Fig. 1.

Fig. 2.

Inventors
Edward S. Marnon,
William H. Cook,
George F. Zier.

Eugene D. Farley
Att'y
MULTI-CAPACITY LIFT TRUCK

Edward S. Marmon, Oregon City, George F. Zier, Milwaukie, and William H. Cook, Jennings Lodge, Ore.; said Zier and said Cook assignors to said Marmon

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This invention pertains to industrial lift trucks and relates particularly to a multi-capacity lift truck which is counterbalanced automatically in response to the weight and position of loads being lifted and transported.

Lift trucks are employed in warehouses, on docks and in various other industries for the transportation of goods over relatively short distances, and it is the primary function of a lift truck to perform this operation with speed and facility. Accordingly, various sizes of lift trucks have been provided heretofore in order best to achieve maximum quantity of handling for the various sizes and weights of goods required to be transported.

The requirement of larger lift trucks for larger and heavier loads not only represents an increased operating cost in equipment, but in addition their use requires more space in which to maneuver and more substantial floors and elevators for support. In warehouses, for example, the requirement for more maneuvering space results in substantial reduction of storage space by providing wider aisles. The conventional floors in trucks and box cars are not constructed to accommodate the weight of these large lift trucks, and therefore a greater hazard is presented. As a consequence it has become the general practice to station the lift truck adjacent the box car, for example, and to manually unload the contents of the box car onto the lift truck with the aid of hand trucks. This procedure is also used in loading the box car or truck. In both instances the procedure requires a substantial amount of manual labor and represents a substantial loss of time in transferring the goods, as compared with the time required when the lift truck performs the entire operation.

It is a principal object of this invention to provide a lift truck which facilitates the handling of loads of substantially greater bulk and weight than provided heretofore by conventional lift trucks of comparable size.

Another important object of this invention is the provision of a lift truck which accommodates the handling of loads of substantially greater bulk and weight than provided heretofore by conventional lift trucks of comparable weight.

Another important object of this invention is the provision of a lift truck in which balance is maintained automatically under conditions of variable load weight and uneven paths of travel, thereby assuring safe and rapid carriage without requiring manual attention to maintain said balance.

A further important object of this invention is the provision of a lift truck in which balance is maintained automatically by the extension or retraction of a counterweight to proper positions within its limits of extension and retraction at which maximum stability of the truck is achieved for various conditions of load and travel.

A still further important object of this invention is the provision of a counterbalanced lift truck in which actuation of the counter-weight is achieved with maximum speed and accuracy in response to changes in load weights and conditions and travel.

A further important object of this invention is the provision of a lift truck which is of minimum size and weight compared with the gross weight and bulk capable of being carried thereon, which is of maximum stability and maneuverability under all conditions of load, and is sturdily constructed for long operating use.

These and other objects and advantages of the present invention will appear from the following detailed description taken in connection with the accompanying drawings, in which:

Figure 1 is a side elevational view of a lift truck embodying the features of this invention, the elements of the same being shown in their intermediate positions during the preliminary stage of lifting a load;

Figure 2 is a side elevational view of the lift truck shown in Figure 1, the elements of the same being shown in their ultimate positions for transporting the load;

Figure 3 is a fragmentary side elevation of the rear portion of a lift truck showing details of the actuating mechanism for the counterweight assembly of the truck;

Figure 4 is a fragmentary side elevation of the counterweight assembly of the lift truck, the elements of the same being shown in extended position in dotted outline;

Figure 5 is a fragmentary sectional view taken along the line 5—5 in Figure 4; and

Figure 6 is a fragmentary side elevation as viewed from the right in Figure 5.

Stated broadly, the lift truck of the present invention comprises a motor driven vehicle having a tiltable load-holding mast on its forward end and an extensible counterweight on its rearward end, and electrically operated power means for actuating the counterweight automatically as the vehicle frame tilts longitudinally in response to varying conditions of load weight and position with respect to the vehicle.

Referring particularly to the Figures 1 and 2 of the drawings, the lift truck comprises a vehicle frame 1 and body 2 mounted upon a pair of forward drive wheels 3 and a rear wheel unit 4 which is rotatable about a vertical axis by means of a steering assembly controlled by steering wheel 5 disposed in front of the operator's seat 6. A pair of spaced upwardly extending masts 7 are secured pivotally adjacent their lower ends to the forward end of the vehicle frame and are connected to power means (not shown) by which they may be tilted forwardly and rearwardly in manner well known in the art. A pair of load-supporting forks 8 are supported slidably on the masts for movement longitudinally of the latter, said movement being effected by such means as the power driven chains 9 or other conventional mechanism.

