

Jan. 8, 1963

R. D. CASSELL

3,072,107

HYDRAULIC LIFT CONTROL SYSTEM AND VALVE THEREFOR

Original Filed Sept. 10, 1959

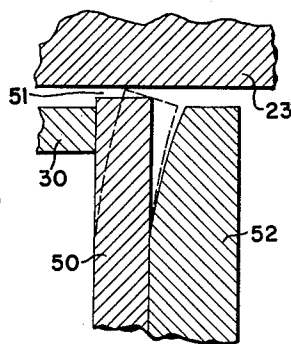
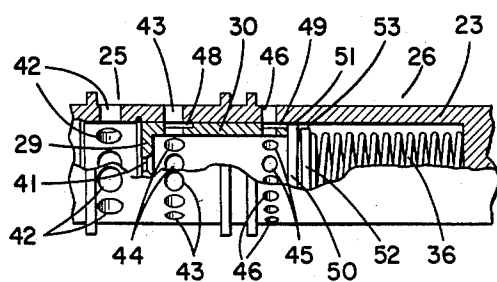
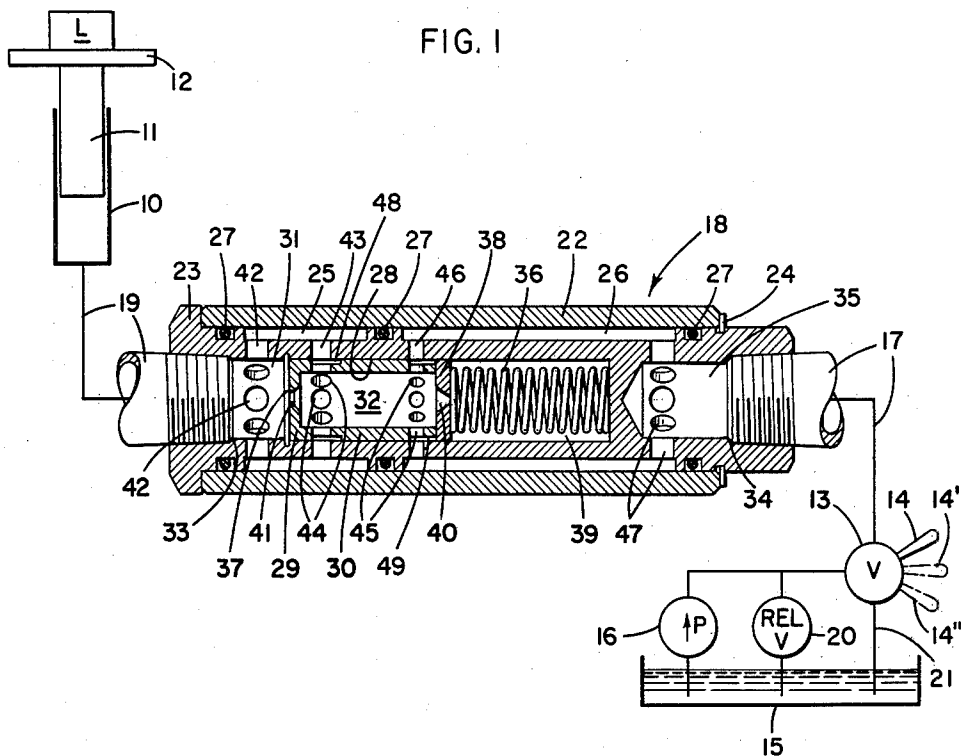


FIG. 2

FIG. 3

INVENTOR.

ROBERT D. CASSELL

BY

Richard W. Trevorton
ATTORNEY

1

2

3,072,107
HYDRAULIC LIFT CONTROL SYSTEM AND
VALVE THEREFOR

Robert D. Cassell, Inkster, Mich., assignor to Flow-
matic Controls Incorporated, Birmingham, Mich., a
corporation of Michigan
Continuation of abandoned application Ser. No. 839,202,
Sept. 10, 1959. This application Mar. 16, 1961, Ser.
No. 96,334

19 Claims. (Cl. 121—46.4)

This application is a continuation of petitioner's co-
pending application Serial No. 839,202, filed September
10, 1959, and allowed September 20, 1960, now
abandoned.

The present invention relates to an improved control
system for hydraulic lifts and to an improved hydraulic
pressure control valve adapted for use in such system.

