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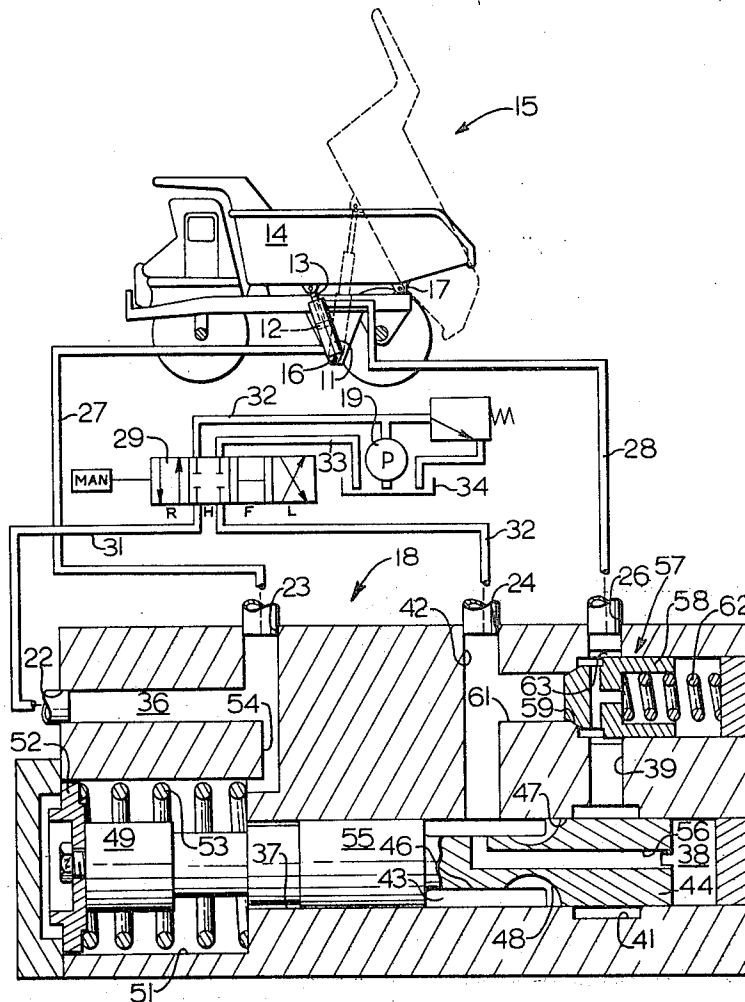
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[54] **ANTI-CAVITATION MECHANISM FOR FLUID DRIVEN SYSTEMS**
1 Claim, 1 Drawing Fig.

