Nov. 17, 1953 W. M. SHAFFER 2,659,505

MECHANISM FOR CONTROLLING THE STABILITY
OF MATERIAL-HANDLING MACHINES

Filed Sept. 5, 1947 3 Sheets-Sheet 1

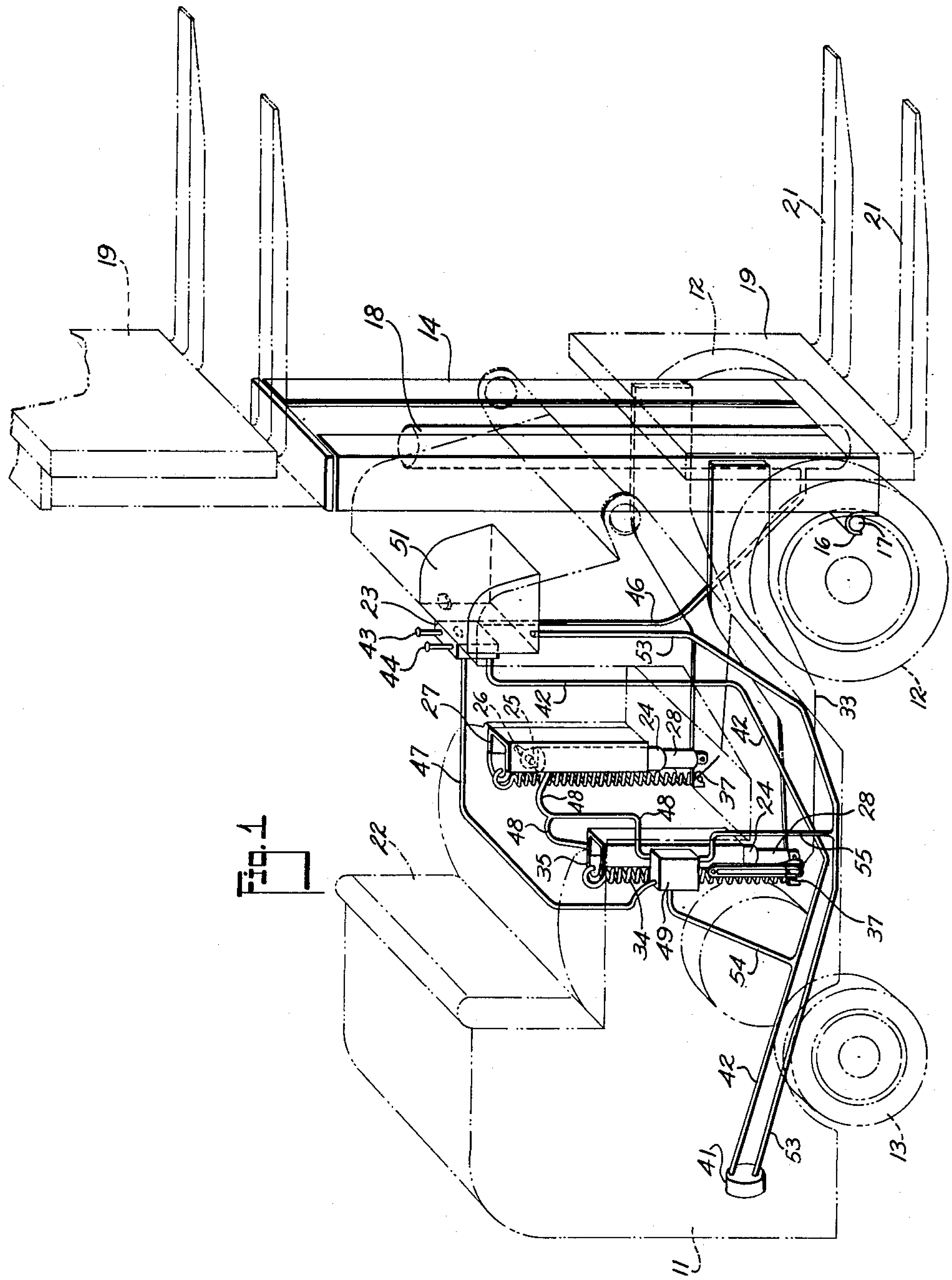

Fig. 1

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FIG. 4

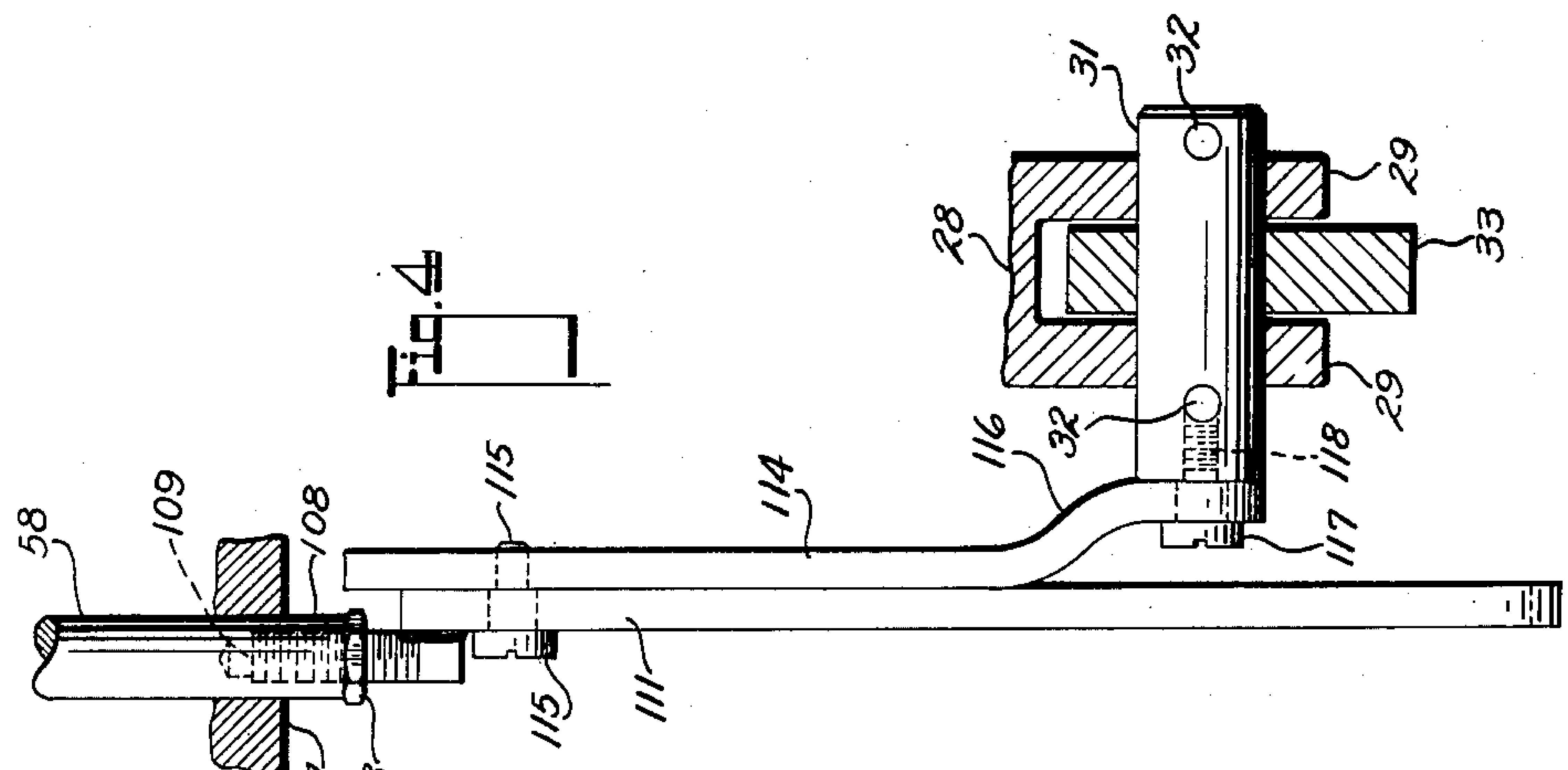

FIG. 3

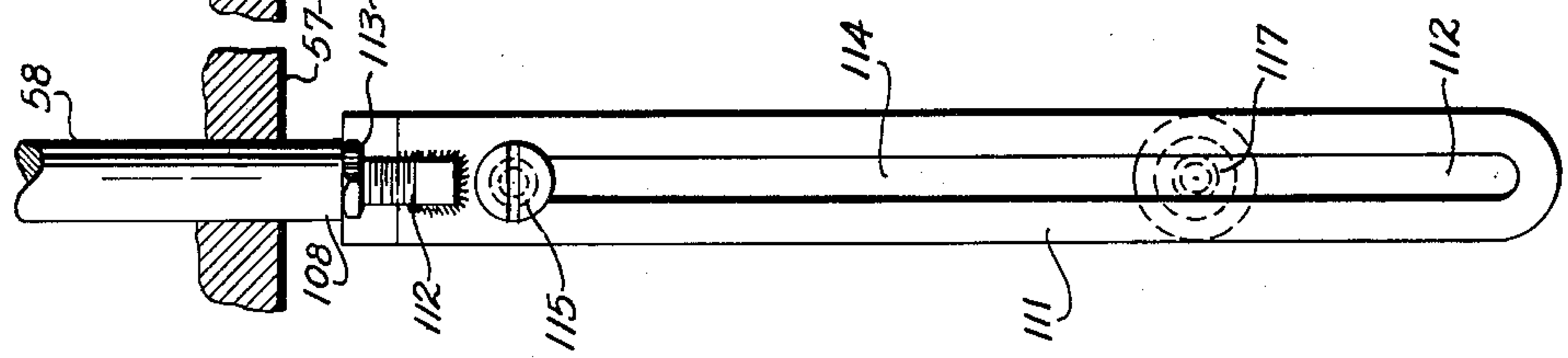

FIG. 2

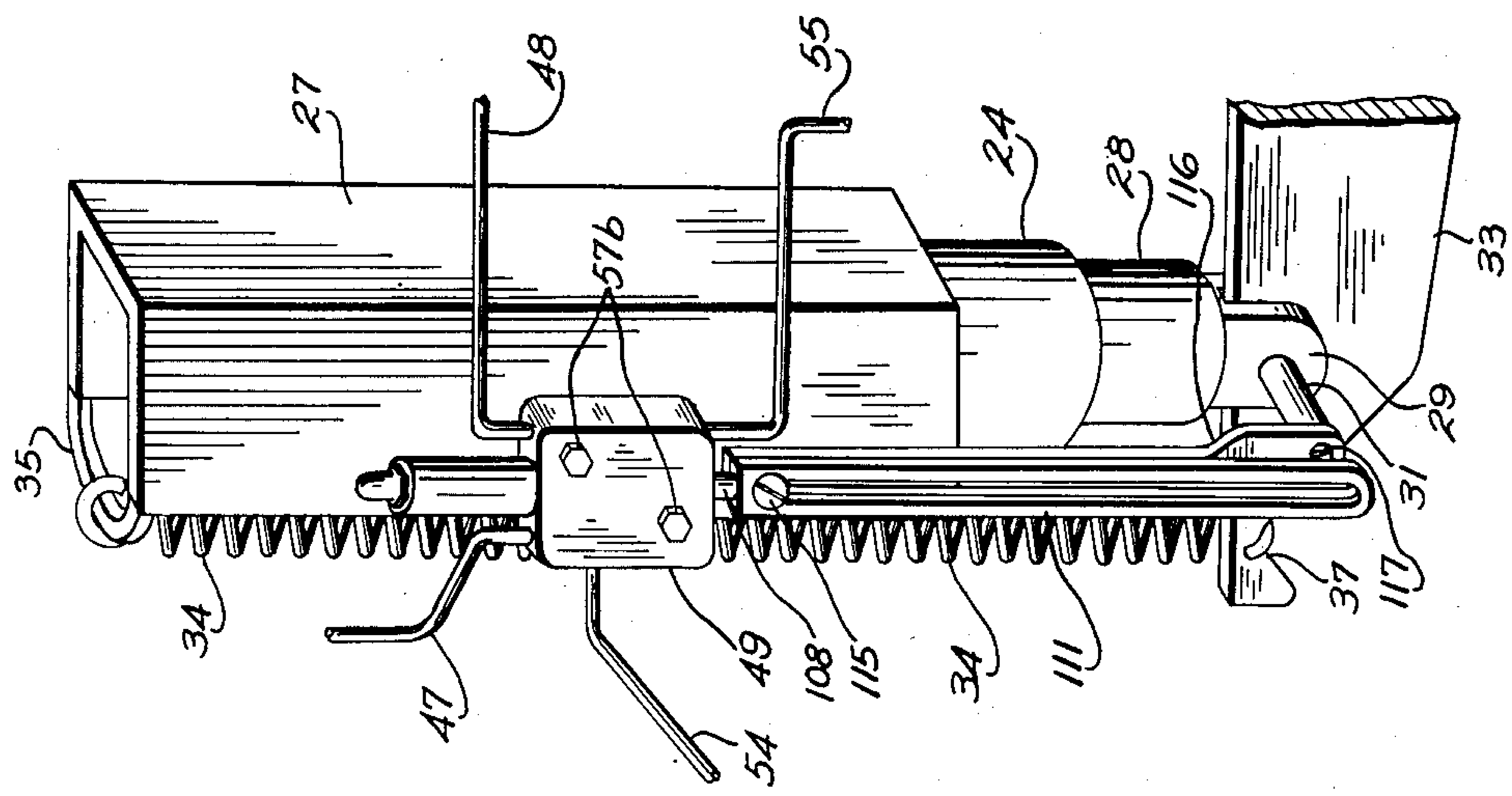

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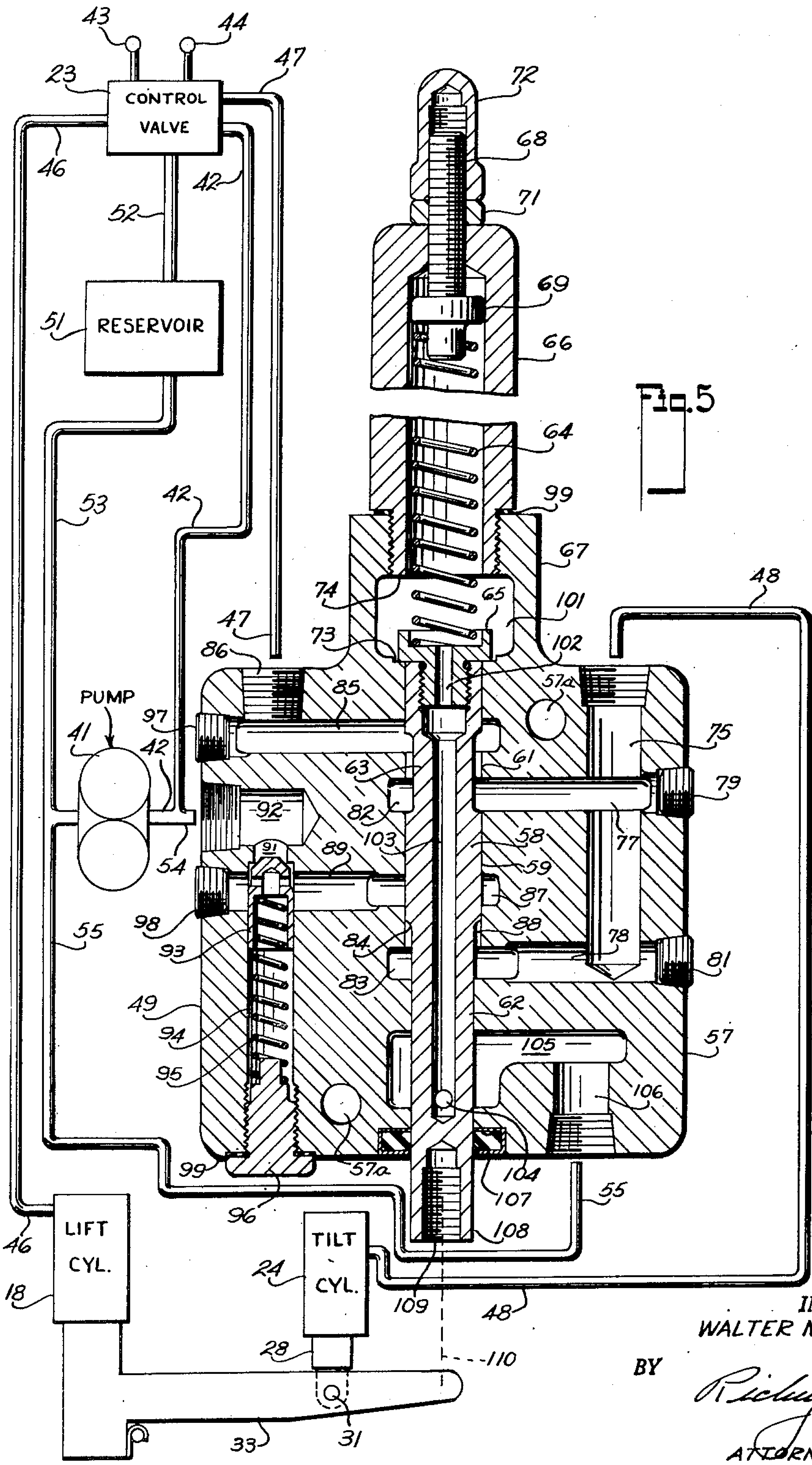
Fig.5



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2,659,505

MECHANISM FOR CONTROLLING THE STABILITY OF MATERIAL-HANDLING MACHINES

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Application September 5, 1947, Serial No. 772,308

28 Claims. (Cl. 214—673)

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This invention relates to mechanism for controlling the stability of material-handling machines, and in the preferred embodiment comprehends apparatus for the automatic control of the hydraulic system for the elevating mechanism in a lift truck, to ensure stability thereof.

The type of truck, toward which the invention is primarily directed, is well known. Such trucks ordinarily comprise a wheeled chassis, a mast on one end thereof, and a carriage mounted for vertical movement on the mast which is usually provided with forwardly-disposed load carrying forks. The mast as contemplated herein is mounted to facilitate the inclination thereof some few degrees forwardly on rearwardly in order to accommodate manipulation of the forks in handling a load.

