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Matthews

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[54] **TILT CYLINDER ANTICAVITATION CIRCUIT**

[75] Inventor: **Dean A. Matthews,** Homewood, Ill.

[73] Assignee: **Allis-Chalmers Corporation,** Milwaukee, Wis.

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[51] **Int. Cl.** **B66f 9/20**

[58] **Field of Search** .....214/672, 674, 673; 187/9; 60/52 HE

[56] **References Cited**

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Primary Examiner—Albert J. Makay

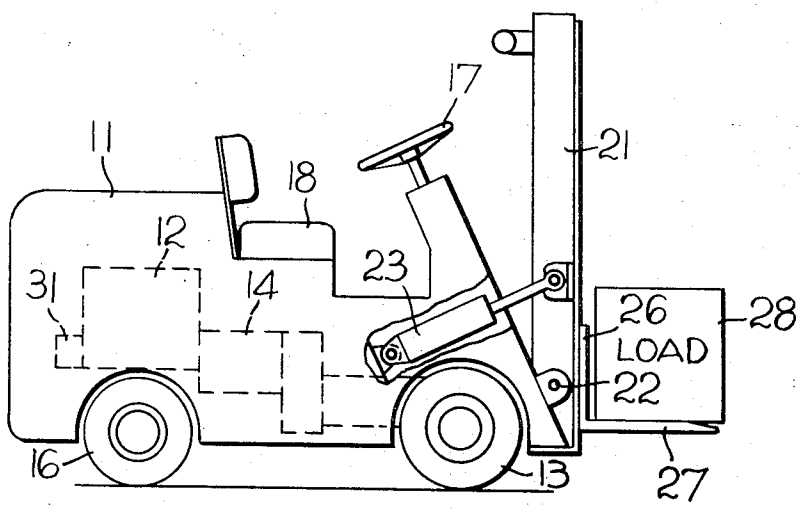
Assistant Examiner—Lawrence J. Oresky

Attorney—Charles L. Schwab et al.

[57] **ABSTRACT**

Cavitation in the tilt cylinder circuit for a lift truck is prevented by cross connecting one of the tilt cylinder supply lines with the return-to-reservoir line of another circuit in the lift truck hydraulic system. A cone-way check valve is incorporated in the cross connecting passage to prevent flow from the tilt cylinder circuit to the second circuit.

8 Claims, 2 Drawing Figures



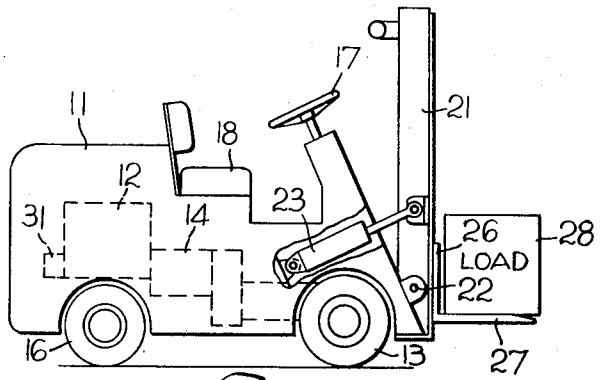

17
11
21
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12
23
31
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LOAD
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Fig. 1