Referring now to Figure 4 of the drawings, the rearward end of the frame 1 is stepped down and is adapted to receive thereupon a massive counterweight 11. The lower central portion of the counterweight is hollow in order to accommodate certain elements of the mechanism hereinafter described. The counterweight is suspended pivotally at its upper end upon shafts 12 which extend through brackets 13 secured to the counterweight, the shafts being supported in suitable bearings provided in the upper end of the transversely spaced support arms 14. Arms 14 are pivotally mounted at their lower ends on shafts 15 secured to the vehicle frame 1.

It is to be noted that when the counterweight is at rest upon the stepped portion of frame 1 the axis of shafts 12 is disposed in a plane normal to the frame forwardly of the axis of shafts 15. By this arrangement the weight of counterweight 11 functions effectively to maintain itself in the retracted position shown in full lines in Figure 4, thereby obviating the necessity of additional restraining force, as explained in greater detail hereinafter.

A shaft 16 is mounted for axial rotation transversely
of the vehicle frame, forwardly of the stepped-down portion of the latter. Secured at one end adjacent the opposite end of shaft 16 for rotation therewith is a lever arm 17. The free end of each lever arm 18 is secured at its pivotally intermediate the ends of the latter, and by link 19 to opposite sides of the counterweight 11.

A single lever arm 21 is secured at one end to shaft 16, as by key 22, for rotation therewith. The free end of arm 21 is pivotally connected to the free end of a drive rod 23. Rod 23 is secured at its opposite end to a piston 24 mounted slidably within the cylinder 25 of a conventional double-acting hydraulic ram. Cylinder 25 is pivotally secured at its end opposite rod 23 to the vehicle frame 1 by means of pin 26, as shown in Figure 3.

Flexible conduits 27 and 28 communicate at one end with the cylinder 25 at opposite sides of piston 24. The opposite end of each conduit is connected to a reversing valve 29 which, in turn, is connected to fluid lines 31 and 32 leading, respectively, to fluid reservoir 33 and to the output of fluid pump 34. Conduit 35 leads from the reservoir to the input of the fluid pump. Valve 29 is of the type in which, when actuated to one position it connects conduit 27 with line 31 and conduit 28 with line 32, and, when actuated to another position interconnects conduit 27 with line 32 and conduit 28 with line 31. In this manner fluid from pump 34 may be directed to either side of piston 24, the exhaust side of the cylinder being returned to reservoir 33.

Valve 29 also has an intermediate neutral position at which fluid lines 31 and 32 are interconnected to circulate the fluid from pump 34 to reservoir 33. In this neutral position conduits 27 and 28 are blocked from each other and from lines 31 and 32. Thus, fluid in cylinder 25 is prevented from flowing and the counterweight may thereby be locked in any position desired.

The valve 29 is actuated to its alternate positions by means of a pair of electrically operated solenoids 36 and 37 arranged in parallel electrical circuits and energized by the electrical supply source 38. Normally closed micro switches 39 and 40 are arranged in series in the electrical circuits of the solenoids 36 and 37, respectively. These micro switches, hereinafter called limit switches, are mounted on frame 1 adjacent arm 21 for engagement therewith, as best shown in Figure 4. By this arrangement micro switch 40 is opened when the counterweight is fully retracted and micro switch 39 is opened when the counterweight is fully extended, thereby deenergizing solenoids 36 and 37 and returning valve 29 to its neutral position. The fluid pump 34 is thereby relieved of unnecessary work when the counterweight is in either of its extreme positions of retraction and extension.

Also arranged in series in the electrical circuits of solenoids 36 and 37 are the normally open micro switches 41 and 42 respectively, for controlling the operation of the solenoids, as explained in detail hereinafter. These micro switches are mounted in vertically spaced relation in such manner as to reach one end 43 of a switch arm 44 between them. The switch arm is mounted pivotally intermediate its ends on pin 45 carried by bracket 46 secured to the vehicle frame 1, the opposite end 47 of the arm extending toward the rear of the vehicle. A tension spring 48 is connected at one end to the switch arm 44 for pivot support 45 and at the opposite end to a bracket 49 secured to the vehicle frame above the arm 44. The spring thereby prevents the switch arm from rotating of its own weight counterclockwise about its pivot support 45.

Referring now to Figures 5 and 6 of the drawings, the rear steering wheel unit 4 preferably comprises a pair of wheels 51 mounted for rotation on an axle 52 by means of bearings 53. The axle is supported at its ends in the spaced sides 54 of a rectangular frame and secured thereon by bolts 55. A structural fender 56 overlies the wheels and is pivotally secured at its forward end by pin 57 to a projection 58 on the forward end of the axle-supporting frame. The fender is extended forwardly to a height of approximately 3 inches, which height being made being to Figure 6 of the drawings: Since frame 1 rests upon fender 56 and the latter is pivotally connected at its forward end by pin 57 to the axle-supporting frame 54, it is apparent that the weight of frame 1 impressed on pin 57 tends to rotate the sides 54 of the axle-supporting frame in a counterclockwise direction about axle 52. Bracket 61 thereby tends to move upwardly toward bracket 62. Thus, the coil springs 63 function to resist this counterclockwise rotation and, in effect, provide a resilient support for frame 1 on axle 52.