An object of the invention is a system wherein the lift,
when lowering by gravity, will have a maximum rate of
descent which is low when the static load on the lift is
great and is progressively higher as such load is decreased.
This is desired in order that the maximum rate of descent
may be as high as possible without danger of damage
when the lift is suddenly stopped. It is desired that the
valve maintain the kinetic energy of the descending lift
approximately constant, irrespective of the static load.

A further object of the invention is a hydraulic pres-
sure control valve of simple and inexpensive construc-
tion, capable of the above-stated control function, and
adapted for use in lift-control systems and also in other
hydraulic systems wherein the control requirements are
similar.

A problem in hydraulic control valves of the afore-
mentioned type, and also in others, is a damping means,
capable of preventing surges in the controlled flow, which
is non-clogging or self-cleaning, and is simple and inex-
pensive in construction. An object of the invention is a
valve having dash-pot damping means which will have
these advantages and which will also compensate auto-
matically for changes in pressure and in viscosity of the
hydraulic fluid occasioned by temperature changes.

The foregoing and other objects and advantages will
appear from the following description of the preferred em-
bodiments of the invention shown in the accompanying
drawings, wherein:

FIG. 1 is a diagrammatic view of the lift control system,
with the pressure control valve shown in detail in longi-
tudinal section;

FIG. 2 is a fragmentary view of the valve with improved
damper, the view being partly in longitudinal section and
partly in side elevation; and,

FIG. 3 is a fragmentary longitudinal section of a part
of the valve of FIG. 2, on an enlarged scale.

The lift comprises a cylinder 10 having slidable therein
a piston 11 connected to a platform 12 adapted to sup-
port a load L. The lift is manually controlled by a valve
13 whose handle 14 is raised, to its full line position, to
raise the lift; is lowered to dotted line intermediate posi-
tion 14' to hold the lift elevated; and is lowered toward
or to its dash-dot line position 14'' to lower the lift at
retarded or full speed. When the valve handle is raised,
hydraulic fluid is drawn from sump 15 by power-operated
pump 16, and is directed by valve 13 through a conduit
17, pressure control valve 18, and conduit 19 into the
cylinder chamber beneath the piston 11, to thereby raise
the piston and platform 12 and the load L thereon. The
pressure in the system is limited by a relief valve 20.
When the valve handle is in its intermediate position 14',
the valve 13 shuts off flow to and from conduit 17 and
allows flow from the pump to discharge to the sump
through conduit 21. Accordingly the lift is held against

lowering. When the handle is lowered from position 14'
the valve 13 continues to allow flow from the pump, but
also allows flow from conduit 17, through conduit 21 to
the sump, the rate of flow from conduit 17 depending
upon how far the handle is moved from position 14' to-
ward position 14''. Accordingly the lift may lower by
gravity at a rate determined by manual control of valve
13; or, if handle 14 is fully lowered so as to allow free
discharge from conduit 17 into the sump, then at a rate
that is determined by pressure control valve 18. This
valve has no control effect when the lift is being raised
and is designed to impose little resistance to fluid flow
under that condition.

Valve 18 comprises a sleeve or other housing 22 having
a bore in which a substantially cylindrical valve body 23
is disposed, being retained by a snap ring 24. The body
has annular grooves 25 and 26 which, together with the
surrounding sleeve or housing, constitute annular fluid
passages that are sealed by means of flexible O-rings 27.
An axial bore 28 in the left end of the body constitutes a
cylinder in which a piston 29 is slidable, the piston having
a skirt 30. The piston divides the cylinder 28 into a
chamber 31, hereinafter called the inlet chamber (inasmuch
as the entire purpose of the valve in this system is the
control of exhaust flow from the lift cylinder 10), and a
control chamber 32 within the skirt 30. Conduit 19 com-
municates with chamber 31 through an inlet opening
33 in the valve body. Conduit 17 communicates, through
an outlet opening 34 in the opposite end of the body 23,
with an axial bore 35 in the body which constitutes the
valve's outlet chamber.

The piston 29 is urged to the left by a spring 36 toward
the limit position shown wherein it abuts a snap ring 37
which serves to hold the piston and spring in assembly
with the valve body. In the embodiment shown in FIG.
1 a disc 38 is interposed between the skirt of the piston
and the spring, to separate the control chamber 32 from
the spring chamber 39. The disc has an orifice 40 there-
through, and, by restricting fluid flow between the control
chamber and the spring chamber, serves to damp motion
of the piston. In cases where no such damping is needed
the disc may be omitted entirely, in which event the
spring 36 bears directly against the piston skirt 30.