Trucks of this character are usually designed to effect the elevation of the load several times the length of the wheel base of the vehicle. Obviously when the mast is inclined forwardly, the higher the elevation of the load, the farther its center of mass from the center of the truck, and the greater the moment of force tending to overturn the truck.

It has been customary to design lift trucks with sufficient ballast to balance, with an adequate margin of safety, the maximum rated load at maximum elevation and maximum forward inclination. Obviously, each pound of ballast decreases the efficiency and maneuverability of the truck, hence it is highly desirable to minimize the amount of dead weight.

On the other hand, it is undesirable to restrict too severely the permissible forward tilt of the mast, particularly at low elevations.

The problem is further complicated by the fact that the reaction of the load on the truck relieves the springs and steering tires and deflects the mast, thus introducing a discrepancy between the actual inclination of the mast to the vertical and the apparent inclination of the mast to the chassis of the truck.

Another complication arises in the use of the lift truck on inclined surfaces. Even a very slight inclination, not apparent to the operator of the truck, may cause it to topple over when the load is elevated.

It will be apparent that the problem of instability is not unique in lift trucks, since it may arise in any material-handling machine in which the load is supported in outboard relation to the base of the machine, and may be complicated by factors analogous to those referred to above. For example, in boom cranes, the permissible load is increased as the boom is elevated.

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The improved tilt compensating mechanism constituting the present invention solves the problem of instability in such cases, and although shown herein as incorporated in a lift truck, it will be apparent to those skilled in the art that the principle of the invention and the preferred mechanisms for exploiting the principle (with appropriate modification in some cases) may be utilized in other types of material-handling machines.

As applied to a lift truck, the invention contemplates the provision of automatic valve structure operatively controlled by the force moment exerted on the truck by the mast, the carriage, and the load supported thereon, to limit such force moment to a value which is less than that required to overturn the truck. This is preferably accomplished by limiting the forward inclination of the mast, and/or reducing the tilt if necessary, when the load is elevated thereon.

By basing the control on a measurement of the force moment tending to overturn the truck rather than upon the inclination of the mast relative to the chassis, all factors such as mast inclination, magnitude of the load, elevation of the load, extension of the truck springs, and inclination of the supporting surface, are given proper weight, and safe operation under all conditions is assured.

Moreover, since the control responds accurately to the resultant of all factors tending to cause the vehicle to overturn, a relatively small margin of safety is sufficient. Ballast may be reduced to a minimum value, with corresponding improvement in the efficiency and maneuverability of the truck.