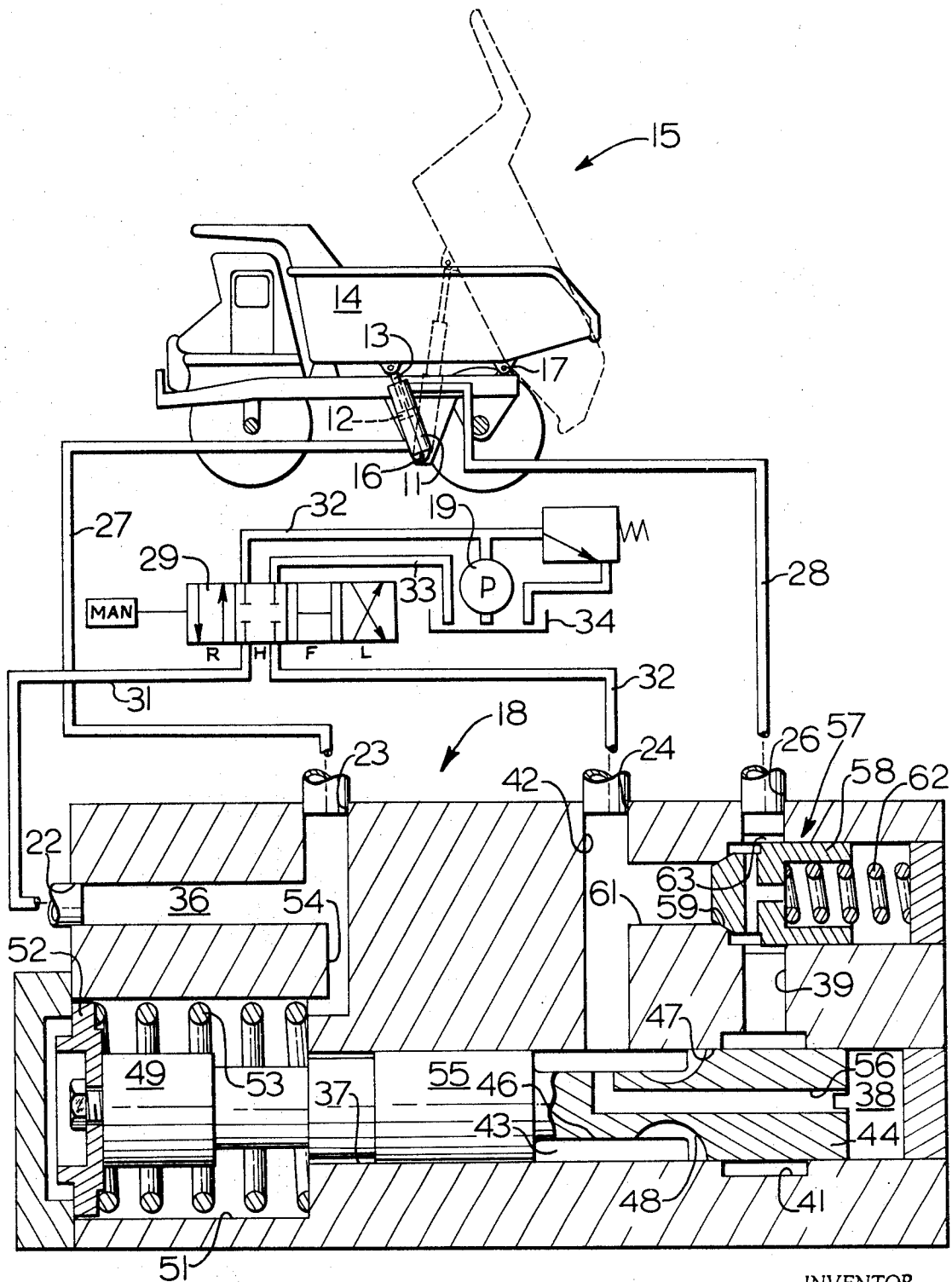
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ABSTRACT: A valve supplies driving fluid to the head end of a hydraulic cylinder while presenting a variable flow restriction to fluid being expelled from the rod end of the cylinder. The flow restriction is varied automatically in response to fluid pressure changes at the head end of the cylinder whereby the rod cannot extend, in response to external load forces, at a rate faster than that provided for by the inflow of driving fluid at the head of the cylinder.



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ANTI-CAVITATION MECHANISM FOR FLUID DRIVEN SYSTEMS

BACKGROUND OF THE INVENTION

This invention relates to fluid operated motors and more particularly to means for avoiding cavitation in such systems.

This invention was initially designed for use in conjunction with a double acting hydraulic jack and will be described with reference thereto for purposes of example, it being understood that the invention is also applicable to many other forms of fluid driven motor.

There are some working conditions under which external forces may pull or push the piston of a hydraulic jack in the same direction as the force of the driving fluid acting thereon but at a greater rate than that provided for by the incoming driving fluid. This condition can occur, for example, where the jack is used to lift the body of a dump truck for unloading purposes. During the initial portion of the working stroke, the jack works against the weight of the load in the truck body but at some point in the cycle the center of gravity of the load may pass over the pivot axis thereof. For the remainder of the stroke, the load tends to move the jack in the same direction as the driving fluid supplied thereto. There are many other fluid operated systems wherein a similar condition may occur. In any of these instances the phenomenon of cavitation may result causing sudden uncontrolled movements, vibrations, possible damage and other undesirable effects. Damage to components from overly rapid travel and subsequent shock loads can also occur under this condition.