Fluid flow from inlet chamber 31 to the control cham-
ber 32 is partially through an orifice 41 in the head of
piston 29, and also through orifices 42 in the valve body
into annular passage 25 and thence through valve ports 43
through the body and registering ports 44 through the
piston skirt 30. Flow from the control chamber 32 into
outlet chamber 35 is through registering valve ports 45
and 46, respectively through the piston skirt and the body,
into the annular passage 26, and thence through openings
47 through the body.

The openings 42 and 47 are large enough to impose
no appreciable restriction to fluid flow through the valve
18, while valve ports 43, 44 and 45, 46 are designed to
restrict flow when the lift is descending by gravity with
the manual control valve 13 open fully or nearly fully.
As the lift descends, the restriction imposed by the vari-
able-area orifice comprising ports 43, 44 and orifice 41
causes a pressure differential to exist between chambers
31 and 32 which tends to move the piston to the right
against the resistance of spring 36, partially closing off
the ports 43 and 44. However, ports 46 are so propor-
tioned and arranged as to present a smaller passage than
orifice 41 and ports 43, so that upon an increase in the
load L, and a consequent increase in the static pressure
in chamber 31 and in the compression of spring 36, the
flow through the valve actually decreases.

Although the spring may of course be designed to pro-
vide whatever sensitivity of control is needed for a par-
ticular application, the general nature of the valve's con-

trol action may be understood by assuming the spring to be so designed that it will exert a nearly constant load on the piston in all control positions of the piston. Since the spring load must always act to balance the pressure differential across the piston, it will be seen that under the assumed condition the piston will so control the ports 46 as to maintain this differential substantially constant, and, accordingly, that any reduction in area of the fluid passages connecting the chambers on opposite sides of the piston will decrease the rate of flow through the valve. Inasmuch as the fixed orifice 41 and the ports 43 controlled by the piston together constitute a variable area orifice which decreases as the piston moves to the right, it will be seen that the flow through the valve will decrease as the magnitude of load L is increased. If, as in practice, the spring load increases as the piston moves to the right, the pressure differential across the piston will increase correspondingly, but by suitable design of the orifice 41, 43, approximately the same control effect described above may be obtained.

The valve ports 43, 46 and the orifice 41 are preferably so proportioned that the velocity of the flow decreases in direct or nearly direct proportion to increase in the square root of the static fluid pressure beneath piston 11 and in inlet chamber 31. Thus irrespective of the load L the valve 18 holds the kinetic energy at an approximately constant magnitude, and when the lift bottoms or is stopped suddenly the maximum impact is the same. This means that the lift can be lowered at the maximum speed consistent with safety under all loads.

The registering ports 43, 44 and the registering ports 45, 46 may be proportioned and arranged so that their respective effective areas are unchanged by rotation of the piston in the valve body. Otherwise, annular grooves as shown at 48 and 49 are provided around the piston skirt 39 to distribute fluid between ports 43 and 44 and between ports 45 and 46.

As mentioned hereinbefore the disc 38 by having only restricted orifice 40 therethrough, and having a sliding fit with bore 28, restricts flow between chambers 32 and 39 and hence damps the action of the piston 29, thus smoothing its pressure control effect.

A superior but also simple and inexpensive damper is shown in FIG. 2. It comprises a disc 50 of resilient material, preferably having a substantially greater coefficient of thermal expansion than the material of which the valve body 23 is made. A clearance space 51 between the periphery of the disc and the bore 28 constitutes a flow-control orifice similar in function to orifice 40. A crowned plate 52 interposed between the disc and spring 36 causes the spring pressure to be applied to the center of the disc. Because of this, the disc is bowed more or less depending on the magnitude of the spring load and the pressure differential between chambers 32 and 39. Due to the edge thickness of the disc, such bowing has the effect of decreasing the clearance space 51, thereby increasing the damping effect upon increase of both the load L and dynamic loads (since these affect the pressure differential between chambers 32 and 39). The effect of the bowing is shown, greatly exaggerated, in FIG. 3, where the disc appears in broken lines in its bowed position wherein it decreases the clearance space 51. The edge thickness of the disc can of course be increased or decreased to vary the magnitude of such increase. Due to the greater thermal expansion of the disc, the clearance space 51 is decreased with rise in temperature of the hydraulic fluid in the system, thereby compensating for the reduction in viscosity of the fluid which accompanies temperature increase. The relatively great circumferential dimension of the disc 50 reduces to a minimum the possibility of clogging of the clearance space or damper flow-control orifice 51, and the flexing of the disc during operation of the system constitutes a self-cleaning action tending to dislodge foreign matter which might otherwise eventually clog this orifice. In order

that the plate 52 will not itself have a damping effect, a clearance space 53 substantially greater than clearance 51 is provided between its periphery and the bore 28.