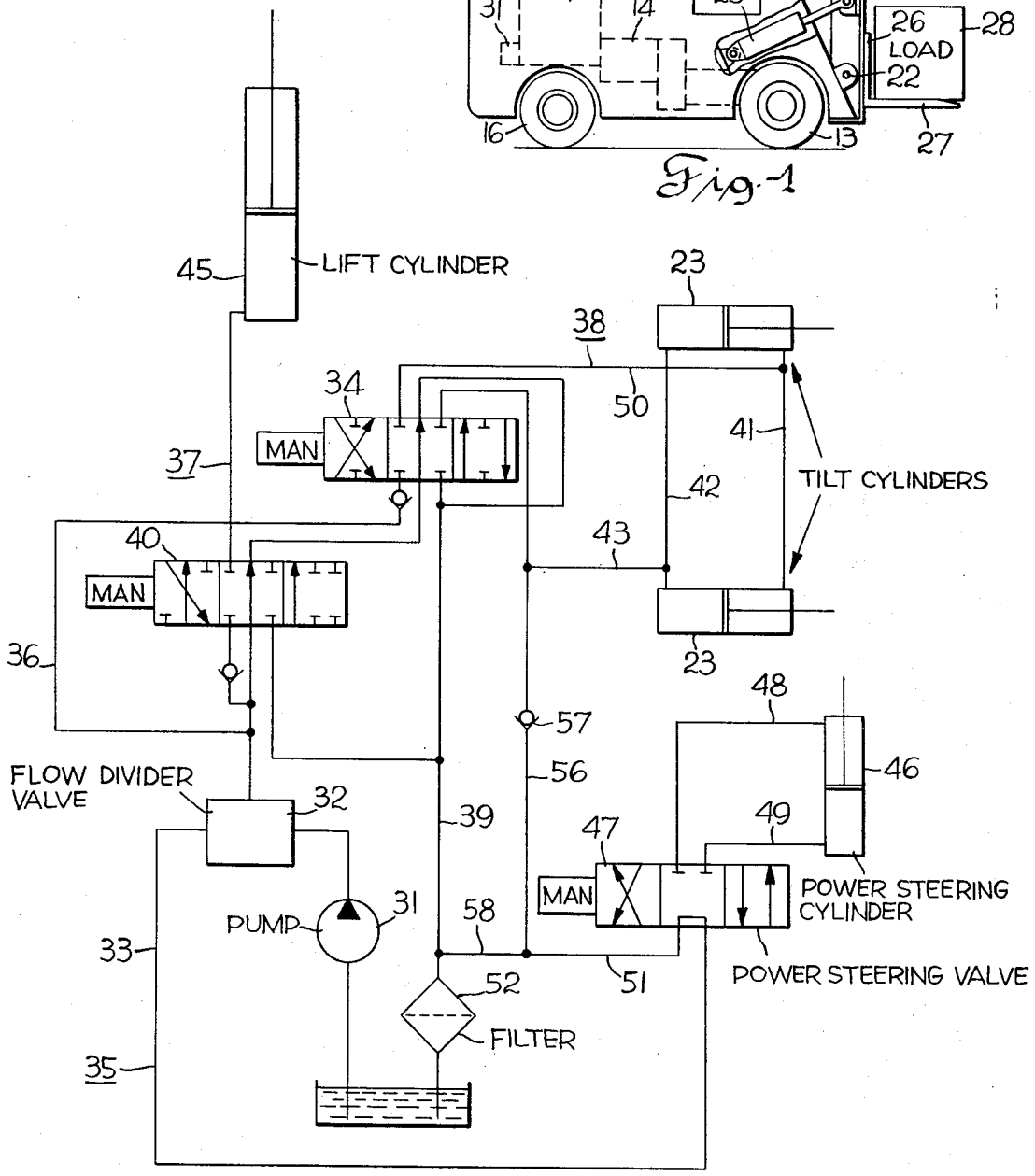

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LIFT CYLINDER
23
38
34
50
41
MAN
37
42
TILT CYLINDERS
40
43
MAN
36
23
48
57
46
56
FLOW DIVIDER VALVE
32
39
47
49
MAN
POWER STEERING CYLINDER
PUMP
31
58
33
52
51
POWER STEERING VALVE
FILTER
35

Fig. 2

TILT CYLINDER ANTICAVITATION CIRCUIT

BACKGROUND OF THE INVENTION

Various means have been employed to prevent cavitation in hydraulic circuits. Heretofore it has been suggested that locking valves be interposed between the tilt cylinder control valve and the tilt cylinders. These type valves prevent the flow of fluid to and from the tilt cylinders unless fluid under pressure is being supplied to the tilt cylinders. Another anticavitation system for tilt cylinders involves the use of a check valve in the tilt cylinder control valve which permits flow of fluid from the exhaust side of the valve to the expanding side of the tilt cylinder.

BRIEF DESCRIPTION OF THE PRESENT INVENTION

In the present invention the side of the tilt cylinder which tends to cavitate, under conditions of low rate of flow from the source of fluid pressure, is cross connected by a one-way circuit to a fluid supply being maintained at a higher pressure than available in the tilt cylinder circuit. If the operator chooses to tilt the mast through operation of the tilt cylinder control valve when no fluid flow is being delivered to the tilt cylinder control valve, the load on the lift truck carriage may cause one side of the tilt cylinders to be exhausted of fluid faster than fluid can be supplied to the expanding side, thus giving rise to cavitation in the expanding side.