To avoid cavitation, it has heretofore been the practice to utilize a makeup valve or the like which directs the fluid being discharged from one end of the jack back to the other end thereof to supplement the incoming driving fluid. This is not always a fully satisfactory means for preventing cavitation and under some circumstances a makeup valve is not effective for this purpose, and because it will not control the rate of jack extension and resultant shock and possible damage when the jack reaches the limit of its extension.

To transfer fluid between the ends of the jack at a rate adequate to forestall cavitation, the makeup valve must sometimes be excessively bulky and costly. In some extreme situations the size and cost of such a valve are prohibitive. This may be the case when the tendency for the jack piston to outrun its driving fluid is unusually pronounced because of a very large load. In instances where there is a very sizeable difference in the cross-section area of the fluid volume on opposite sides of the piston, fluid is discharged at a rate which is insufficient to supplement the driving fluid. For these and other reasons, a conventional makeup valve, at least of practical size, cannot always be relied upon to prevent shock loads from damaging the fluid motor or to provide positive assurance against cavitation and its undesirable effects.

SUMMARY OF THE INVENTION

This invention is a fluid system which provides positive assurance against cavitation in a hydraulic cylinder or other fluid motor by automatically limiting the rate at which fluid is discharged to accommodate to the rate at which driving fluid is being supplied to the motor at any given time. The size of the variable flow passage at the motor fluid discharge is determined by a valve member which shifts in response to variations of pressure within the driving fluid of the motor. In particular, the valve member shifts to decrease the size of the discharge flow passage in response to a pressure decrease within the driving fluid thereby maintaining adequately balanced fluid pressures throughout the motor irrespective of the external forces acting thereon. The invention also prevents a dynamic effect caused by the impact of load against the jack stops at the end of the stroke.

Accordingly, it is an object of this invention to provide a compact and a more reliable means for avoiding cavitation in fluid driven systems.

The invention together with further objects and advantages thereof will best be understood by reference to the following specification in conjunction with the accompanying drawing.

BRIEF DESCRIPTION OF THE DRAWING

The accompanying drawing is an axial section view of an anti-cavitation valve according to the invention with certain associated elements of the hydraulic system being shown in schematic form.

DESCRIPTION OF A PREFERRED EMBODIMENT

Referring now to the drawing, there is shown a hydraulic jack or cylinder 11 of the class having a piston 12 therein which operates an axially disposed extensible and contractible rod 13. For purposes of illustration, the cylinder 11 is shown in this example in a typical usage of the type wherein anti-cavitation measures are desirable. In particular, the cylinder 11 is herein employed for dumping the body 14 of a truck 15, it being understood that the invention is equally applicable to other fluid systems where cavitation may be a problem.

In this example, the truck body 14 is coupled to the truck frame 16 at a pivot 17 which is situated somewhat forwardly from the back end of the body. The cylinder 11 is connected between the body 14 and truck frame 16 forwardly from pivot 17 whereby extension of the cylinder lifts the forward end of the body to provide for a rear dumping action.

During the initial portion of the extension stroke of cylinder 11, the cylinder must work against the weight of the truck body 14 and contents. However with this construction, the center of gravity of the truck body 14 and contents moves rearwardly as the body is raised and eventually passes to the rear of the pivot 17. At this point in the travel the weight of the body and contents exerts a pull on the rod 13 of the cylinder 11 thereby giving rise to the possibility of cavitation. In particular cavitation could occur, in the absence of corrective provisions, if the weight of the truck body pulls the cylinder piston 12 towards the rod end of the cylinder at a rate faster than that provided for by the driving fluid which is entering the head end of the cylinder.