The principal objects of the invention are to improve material-handling machines such, for example, as lift trucks, cranes, and the like, as follows:

To increase safety;

To assure stability;

To improve maneuverability, efficiency, and economy;

To eliminate unnecessary weight formerly required for stability;

To control the outboard extension of the mast, boom, or analogous structure in accordance with factors tending to overturn the machine;

To limit outboard extension of the load in accordance with the moment tending to overturn the vehicle;

To reduce outboard extension of the load when necessary to preserve stability;

To provide a simple, accurate, and reliable automatic control of stability;

To provide a stability control adapted for incorporation in existing machines;

To provide a stability control which will not unnecessarily restrict the operator's control of the machine;

To provide a power system which incorporates stability control;

To provide a hydraulic power system especially adapted to automatic control of stability; and

To ensure stability control even in extreme positions of the controlled member of the machine.

Other objects and advantages of the invention, more or less ancillary in nature, will be apparent to those skilled in the art from the description herein of the preferred form of the invention.

Referring to the drawings:

Fig. 1 is a view in perspective of a lift truck of a known type illustrating particularly the hydraulic system;

Fig. 2 is an enlarged view of a portion of Fig. 1 illustrating the general arrangement of the stability control valve installation;

Figs. 3 and 4 are elevational views of a lost-motion linkage connecting the stability control valve and a tilt arm; and

Fig. 5 is a sectional view of the stability control valve including a schematic view of the hydraulic system.

The lift truck shown generally in Fig. 1 comprises a body or chassis 11 supported on front driving wheels 12 and rear steering wheels 13. An extensible mast 14 is mounted on the chassis through trunnions 16 supported on a bar 17, for tilting movement relative to the axis thereof. A lift cylinder 18, which may be a single-acting ram, is coupled to a carriage 19, slidable longitudinally of the mast. The material being handled is supported by outboard forks 21 extending from the lower end of the carriage, forward of the wheels of the truck.

The vehicle is provided with a seat 22 for the operator, controls (not shown) for driving the vehicle, a valve assembly 23 for controlling the ram 18 and tilt cylinders 24 rocking the mast upon its fulcrum 17.

The tilt cylinders are single-acting rams, having eyes 25 in the heads thereof for the reception of pins 26 mounted in vertical channel irons 27 fixed to the frame of the vehicle. The plungers 28 of the rams are provided with clevised ends 29 bored for the reception of hinge pins 31 mounted in bores adjacent the outer ends of the tilt arms 33. The tilt arms are biased upwardly by tension springs 34, the upper ends thereof being supported by brackets 35 mounted on the channels 27 and the lower ends thereof being hooked in notches 37 adjacent the outer ends of the arms. The springs 34 are provided to effect the forward inclination of the mast under no load conditions. When a load is imposed upon the forks, the reaction thereof is sufficient to tilt the mast forwardly hence the tensive effort of the springs need not be very great.

The hydraulic power system for elevating the carriage and tilting the mast is shown generally in the vehicle assembly of Fig. 1 and in the diagrammatic view of Fig. 5. Fluid, usually oil for energization of the pistons in the cylinders 18 and 24 is supplied by a positive displacement pump 41 through a line 42 to the manual control valve assembly 23, which includes a lift control valve operated by the lever 43 and a tilt control valve actuated by the lever 44. A line 46 is coupled with the valve assembly and the lift cylinder 18. Lines 47 and 48 connect the manual valve with the tilt cylinders through a stability control valve 49 mounted on the right hand channel member 27. Only one tilt cylinder is illustrated in Fig. 5, in the interest of clarity. The valve assembly 23 also is connected to a low pressure fluid reservoir 51 through a connection indicated schematically by the line 52 in Fig. 5, although in practice the valve may be mounted on the reservoir. A return line 53 connects the reservoir with the inlet of the pump 41. The stability control valve 49 is also connected to the oil supply and return lines 42 and 53 respectively by lines 54 and 55.

The hydraulic system, with the exception of the stability control valve 49, may be of conventional design, hence a detailed description thereof is deemed unnecessary herein. The manually operated valve 23 may be of any of the usual forms that are designed for control of two distinct functions. The tilt control valve 44 and lift control valve 43 may each be set to three positions, one in which the pump is connected to the cylinder to extend the ram, one in which flow to or from the cylinder is restrained and the pump is discharged into the reservoir 51, and one in which both the pump and cylinder are connected to the reservoir and the load forces the ram into the cylinder. When both valves are in their neutral or hold position, the pump is discharged into the reservoir. When either valve is set to fill its corresponding cylinder, the pump vent is closed. A mechanical interlock between the valve operating levers may be provided if desired so that only one of the levers may be moved at a time from the neutral position, thus preventing cross-feeding between the lift and tilt cylinders.

In operation the mast is first tilted forward to position the carriage forks at the appropriate angle, then the vehicle is moved forward to engage the forks with the load-supporting pallet. The carriage is then elevated slightly to pick up the load and the mast is tilted rearwardly to assure retention of the load on the forks. The vehicle is then driven to its destination where the vehicle is maneuvered into position to deposit the load, the carriage is next elevated or lowered as required, then the mast is tilted to facilitate positioning and removal of the pallet.

It will be apparent that when the forks are loaded and the mast is tilted forward, the moment of the load tending to overturn the vehicle is increased. This effect is particularly marked when the elevation of the load is great, and in some known lift trucks it may be as great as eighteen feet. In previously known lift trucks, the forward inclination of the mast with respect to the chassis has been limited to a value such as 5°, but even with this small inclination, additional ballast is required at the rear of the truck over that required to balance the rated load with the mast in a vertical position. If the permissible forward inclination is decreased, the ease of handling of the truck is diminished during low lift and less than rated load operations.

By applying the principles of this invention, the tilt may be limited under all operating conditions to a value slightly less than that which will overbalance the truck. By slight sacrifice of forward tilt under maximum load and elevation positions, the weight of the vehicle may be greatly reduced by the elimination of unnecessary ballast, and full forward inclination may be used under most operating conditions. Furthermore, the inclination automatically compensates for deflection of the springs of the vehicle and inclination of the supporting surface, so that, under all operating conditions, a dangerous degree of inclination is avoided. Due to the precision of the automatic control of inclination, a moment as great as 90% of that required to overturn the vehicle may be developed with complete safety.

These results are obtained by the automatic stability control valve 49 which may be readily incorporated in the hydraulic power system heretofore described. The stability control valve is interposed in the line from manual valve to the tilt cylinder and is connected to the supply and return lines of the pump. No other change in the hydraulic system is required.

The automatic valve performs two basic functions. First, it closes the line from the tilt cylinders to the manual valve when the overturning moment reaches the designed maximum value, thus preventing further venting of oil from the tilt cylinders and additional forward inclination. The second function of the stability control valve is to supply oil directly from the pump to the tilt cylinders to decrease the forward inclination of the mast when the overturning moment approaches the maximum value. This function is of particular importance when the carriage is elevated with the mast inclined forwardly. Under these conditions, as the carriage is elevated, its lateral displacement from the point of support at the front wheels of the truck increases and thus the force moment increases. The stability control valve supplies oil to the tilt cylinders when the moment reaches the limiting value and prevents further increase of the force arm of the load.