Having now described the preferred embodiments of my invention and their operation, what I claim is:

1. A hydraulic lift control system comprising a valve through which fluid may flow to and from the lift cylinder when the lift is being raised and lowered, the valve allowing free flow to the cylinder and limiting the maximum rate of exhaust flow from the cylinder, said valve having a spring-backed piston movable in response to changes in exhaust fluid pressure upstream therefrom, said valve having variable-area orifices so controlled by the piston as to decrease and increase in area respectively upon increase and decrease in such pressure, whereby the maximum rate of descent of the lift cylinder decreases as the static load on the lift increases, said valve comprising a body having a cylinder divided by said piston into an inlet chamber and a control chamber, with said inlet chamber arranged to receive exhaust fluid from the lift cylinder when the lift is lowering, and said valve body also having an outlet opening for such exhaust fluid, the piston-backing spring being arranged to resist motion of the piston in a direction to expand said inlet chamber, a first variable-area orifice connecting the inlet chamber with the control chamber, and a second variable-area orifice connecting the control chamber with said outlet opening, the areas of both of said orifices being controlled by the piston and being decreased by motion of the piston in said direction.

2. A control system according to claim 1 in which the area of the second variable-area orifice is decreased more rapidly than the first variable-area orifice upon motion of the piston in said direction.

3. A hydraulic valve comprising a body having inlet and outlet openings and a cylinder, a piston dividing the cylinder into an inlet chamber communicating with said inlet opening and a control chamber, a spring arranged to resist motion of the piston in a direction to expand the inlet chamber, registering valve ports in the walls of the cylinder and piston constituting a first variable-area orifice to control the fluid flow from the inlet chamber to the control chamber, and other registering valve ports in the walls of the cylinder and piston constituting a second variable-area orifice to control fluid flow from the control chamber to the outlet opening, both of said orifices decreasing in area upon motion of the piston in said direction.

4. A valve according to claim 3 in which said valve ports are so arranged that said second variable-area orifice is constricted more rapidly than the first variable-area orifice upon motion of the piston in said direction.

5. A valve according to claim 3 in which there are dash-pot means to impede motion of the piston.

6. A valve according to claim 5 in which the dash-pot means comprises a disc interposed between the piston and the spring, said disc being of smaller diameter than the cylinder to provide an annular flow-control orifice between the control chamber and the chamber containing said spring, the peripheral portion of the disc bearing against the piston and the spring being arranged to bear on the central portion of the disc, whereby the disc is flexed to decrease the area of said flow-control orifice as the spring load and pressure differential across the disc increase.

7. A valve according to claim 6 in which the disc has a greater coefficient of thermal expansion than the valve body, whereby the area of said flow-control orifice is reduced upon temperature increase.

8. A hydraulic valve comprising a housing having a bore, a body telescoped in the bore having spaced annular grooves closed by the wall of the bore to define first and second fluid passages, said body having inlet and outlet openings respectively in its opposite ends and also having a cylinder which opens into said inlet opening, a

5

piston in said cylinder and means for limiting motion of the piston toward said inlet opening, a spring in the cylinder for resisting motion of the piston in the opposite direction, said piston having a skirt extending from the head thereof away from said inlet opening and defining a control chamber, registering valve ports in said body and skirt constituting a first variable-area orifice between said first passage and the control chamber, registering valve ports in said member and skirt constituting a second variable-area orifice between the control chamber and said second passage, both of said orifices decreasing in area upon motion of the piston in said opposite direction, with the area of the second orifice decreasing more rapidly than that of the first orifice, and ports in said member connecting said second passage and said outlet opening.