To avoid this effect, an anti-cavitation valve 18 is situated in the fluid lines between cylinder 11 and the pump 19 or other source of fluid under pressure. Anti-cavitation valve 18 acts to restrict the discharge of hydraulic fluid from the rod end of cylinder 11 in response to any pressure decrease in the driving fluid at the head end of the cylinder.

For this purpose anti-cavitation valve 18 has a valve body 21 with four hydraulic fluid ports 22, 23, 24 and 26. Port 23 is coupled to the head end of cylinder 11 by a conduit 27 while port 26 is coupled to the rod end of the cylinder by a second conduit 28. Ports 22 and 24 are coupled to a dump cylinder control valve 29 through separate conduits 31 and 32, respectively. Control valve 29 may be shifted by the operator to extend or contract the hydraulic cylinder 11 and thus to raise or lower the truck body 14.

Control valve 29 has an inlet conduit 32 which receives a fluid, such as oil, under pressure from pump 19 and has an outlet conduit 33 to the fluid reservoir 34. The control valve 29 has a first position at which high pressure fluid is supplied to port 22 of the anti-cavitation valve 18 while port 24 thereof is vented to the reservoir 34 thereby extending the cylinder 11 as will hereinafter be discussed in more detail. At a second position of the control valve 29, anti-cavitation valve port 24 receives the hydraulic fluid under pressure while port 22 is vented, thereby contracting the cylinder 11; while at the third position of the control valve both of the ports 22 and 24 are blocked to hold the cylinder 11 at any selected position. Valve 29 may also have a fourth "float" position at which conduits 31 and 32 are connected to provide for the exchange of fluid from the head end to the rod end of cylinder 11.

To provide for the passage of driving fluid to the head end of cylinder 11 during extension and for the discharge of fluid therefrom during the contraction stroke, an unobstructed

passage 36 within valve body 21 communicates ports 22 and 23.

To provide a variable flow passage from the rod end of hydraulic cylinder 11 to control valve 29, valve body 21 has a stepped bore 37 with an axially movable spool 38 therein. A passage 39 within valve body 21 communicates port 26 with a large diameter portion 41 of bore 37. A second passage 42 within the valve body 21 connects port 24 with a second smaller diameter portion 43 of bore 37. Spool 38 has a land section 44 at the large diameter portion 41 of bore 37 and a small diameter portion 46 at bore portion 43. Thus by appropriate axial movement of the spool 38, communication between valve body passages 42 and 39 may be blocked by an edge 47 of land 44 or a flow passage therebetween of variable size may be provided. To avoid overly extreme sensitivity of the flow aperture between passages 42 and 39 to movement of spool 38, radially directed grooves 48 are provided in the spool at edge 47.

Thus when the cylinder 11 is undergoing an extension stroke edge 47 provides a variable flow restriction between the rod end of the cylinder and control valve 29 with the degree of restriction being a function of the axial position of spool 38. The axial position of spool 38 is in turn determined by the fluid pressure at the head end of cylinder 11. In particular spool 38 is controlled by the fluid pressure in the previously described passage 36 which communicates with the head end of cylinder 11.

For this purpose, an end 49 of the spool extends into an enlarged chamber region 51 at the end of bore 37 and carries a flange 52. A compression spring 53 is disposed coaxially around spool end 49 within bore region 51 and bears against flange 52 in a direction which tends to move the spool 38 to close communication between valve passages 39 and 52 at edge 47. Thus in the absence of a counterbalancing force on spool 38, the flow passage from the rod end of cylinder 11 is closed. To provide such a counterbalancing force, region 51 of bore 37 is communicated with the passage 36 leading to the head end of cylinder 11 by an additional passage 54. The fluid pressure at the head end of the cylinder 11 is thus transmitted to region 51 where it acts against a land 55 adjacent one end of bore region 51. A passage 56 in spool 38 communicates bore section 43 with the end region of the bore opposite from the spring 53 to avoid trapping of fluid therein.