In the illustrated embodiment of the invention a single pump supplies fluid to a flow divider which gives priority of flow to the power steering circuit. Low priority flow is provided to the lift cylinder and tilt cylinder circuits. Thus, at low engine speed the available fluid flow is directed to the power steering circuit and little or no flow is provided to the lift cylinder and tilt cylinder circuits. If the operator choose to tilt the mast through operation of the tilt cylinder control valve when the engine is running at a very low speed, and a reasonably large load is being carried by the forks of the lift truck, it is possible for the load to force fluid from one end of the tilt cylinders faster than fluid can be supplied to their corresponding opposite ends. In the typical mast tilt arrangement, fluid would be exhausted from the rod end of the tilt cylinders and the closed end of the cylinders would then need to be supplied with fluid and if not so supplied, cavitation will occur. As is well known in the art, cavitation occurs when a partial vacuum exists in a hydraulic cylinder. The air pockets evolving from cavitation give rise to problems in controlling the mast in the desired tilt condition, particularly when the load is elevated to a near maximum height and the truck is moved to adjust position for depositing the load. In order to supply an adequate quantity of fluid to the closed end of the cylinders under these conditions, applicant conceived of cross connecting the closed end of the cylinders with the return flow from the higher priority power steering circuit. This insures an adequate flow of fluid to the closed end of the tilt cylinders when supply from the pump is inadequate to fill the displaced volume. A check valve is provided in the cross connecting passage to prevent undesirable reverse flow.

It is an object of this invention to provide a tilt cylinder anticavitation circuit wherein the side of the tilt cylinder tending to cavitate is supplied with fluid from another circuit.

It is more specifically an object of the present invention to provide the side of the tilt cylinder tending to cavitate with fluid under pressure from the return side of the power steering circuit.

It is a further object of the present invention to provide a hydraulic system for a lift truck wherein a single pump supplies fluid to a tilt cylinder circuit and a power steering circuit through a flow divider which gives priority to the power steering circuit and wherein the tilt cylinder circuit is interconnected through a one-way valve with the return flow from the power steering circuit in a manner preventing cavitation in the tilt cylinder circuit.

These and other objects and advantages of the present invention will be obvious to those who are familiar with the art when the following description is read in conjunction with the drawings in which:

FIG. 1 is a side view of the lift truck of the type in which the present invention is incorporated; and,

FIG. 2 is a schematic illustration of a hydraulic system incorporation the present invention.

Referring to FIG. 1 a fork lift truck 11 is illustrated wherein an internal combustion engine 12 drives a pair of drive wheels 13 at the front of the truck through a transmission 14. The rear of the truck is supported by a pair of steerable wheels 16 controlled by a manually operated steering wheel 17 adjacent the operator's seat 18. A mast 21 is connected on a transverse axis by appropriate pivot means 22 and it is tilted from the vertical position, in which illustrated, by a pair of double-acting tilt cylinders 23, only one of which is shown in FIG. 1. A lift truck carriage 26 is supported on the mast 21 for vertical reciprocal movement thereon and has forks 27 thereon for supporting and carrying load 28. The carriage 26 is elevated and lowered through operation of a conventional lift cylinder not shown in FIG. 1.

Referring to FIG. 2, which shows a hydraulic system for the lift truck illustrated in FIG. 1, a single positive displacement pump 31 supplies fluid under pressure to a conventional flow divider valve 32 which awards priority of flow to a steering valve 47 by way of a supply passage 33 of a power steering circuit 35. Second priority flow is directed by the flow divider valve 32 to a tilt control valve 34 through a supply conduit 36 of the tilt cylinder control circuit 38. A control valve 40 controls fluid flow to a lift cylinder 45 via circuit 37. Thus, it is seen that a single pump 31 supplies pressure fluid for the auxiliary or steering circuit 35, the lift circuit 37 and tilt circuit 38. A single reservoir line 39 handles the return flow from all three control valves 34, 40 and 47. The tilt cylinders 23 42, corresponding ends interconnected by conduits 41, 2, which in turn are connected to the tilt cylinder control valve 34 by tilt cylinder control conduits 50, 43, respectively.