The pressure of the oil in the tilt cylinders, which is proportional to the moment of force exerted by the load and its supporting structure, is utilized to control the operation of the valve 49. The principles of the stability control system may be best understood by reference to the detailed description of the preferred embodiment of the control valve shown in Fig. 5. This valve comprises a body 57 formed with openings 57*a* therein for the reception of bolts 57*b* for the anchorage of the body to the channel 27. A valve plunger 58 is slidably engaged in a longitudinal bore 59 in the casing, the bore 59 being formed with an upper portion 61 and a lower portion 62, the latter being of a smaller diameter than the portion 61. The lower portion of the plunger 58 is machined to effect a substantially oil-tight sliding fit in the bore 62 and the upper portion of the plunger 58 above the neck 63 is likewise snugly fitted in the bore 61. The plunger 58 is biased downwardly by a compression spring 64 seated in a cup 65 having a shank thereon which is threaded into the upper end of the plunger. A sleeve 66 threaded in a boss 67 in the upper end of the valve body is tapped to receive a tension adjusting screw 68 having a spring guide 69 on the end thereof for the support of the upper end of the spring 64. The face end of the screw 68 is proved with a jam nut 71 and a tapped sleeve 72 to prevent movement of the adjusting screw. The spring cup 65 is formed for abutting engagement with the face 73 of the valve body and the inner face 74 of the sleeve 66 to limit the travel of the valve plunger.

A passage 75, tapped to receive a pipe fitting for the line 48 which communicates with the tilt cylinder 24, intersects two passages 77 and 78, the outer ends of which are closed by plugs 79 and 81 respectively. The passage 77 leads to an enlarged channel in the bore 61 forming a valve port 82 and the passage 78 to a second channel in the bore which constitutes a valve port 83. The hydrostatic pressure within the tilt cylinder 24 is thus transmitted at all times to the ports 82 and 83. Pressure within the port 82 acts upon the shoulders formed by the necked portion 63 of the valve plunger, but since these shoulders are of equal area, there is no tendency to move the valve. Pressure in the port 83, however, acts against the shoulder 84 at the upper end of the reduced portion 62 of the plunger, and thus urges the plunger upwardly against the force of the spring 64.

The line 47 from the manual valve is connected to a passage 85 within the valve body through a threaded inlet connection 86. With the valve plunger in the position shown in Fig. 5, fluid may flow freely from the manual valve 23 to the tilt cylinder 24 through the line 47 and passage 85, around the reduced portion 63 of the plunger, and through passages 77 and 75 and line 48. As stated above, the tilt control lever 44 may be set to feed the oil to the ram 24, to hold the oil in the ram, or to vent the oil into the reservoir 51. When the oil is vented from the cylinder, permitting the mast to incline forwardly and increase the force moment of the load and mast, the pressure in the cylinder 24 and therefore in the chamber 83 increases in direct proportion to the overturning moment. As the moment approaches the maximum desired value, the pressure of the fluid in the port 83 exerted against the shoulder 84 overcomes the force of the spring 64 and raises the valve plunger, closing the port 82, and thus preventing further flow of oil from the tilt cylinder. In this manner the valve performs its first function of limiting the forward tilting movement of the mast under the manual control to a safe value. The spring 64 is designed to effect a relatively slow movement of the valve so that no shock will occur when the valve passes the port 82. As an alternate, grooves may be formed in the plunger 58 to provide a by-pass for the fluid and thus avoid any shock arising from the sudden closure of the valve.

Shortly before the port 82 is closed, the shoulder 84 of the valve plunger enters the port 87 formed by an enlargement of the bore 59, thus establishing communication through the portion 88 of the bore 59 between the ports 83 and 87. The port 87 communicates with an external connection to the high pressure line 54 through passages 89, 91, and 92. The passage of fluid from the ram 24 through this connection is arrested by a check valve which comprises a plunger 93 slidable in a longitudinal bore 94 in the valve casing and adapted for seated engagement with the throat of the opening in the passage 91 under the action of a compression spring 95 retained by a threaded plug 96. Oil from the pump 41 to the ram 24 is checked under the conditions described, since the control 44 is set for forward tilting movement. The pump is vented to the reservoir by the valve 23, and the pressure in the passage 91 is lower than the pressure in the passage 89 corresponding to that in the ram 24.

If, however, the manual tilt control valve is set to its holding position, and the lift valve is actuated manually to supply fluid to the lift cylinder 18 through the line 46, the pump will not be vented, and a positive pressure will be formed in the lines 42 and 54, resulting from the reaction of the load and the parts of the machine being elevated on the lift cylinder 18. Under these conditions, if the mast is inclined forwardly, pressure in the ram 24 will increase as the carriage is elevated. If the pressure reaches the value required to elevate the plunger 58, as previously described, fluid will flow from the pump through the lines 42 and 54, the passages 92 and 91, the check valve 93, thence through the passage 89, port 87, passage 88, port 83, passages 78 and 75, and line 48 to the tilt cylinder. The passage of the oil in this manner is realized through the ratio of the diameter of the tilt to that of the lift cylinders which are proportioned so that, under all conditions, the pressure required to lift the load is greater than the pressure required to extend the plungers 28 of the tilt rams. The most unfavorable condition is that in which the load is at maximum elevation and the mast is inclined to its maximum forward position. Thus, as the load lifting effort increases the overturning moment, fluid will be automatically supplied from the pump to the tilt cylinder to retract the mast. As the mast is retracted, and the pressure in the cylinders 24 decreases, the plunger 57 will descend and arrest the flow of oil into the tilt cylinders. In practice, as the load is elevated, the stability control valve may operate either continuously or intermittently to hold the overturning moment at the requisite value.

Plugs 97 and 98 close the outer ends of the passages 85 and 89. Gaskets 99 seal the sleeve 66 and plug 96, respectively, against leakage of oil. Any fluid escaping the valve plunger and flowing into the chamber 101 in the boss 67 is drained through central passageways 102 and 103 in the member 65 and valve plunger 58, respectively. The passage 103 is vented by a radial opening 104, which, in all positions of the valve, is in registration with the chamber 105 which discharges through an outlet 106 into the pump return line 55. Fluid escaping from the port 83 downward along the valve plunger is likewise received in the chamber 105. A seal 107 prevents the escape of fluid around the lower end of the plunger.

The stability control valve as described so far will perform its function under normal operating conditions. However, if the mast is tilted against a positive stop at either end of its range of inclination, conditions are encountered which adversely affect the operation of the stability control valve as outlined above.

When the mast is tilted forward against a stop, the pressure in the tilt rams may be zero regardless of the load, since the force moment is opposed by the stop. Therefore, there will be no hydraulic force to open tthe valve and admit oil from the pump to the tilt rams when the force moment is excessive.