9. A hydraulic valve comprising a body having a cylinder, a piston slidable in the cylinder, a compression spring in the cylinder acting on the piston, a disc interposed between the piston and the valve, said disc being of smaller diameter than the cylinder to allow restricted fluid flow to and from the spring chamber, the peripheral portion of the disc bearing against the piston and the spring being arranged to bear on the central portion of the disc, whereby the disc is flexed to increase the diameter thereof as the spring is compressed and the pressure differential across the disc is increased.

10. A valve according to claim 9 in which the disc has a greater coefficient of thermal expansion than the valve body, whereby the effective area between the disc and the cylinder wall is reduced upon temperature increase.

11. A valve according to claim 9 in which there is a plate interposed between the disc and the spring, said plate being of smaller diameter than the disc and having a convex face contacting the central portion of the disc.

12. A valve according to claim 9 in which the piston has a skirt whose edge engages the disc, the portion of the skirt adjacent the disc being of smaller external diameter than the disc to provide an annular chamber between the skirt and the cylinder wall, and a fluid passage through the piston into said annular chamber.

13. A hydraulic device comprising a body having a cylindrical chamber, a resilient circular disc disposed transversely of the chamber, the disc being of slightly smaller diameter than the chamber and of finite edge thickness to provide an orifice around the periphery of the disc through which fluid may pass from one side of the disc to the other and which is reduced in area upon flexure of the disc, and a support engageable with one face of the disc adjacent the periphery thereof whereby such flexure may occur upon application of pressure against the opposite face of the disc.

14. A device according to claim 13 in which there is a transversely crowned member movable relative to said support in a direction axial of the chamber for abutting and thereby applying said pressure to the central portion of said opposite face of the disc.

15. A hydraulic device comprising a body having a cylindrical chamber, a resilient disc disposed transversely of the chamber, the disc being of slightly smaller diameter than the chamber and of finite edge thickness to provide an orifice around the periphery of the disc through which fluid may pass from one side of the disc to the other and which is reduced in area upon flexure of the

6

disc, and a member supporting the disc adjacent the center thereof for such flexure in response to pressure applied against the area of the disc outwards of the supported center thereof.

16. A device according to claim 15 in which said member is a transversely crowned plate engaging one face of the disc at the central portion thereof, for supporting the disc for such flexure by pressure applied against the opposite face thereof.

17. A device according to claim 16 in which there is a member having a circle of contact with said opposite face of the disc adjacent the periphery thereof, for applying said pressure thereto.

18. A hydraulic lift system comprising a cylinder, a piston in said cylinder, a load-bearing member supported by the piston and adapted to lower with the piston by gravity and to be raised by fluid pressure in the cylinder beneath the piston, a valve through which fluid may flow to and from the cylinder, respectively to effect raising and to allow lowering of said member and piston, said valve allowing free flow to the cylinder from a source of hydraulic pressure but limiting the maximum rate of exhaust flow from the cylinder to a sump associated with said source, said valve having a spring-backed piston movable in response to changes in exhaust fluid pressure upstream therefrom, said valve having variable area orifices so controlled by the spring-backed piston as to decrease and increase in area respectively upon increase and decrease in such pressure, whereby the maximum rate of descent of the first-mentioned piston and said load-bearing member decreases as the static load thereon increases.

19. A hydraulic lift system comprising a cylinder, a piston in said cylinder, a load-bearing member supported by the piston and adapted to lower with the piston by gravity and to be raised by fluid pressure in the cylinder beneath the piston, a valve through which fluid may flow to and from the cylinder, respectively to effect raising and to allow lowering of said member and piston, said valve allowing free flow to the cylinder from a source of hydraulic pressure but limiting the maximum rate of exhaust flow from the cylinder to a sump associated with said source, said valve comprising a body having a cylinder and a spring-backed piston slidable therein, said valve cylinder being divided by said valve piston into an inlet chamber and a control chamber, with said inlet chamber arranged to receive exhaust fluid from the lift cylinder when said load-bearing member is lowering, and said valve body also having an outlet opening for such exhaust fluid, the piston-backing spring being arranged to resist motion of the valve piston in a direction to expand said inlet chamber, a first variable-area orifice connecting the inlet chamber with the control chamber, and a second variable-area orifice connecting the control chamber with said outlet opening, the areas of both of said orifices being controlled by the valve piston and being decreased by motion of the valve piston in said direction.

References Cited in the file of this patent

UNITED STATES PATENTS

2,495,785	Stephens	Jan. 31, 1950
2,676,573	Abbe	Apr. 27, 1954
2,785,660	Jaseph	Mar. 19, 1957