The power steering cylinder 46 is connected to the power steering control valve 47 by a pair of supply conduits 48, 49. An exhaust passage 51 connects the open center power steering control valve 47 to the reservoir line 39 upstream of a filter 52. The filter 52 provides a substantial resistance to return flow and thus creates a back pressure in exhaust passage 51.

The hydraulic pump 31 is directly coupled to the engine 12 and, therefore the output of the pump is proportional to the speed of the engine. The output of the pump is fed to the priority type flow divider valve 32 which directs a certain minimum flow to the auxiliary

power steering circuit **35**. As the output of the pump **31** increases with engine speed, the excess flow is directed to the control valves, **34**, **40** through the supply conduit **36**. At low engine or idle speed, it is possible to get very little or no fluid delivery to supply conduit **36**. If at such time the operator decides to tilt the mast **21** forwardly by operation of the tilt control valve **34**, fluid will be exhausted from the rod ends of the tilt cylinders **23** by way of conduits **41**, **50** and **39**. The closed ends of the tilt cylinders **23** will be supplied fluid through conduits **36**, **43**, **42**. However, at low engine speed, there will be little or no flow to the closed ends of the tilt cylinders. Accordingly, a partial vacuum is created in the closed ends of the tilt cylinders **23** which, as is well known in the art, gives rise to cavitation.

Applicant conceived of providing a one-way flow means, in the form of conduit **56** and check valve **57**, between the exhaust passage **51** and the supply conduit **43** connected to the closed ends of the tilt cylinders. The flow resistance of filter **52** insures a relatively high back pressure which assures a fairly rapid flow of make-up fluid to the closed ends to the tilt cylinders **23** from the exhaust passage **51**. Check valve **57** prevents flow from the tilt cylinder supply conduit **43** to exhaust passage **51**. By joining the reservoir line **39** and the exhaust passage **51** upstream of the filter **39**, the return flow from the tilt cylinders is added to the exhaust flow from the high priority auxiliary circuit **35**, thus insuring adequate flow to avoid tilt cylinder cavitation even at low engine speed. Preferably, the cross connecting conduit **56** is connected as close as possible to the power steering valve **47** so as to take full advantage of the line pressure drop between the power steering valve **47** and the reservoir. If the filter does not afford sufficient resistance, a simple flow restrictor could be placed at point **58** in the exhaust passage **51** to artificially create the desired back pressure to insure flow to the closed ends of the cylinders **23** whenever a cavitation condition might exist.

From the foregoing description it is apparent that the present invention solves a tilt cylinder cavitation problem in an economical and effective manner.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. In a lift truck having a tiltable mast with elevatable load carrying carriage, the combination comprising:

a hydraulic tilt cylinder;

a hydraulic circuit for controlling said tilt cylinder including

a tilt control valve,

tilt cylinder supply conduits interconnecting said tilt control valve and said tilt cylinder and

supply and exhaust conduits connected to said tilt control valve;

an auxiliary hydraulic cylinder;

a hydraulic circuit for controlling said auxiliary cylinder including

control valve means,

input and exhaust passages connected to said control valve means, and

supply passages interconnecting said auxiliary cylinder and said control valve means;

fluid supply means operable to supply fluid under pressure to said input conduit and said input passage; and

an anticavitation circuit including a cross passage interconnecting one of said tilt cylinder supply conduits and said exhaust passage including one-way flow control means in said cross passage permitting flow to fluid therein only from said exhaust passage to said one supply conduit.

2. The combination of claim **1** wherein said fluid supply means includes a pump and a flow divider valve connected to the output side of said pump and connected in fluid delivery relation to said input conduit and said input passage, said flow divider valve effecting priority of flow from said pump to said input passage.

3. The combination of claim **2** wherein said control valve means is an open center control valve.

4. The combination of claim **3** wherein said auxiliary hydraulic cylinder is a steering cylinder for said lift truck.

5. The combination of claim **1** wherein said fluid supply means effects a priority of fluid supply to said input passage.

6. The combination of claim **5** wherein said auxiliary hydraulic cylinder is a steering cylinder for said lift truck.

7. The combination of claim **6** wherein said control valve means is an open center steering control valve.

8. The combination of claim **7** wherein said one-way flow control means is a check valve.

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