If the mast is fully retracted when it engages the stop, hydraulic pressure to the value of a relief valve will be built up in the tilt cylinder by the pump regardless of the load. This pressure will close the port 83 and trap the fluid in the tilt rams.

To provide for such contingencies, a mechanical connection is provided between the valve plunger 58 and the tilt arm 33. This mechanical connection effects the elevation of the valve plunger 58 to a height which will provide communication between the passages 89 and 78 when the mast is tilted forward and also position the valve plunger for communication between the passages 85 and 77 when the mast is fully retracted, thus preventing entrapment of the oil.

As a result of the mechanical interlock, as soon as the lift cylinder is energized to raise the load while the mast is tilted forward against the stop, the fluid under positive pressure from the pump will lift the check valve 93 and force a small amount of fluid into the tilt rams, retracting the mast slightly. As the mast is retracted, the valve plunger will close the port 87 through the action of the spring 64, but since fluid is now in the cylinder, the pressure thereof will actuate the valve 58 to admit more fluid to the tilt cylinder if required.

To provide for this mechanical overriding control, the lower end 108 of the valve plunger is formed to protrude from the valve body and is machined with an axially threaded bore 109 for the support of linkage indicated schematically in Fig. 5 by the dotted line 110. This linkage which is shown most clearly in Figs. 2, 3, and 4 is basically a lost motion connection between the mast and the valve plunger which becomes effective only at the extreme positions of inclination of the mast. This connection is preferably supported by the hinge pin 31 on the right hand tilt arm 33. A link 111, formed with a slot 112 disposed throughout the major portion of its length, is welded to a stud 112 which is threaded into the tapped bore 109 in the lower end 108 of the valve plunger. A lock nut 113 on the stud is provided to maintain the adjustment of the linkage valve to the plunger. A second link 114 is disposed in contiguous parallel relation with the link 111, the upper end thereof being tapped to receive a shouldered cap screw 115 which slides freely in the slot 112 of the link 111. The lower end of the link 114 is formed with an offset portion 116 which is bored for rotational clearance over a shouldered screw 117 mounted in a tapped opening 118 in the end of the hinge pin 31. The parts as shown in Figs. 3 and 4 are disposed to correspond to the full forwardly tilted position of the mast, with the screw 115 engaging the upper end of the slot 112. As the mast is retracted, the tilt arm 33 descends and the screw 115 moves downwardly in the slot 112. As full rearward tilting movement of the mast is approached, the screw 115 will engage the lower end of the slot 112. Thus, with full forward inclination, the valve plunger 58 is forced upwardly so that the shoulder 84 will lie within the port 87, and with full rearward inclination the plunger 58 is forced downwardly so that port 82 will be held at least partially open. In either of the foregoing operations the effort exerted by the linkage will override the hydraulic pressure exerted against the shoulder 84 in the plunger.

It will be apparent to those skilled in the art from the description herein of the preferred embodiment of the invention that the principles thereof may be readily applied to and embodied in other types of machines than the lift truck chosen as an illustrative environment, and that mechanisms embodying the principles of the invention and securing the results thereof may be incorporated in diverse types of power systems. The invention, therefore, is not to be considered as limited to the structures disclosed herein, but the scope is to be determined from the claims appended hereto.

I claim:

1. In a lift truck, a chassis, a mast pivoted thereon, a carriage slidable on the mast, a pump, a first hydraulic motor for elevating the carriage, a second hydraulic motor for decreasing the for-

ward inclination of the mast in opposition to the force moment exerted by the carriage, the parts being so proportioned that less hydraulic pressure is required to decrease the mast inclination than to elevate the carriage, and a valve connected to the pump and second motor adapted to admit fluid from the pump to the second motor when the pressure therein reaches a predetermined value whereby the second motor is actuated to decrease the forward inclination of the mast.

2. In a lift truck, a chassis, a mast pivoted thereon, a carriage slidable on the mast, a pump, a first hydraulic motor for elevating the carriage, a second hydraulic motor for decreasing the forward inclination of the mast in opposition to the force moment exerted by the carriage, the parts being so proportioned that less hydraulic pressure is required to decrease the mast inclination than to elevate the carriage, and a stability control valve opened by the pressure in the second motor when said pressure reaches a predetermined value to admit fluid from the pump to the second motor whereby stability of the truck is attained by actuation of the second motor and the consequent rearward inclination of the mast.

3. In a lift truck, a chassis, a mast pivoted thereon, a carriage slidable on the mast, a pump, a first hydraulic motor for elevating the carriage, a second hydraulic motor for decreasing the forward inclination of the mast in opposition to the force moment exerted by the carriage, the parts being so proportioned that less hydraulic pressure is required to decrease the mast inclination than to elevate the carriage, means sensitive to the force moment of the mast, and a valve opened by the sensitive means when the moment reaches a predetermined value to admit fluid from the pump to the second motor whereby the second motor is actuated to bias the mast rearwardly and thus effect the stability of the vehicle.

4. In a lift truck, a chassis, a mast pivoted thereon, a carriage slidable on the mast, a pump, a first hydraulic motor for elevating the carriage, a second hydraulic motor for decreasing the forward inclination of the mast in opposition to the force moment exerted by the carriage, manually operable valve means adapted to direct the flow from the pump alternatively to either motor or to a vent, and automatic valve means adapted to direct flow from the pump to the second motor to maintain the stability of the truck, the parts being so proportioned that less hydraulic pressure is required to decrease the mast inclination than to elevate the carriage, whereby sufficient pressure is available to operate the second motor when the first motor is energized.

5. In a lift truck comprising a mast, means including a hydraulic motor for advancing and retracting the mast, a source of fluid under pressure, a reservoir, and a manually-operable valve for controlling flow of fluid between the source, the motor, and the reservoir, the pressure of fluid in the motor being indicative of the force moment of the mast and therefore of the degree of stability of the truck: a stability control device for the truck comprising means responsive to motor fluid pressure, a cutoff valve actuated by the responsive means to interrupt control of the motor by the manual valve, and a stabilizing valve actuated by the responsive means to energize the motor to retract the mast, the cutoff and stabilizing valves being actuated upon the occurrence of pressure indicating the approach of instability of the truck.

6. In a lift truck comprising a mast, means including a hydraulic motor for advancing and retracting the mast, a source of fluid under pressure, a reservoir, and a manually-operable valve for controlling flow of fluid between the source, the motor, and the reservoir, the pressure of fluid in the motor being indicative of the force moment of the mast and therefore of the degree of stability of the truck: a stability control device for the truck comprising means responsive to motor fluid pressure and means actuated by the responsive means to terminate advancing movement of the mast upon the occurrence of pressure indicating the approach of instability of the truck.

