinder units comprises a pair of such units, and connection means for said opposite set of ends of the cylinders of said pair of units, said valve being disposed in said connection means to prevent communication of the pair of cylinders therethrough before occurrence of said predetermined pressure.

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