In operation, the hydraulic cylinder 11 is extended by adjusting control valve 29 to supply fluid under pressure from pump 19 to anti-cavitation valve port 22. Such fluid is transmitted through passage 36, port 23 and conduit 27 to the head end of the cylinder to act against the piston 12 therein. As the piston 12 and rod 13 advance, fluid is discharged from the rod end of the cylinder 11 through conduit 28, port 26, and passage 39. The discharging fluid then passes spool edge 47 and enters passage 42 and port 24 to be returned to the reservoir 34 through the control valve 29.

The size of the flow passage past edge 47 is determined by the axial position of spool 38 and this in turn is a function of the fluid pressure at the head end of the cylinder 11 as hereinbefore described. If the fluid pressure at the head end of the cylinder increases, this pressure increase is communicated to bore region 51 and acts against land 55 of the spool to increase the flow passage past edge 47 and thereby provides for a correspondingly greater rate of discharge from the rod end of the cylinder. Conversely, if the fluid pressure at the head end of the cylinder 11 decreases, due to a movement of the piston 12 in excess of that produced by the driving fluid at the head end, the pressure decrease is communicated to region 51 whereby spring 53 may move the spool 58 to increase the

degree of flow restriction at edge 47. This prevents excessively fast travel of piston 12 and thereby avoids cavitation effects.

In the absence of further provisions, the above described structure would block the flow passage to the rod end of the cylinder when control valve 29 is manipulated to effect a contraction stroke. To provide for the supply of hydraulic fluid from pump 19 to the rod end of the cylinder 11 to contract the cylinder, a check valve 57 provides for direct communication between valve body passages 39 and 42, bypassing edge 47, but limits direct flow to a direction from passage 42 to passage 39. For this purpose, the check valve 57 may include a valve member 58 which seats against a valve seat 59 in a passage 61 extending between passages 39 and 42. A spring 62 biases valve member 58 to the closed position. Where, as in the present instance, the valve member 58 extends across flow passage 39, an enlargement 63 is provided to avoid obstruction thereof. Accordingly direct flow between passages 39 and 42 is prevented during the extension stroke of the cylinder 11 as indicated above but valve 57 opens during the contraction stroke whereby fluid under pressure at port 24 may be transmitted to port 26 and thus to the rod end of the cylinder.

In the present example where the cylinder 11 dumps a truck body as hereinbefore described, there is not a serious problem with respect to cavitation during the contraction stroke of the cylinder in that the load has been released from the truck body 14 at this time. However in other instances where there is a cavitation problem on both the extension and contraction strokes, it will be apparent that a similar variable flow restriction may be provided in the flow passage to the head end of the cylinder.

I claim:

1. In a fluid system for supplying driving fluid to a cylinder of the class having a piston therein and having an axially directed extensible and contractible rod coupled to said piston and wherein said cylinder has a fluid port at each end thereof, the combination comprising:

a source of fluid under pressure,

a control valve coupled between said fluid source and said cylinder for directing fluid to one end of said cylinder while discharging fluid from the other end thereof, and

an anti-cavitation valve connected to said other end of said cylinder and forming a flow passage for said fluid discharging therefrom, said flow passage being isolated from said one end of said motor to transmit all of said discharging fluid away therefrom, said anti-cavitation valve having an element at said passage which is movable to vary the flow aperture there-through in an incremental manner from a fully closed position to a fully open position, said element being responsive to incremental changes of the fluid pressure at said one end of said cylinder, wherein said control valve has a first setting at which fluid is directed to said one end of said cylinder and at which fluid is received from said other end of said cylinder through said anti-cavitation valve for return to said source, said control valve having a second setting at which fluid is directed to said other end of said cylinder and received from said one end thereof, and

a check valve defining an additional passage between said control valve and said other end of said cylinder which additional passage bypasses said movable element, said check valve being capable of transmitting fluid from said control valve to said other end of said cylinder and blocking flow in a reverse direction through said check valve.