7. In a lift truck comprising a mast, means including a hydraulic motor for advancing and retracting the mast, a source of fluid under pressure, a reservoir, and a manually-operable valve for controlling flow of fluid between the source, the motor, and the reservoir, the pressure of fluid in the motor being indicative of the force moment of the mast and therefore of the degree of stability of the truck: a stability control device for the truck comprising means responsive to motor fluid pressure and a cutoff valve actuated by the responsive means to interrupt control of the motor by the manual valve upon the occurrence of pressure indicating the approach of instability of the truck.

8. In a lift truck comprising a mast, means including a hydraulic motor for advancing and retracting the mast, a source of fluid under pressure, a reservoir, and a manually-operable valve for controlling flow of fluid between the source, the motor, and the reservoir, the pressure of fluid in the motor being indicative of the force moment of the mast and therefore of the degree of stability of the truck; a stability control device for the truck comprising means responsive to motor fluid pressure and means actuated by the responsive means to retract the mast upon the occurrence of pressure indicating the approach of instability of the truck.

9. In a lift truck comprising a mast, means including a hydraulic motor for advancing and retracting the mast, a source of fluid under pressure, a reservoir, and a manually-operable valve for controlling flow of fluid between the source, the motor, and the reservoir, the pressure of fluid in the motor being indicative of the force moment of the mast and therefore of the degree of stability of the truck: a stability control device for the truck comprising means responsive to motor fluid pressure and a stabilizing valve actuated by the responsive means to energize the motor to retract the mast upon the occurrence of pressure indicating the approach of instability of the truck.

10. In a lift truck comprising a chassis, a mast on the chassis, means including a hydraulic motor for varying the inclination of the mast, a source of fluid under pressure, and a manually-operable valve for controlling flow of fluid to and from the hydraulic motor: a stability control device for the truck comprising a cutoff valve interposed between the motor and manual valve, means biasing the cutoff valve to open position, means responsive to fluid pressure in the motor operative to close the cutoff valve upon occurrence of a first predetermined pressure in the motor, and a stabilizing valve movable with the cutoff valve and interposed between the source and the motor, the stabilizing valve being adapted to direct fluid from the source to the motor to

energize the motor to retract the mast, the stabilizing valve being actuated substantially concurrently with closing of the cutoff valve.

11. In a lift truck comprising a chassis, a mast on the chassis, means including a hydraulic motor for varying the inclination of the mast, a source of fluid under pressure, and a manually-operable valve for controlling flow of fluid to and from the hydraulic motor: a stability control device for the truck comprising a cutoff valve interposed between the motor and manual valve, means biasing the cutoff valve to open position, and means responsive to fluid pressure in the motor operative to close the cutoff valve upon occurrence of a predetermined pressure in the motor.

12. In a lift truck comprising a chassis, a mast on the chassis, means including a hydraulic motor for varying the inclination of the mast, a stop for limiting the inclination of the mast under action of the motor, a source of fluid under pressure, and a manually-operable valve for controlling flow of fluid to and from the hydraulic motor: a stability control device for the truck comprising a cutoff valve interposed between the motor and manual valve, means biasing the cutoff valve to open position, means responsive to fluid pressure in the motor operative to close the cutoff valve upon occurrence of a first predetermined pressure in the motor, and means coupling the mast with the cutoff valve and adapted to override the responsive means and open the cutoff valve when the mast approaches the stop.

13. In a lift truck comprising a chassis, a mast on the chassis, means including a hydraulic motor for varying the inclination of the mast, a source of fluid under pressure, and a manually-operable valve for controlling flow of fluid to and from the hydraulic motor: a stability control device for the truck comprising a stabilizing valve interposed between the motor and source, means biasing the stabilizing valve to closed position, and means responsive to fluid pressure in the motor operative to open the stabilizing valve upon occurrence of a predetermined pressure in the motor.

14. In a lift truck comprising a chassis, a mast on the chassis, means including a hydraulic motor for varying the inclination of the mast, a stop for limiting the inclination of the mast under action of the load thereon, a source of fluid under pressure, and a manually-operable valve for controlling flow of fluid to and from the hydraulic motor: a stability control device for the truck comprising a stabilizing valve interposed between the source and the motor, the stabilizing valve being actuatable to direct fluid from the source to the motor to energize the motor to retract the mast, means for actuating the stabilizing valve upon occurrence of a predetermined fluid pressure in the motor, and means for actuating the stabilizing valve when the mast approaches the stop.

15. In a lift truck comprising a chassis, a mast pivoted on the chassis and biased to swing outwardly from the chassis, a hydraulic ram connected to the mast, a source of fluid under pressure, and a manually-operable valve adapted to direct fluid from the source to the ram to retract the mast, to hold fluid in the ram to hold the mast in position, and to bleed fluid from the ram to permit advance of the mast: a stability control means comprising a movable valve mechanism, means biasing the valve mechanism in a first direction, means responsive to pressure in the ram operative to move the valve mechanism in a second direction, the valve mechanism including a cutoff valve and a retracting valve, the cutoff valve being interposed between the manual valve and the ram and being closed by movement of the valve mechanism in the second direction, and the retracting valve being interposed between the source and the ram and being operated by movement of the valve mechanism in the second direction to energize the ram and retract the mast.

16. In a lift truck comprising a chassis, a mast pivoted on the chassis and biased to swing outwardly from the chassis, a hydraulic ram connected to the mast, a source of fluid under pressure, and a manually-operable valve adapted to direct fluid from the source to the ram to retract the mast, to hold fluid in the ram to hold the mast in position, and to bleed fluid from the ram to permit advance of the mast: a stability control means comprising a movable valve mechanism, means biasing the valve mechanism in a first direction, means responsive to pressure in the ram operative to move the valve mechanism in a second direction, the valve mechanism including a cutoff valve and a retracting valve, the cutoff valve being interposed between the manual valve and the ram and being closed by movement of the valve mechanism in the second direction, and the retracting valve being interposed between the source and the ram and being operated by movement of the valve mechanism in the second direction to energize the ram and retract the mast; and a lost-motion connection between the mast and the valve mechanism adapted to overrule the biasing and pressure-responsive means and so connected as to actuate the retracting valve when the mast is fully advanced and to open the cutoff valve when the mast is fully retracted.

17. In a lift truck comprising a chassis, a mast pivoted on the chassis and biased to swing outwardly from the chassis, a hydraulic ram connected to the mast, a source of fluid under pressure, and a manually-operable valve adapted to direct fluid from the source to the ram to retract the mast, to hold fluid in the ram to hold the mast in position, and to bleed fluid from the ram to permit advance of the mast: a stability control means comprising a movable valve mechanism, means biasing the valve mechanism in a first direction, means responsive to pressure in the ram operative to move the valve mechanism in a second direction, the valve mechanism including a cutoff valve interposed between the manual valve and the ram and closed by movement of the valve mechanism in the second direction; and a lost-motion connection between the mast and the valve mechanism adapted to overrule the pressure-responsive means and so connected as to open the cutoff valve when the mast is fully retracted.

18. In a lift truck comprising a chassis, a mast pivoted on the chassis and biased to swing outwardly from the chassis, a hydraulic ram connected to the mast, a source of fluid under pressure, and a manually-operable valve adapted to direct fluid from the source to the ram to retract the mast, to hold fluid in the ram to hold the mast in position, and to bleed fluid from the ram to permit advance of the mast: a stability control means comprising a movable valve mechanism, means biasing the valve mechanism in a first direction, means responsive to pressure in the ram operative to move the valve mechanism in a second direction, the valve mechanism including a retracting valve interposed between the source and the ram and operated by movement

of the valve mechanism in the second direction to energize the ram and retract the mast; and a lost-motion connection between the mast and the valve mechanism adapted to overrule the biasing means and so connected as to actuate the retracting valve when the mast is fully advanced.

19. A hydraulic system comprising a ram for moving a body the reaction of which decreases with increasing displacement of the ram, a pump, a manual valve for controlling the ram; valve means actuated by fluid pressure in the ram including a cutoff valve adapted to isolate the ram from the manual valve when the ram pressure reaches a predetermined value and an overriding valve opened when the ram pressure reaches a predetermined value; a fluid connection from the pump through the overriding valve to the ram; and a check valve in the said connection constructed to block flow therethrough away from the ram.

20. A hydraulic system comprising a ram for moving a body the reaction of which decreases with increasing displacement of the ram, a pump, a manual valve having a first position in which the pump is connected to the ram, a second position in which the fluid is locked in the ram, and a third position in which the ram is vented; valve means actuated by fluid pressure in the ram including a cutoff valve adapted to isolate the ram from the manual valve when the ram pressure reaches a predetermined value and an overriding valve opened when the ram pressure reaches a predetermined value; a fluid connection from the pump through the overriding valve to the ram; and a check valve in the said connection constructed to block flow therethrough away from the ram.

21. A hydraulic system comprising a ram for moving a body the reaction of which decreases with increasing displacement of the ram, a pump, a manual valve having a first position in which the pump is connected to the ram, a second position in which the fluid is locked in the ram and the pump is vented, and a third position in which the ram is vented; valve means actuated by fluid pressure in the ram including a cutoff valve adapted to isolate the ram from the manual valve when the ram pressure reaches a predetermined value and an overriding valve opened when the ram pressure reaches a predetermined value; a fluid connection from the pump through the overriding valve to the ram; and a check valve in the said connection constructed to block flow therethrough away from the ram.

22. A hydraulic system comprising a ram for elevating a body the reaction of which decreases with increasing displacement of the ram, a pump, a manual valve having a first position in which the pump is connected to the ram, a second position in which the fluid is locked in the ram, and a third position in which the ram is vented; valve means actuated by fluid pressure in the ram including an overriding valve having a normally closed passageway that is opened when the ram pressure reaches a predetermined value; a fluid connection leading from the pump through the overriding valve by means of said passageway to the ram; said overriding valve likewise having a normally open passageway connected between said manual valve and said ram that is closed when said normally-closed passageway is open, and a check valve in the said fluid connection constructed to block flow therethrough away from the ram.

23. A hydraulic system comprising a motor connected to a load the reaction of which normally tends to drive the motor in a reverse direction, a source of fluid under pressure, valve means connected to said source, a conduit between said valve means and motor, said valve means being settable to supply fluid from the source to the motor to drive it in a forward direction, and settable to allow fluid flow from the motor resulting from driving thereof in the reverse direction by the load; and an automatic cutoff valve responsive to fluid pressure in the motor and including means in said conduit effective to prevent fluid flow from the motor whenever the said pressure exceeds a predetermined value.

24. A hydraulic system comprising a motor connected to a load the reaction of which normally tends to drive the motor in a reverse direction, a source of fluid under pressure, valve means settable to supply fluid from the source to the motor to drive it in a forward direction, and settable to allow fluid flow from the motor resulting from driving thereof in the reverse direction by the load, and an automatic overriding valve responsive to fluid pressure in the motor and connected to said source to supply fluid directly from the source to the motor to drive the same in the forward direction whenever the said motor pressure exceeds a predetermined value, said overriding valve likewise being connected between said settable valve means and said motor and including means to isolate said motor and settable valve means when the motor pressure reaches said predetermined value.

25. A hydraulic system comprising a motor connected to a load the reaction of which normally tends to drive the motor in a reverse direction, a source of fluid under pressure, valve means connected to said source, a conduit between said valve means and motor, said valve means settable to supply fluid from the source to the motor to drive it in a forward direction, and settable to allow fluid flow from the motor resulting from driving thereof in the reverse direction by the load; an automatic cutoff valve responsive to fluid pressure in the motor and including means in said conduit effective to prevent fluid flow from the motor whenever the said motor pressure exceeds a predetermined value; and means driven by the motor and connected to said cut-off valve operative to disable the cutoff valve within a selected portion of the range of movement of the load.

26. A hydraulic system comprising a motor connected to a load the reaction of which normally tends to drive the motor in a reverse direction, a source of fluid under pressure, valve means settable to supply fluid from the source to the motor to drive it in a forward direction, and settable to allow fluid flow from the motor resulting from driving thereof in the reverse direction by the load; an automatic overriding valve responsive to fluid pressure in the motor and connected to said source to supply fluid from the source to the motor to drive the same in the forward direction whenever the said motor pressure exceeds a predetermined value; said overriding valve likewise being connected between said settable valve means and said motor and including means to isolate said motor and settable valve means when the motor pressure reaches said predetermined value, and means driven by the motor and connected to said overriding valve operative to disable the overriding valve at the limits of the range of movement of the load.

27. A hydraulic system comprising a motor con-

nected to a load the reaction of which normally tends to drive the motor in a reverse direction, a source of fluid under pressure, valve means settable to supply fluid from the source to the motor to drive it in a forward direction, and settable to allow fluid flow from the motor resulting from driving thereof in the reverse direction by the load; an automatic cutoff valve connected between said settable valve means and said motor and responsive to fluid pressure in the motor effective to prevent fluid flow from the motor whenever the said motor pressure exceeds a predetermined value; and an automatic overriding valve connected between said source and said motor and responsive to fluid pressure in the motor to supply fluid from the source to the motor to drive the same in the forward direction whenever the said motor pressure exceeds a higher predetermined value.

28. A hydraulic system comprising a motor connected to a load the reaction of which normally tends to drive the motor in a reverse direction, a source of fluid under pressure, valve means settable to supply fluid from the source to the motor to drive it in a forward direction, and settable to allow fluid flow from the motor resulting from driving thereof in the reverse direction by the load; an automatic cutoff valve connected between said settable valve means and said motor and responsive to fluid pressure in the motor effective to prevent fluid flow from the motor whenever the said motor pressure exceeds a predetermined value; an automatic overriding valve connected between said source and said motor and responsive to fluid pressure in the motor to supply fluid from the source to the motor to drive the same in the forward direction whenever the said motor pressure exceeds a higher predetermined value; and means driven by the motor and connected to said overriding and cut-off valves operative to disable the cutoff and overriding valves, respectively, at the limits of the range of movement of the load.

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