A stepped shaft 65 is secured at its lower end to the fender 56 and extends vertically through the aperture 66 in the vehicle frame 1. A bearing 67 is interposed between the frame 1 and the lowermost shoulder of shaft 65 to support the frame thereon and facilitate relative rotation between said shaft and frame. A gear 68 is secured removably to the intermediate stepped portion of shaft 65 by means of bolt 69. Gear 68 is connected through conventional mechanism (not shown) to the steering wheel 5 by which the wheel unit 4 is rotated and the vehicle is guided.

A rod 71 extends slidably through a bore 72 formed vertically through the axis of shaft 65 and through fender 56. The lower end of rod 71 is connected to a flange 73 extending from a circular sleeve 74 which freely encircles the axle 52 between the wheels 51. The upper end of rod 71 contacts the head 75 of an adjustment screw 76 which is threaded into the rear end 47 of the switch arm 44. A lock nut 77 is employed to secure the screw 76 in any desired position of adjustment.

The operation of the mechanism described hereinbefore is as follows: With the lift truck in an unloaded condition and counterweight 11 in retracted position on frame 1, adjustment screw 76 is set so that the forward end 43 of switch arm 44 is positioned in contact with micro switch 42. But since counterweight 11 is fully retracted, limit switch 40 is opened and therefore the circuit of solenoid 37 remains deenergized and valve 29 is in its neutral position, preventing the flow of fluid pressure to either side of piston 24 in the hydraulic cylinder 25.

When the operator engages the lifting forks 8 under a load 80 and starts to elevate the forks, as in Figure 1, the weight of the load causes the frame 1 to tilt forwardly, i.e. the coil spring 63 supporting the rear end of the vehicle frame 1 on the axle extends because of the forward shift of the center of gravity. The extension of coil spring 63 elevates the rear end of the vehicle frame 1 with respect to the forward end thereof. This elevation of the rearward end of frame 1 in turn causes elevation of the pivot support 45 of switch arm 44. Since the rearward end 47 of the switch arm rests upon the upper end of rod 71 and, since rod 71 is secured to the axle 52 of the rear wheel unit 4 which has not become elevated, switch arm 44 pivots clockwise about pin 45 and the forward end 43 of the switch arm is caused to rise toward micro switch 41.

It will be apparent that the lift truck is capable of lifting a certain maximum load with the counterweight retracted without becoming unstable to any serious degree. For purposes of illustration let it be assumed that this maximum load is one ton. Accordingly, micro switch 41 is so adjusted vertically above the foregoing initial position of the forward end 43 of switch arm 44 that a load of at least one ton must be applied to the
Assuming that load 80 is in excess of the exemplified maximum, closure of micro switch 41 completes the electrical circuit of solenoid 36 which thereupon moves fluid valve 29 to the position at which fluid lines 32 and 28 are interconnected and fluid lines 31 and 27 are also interconnected. Fluid pressure from pump 34 is thereby injected into the right-hand end of cylinder 25 (Figure 3) to move piston 24 to the left.

As piston 24 and rod 23 move to the left, shaft 16 is rotated in a clockwise direction (Figure 4) and the upper end of lever 17 begins to move in the direction of arrows 81. Links 18 exert a force against counterweight support arms 14, causing the latter to pivot clockwise about shafts 15. The upper end of arms 14 swing in the direction of arrows 82 in Figure 4, carrying the suspended counterweight 11 rearwardly.

Fluid pressure against piston 24 is required only to pivot the support arms 14 clockwise until the axis of counterweight support shaft 12 passes rearwardly of the vertical plane of the axis of shafts 15. The weight of the suspended counterweight 11 is then sufficient to swing the supporting assembly rearwardly to the position shown in dotted lines in Figure 4, at which the counterweight is fully swiveled. In this position, shaft 25 is opened by contact with arm 21 and valve 29 is returned to its neutral position, as previously explained. The extended counterweight is stabilized in a vertical position against swinging movement about shaft 12 by means of link 19.

It is to be pointed out here that the counterweight 11 is extended rearwardly by only the distance required to offset the load 80 and thereby achieve optimum balance and stability of the lift truck. As an illustration, it is to be assumed that the counterweight will extend fully only when the load being lifted exceeds three tons. Thus, when lifting a load of, say, two tons, counterweight 11 will be extended to some position intermediate the extreme limits of retraction and extension. At that intermediate position of extension the lift truck will be stabilized, and the rearward end of frame 1 will be lowered sufficiently to move the forward end 43 of switch arm 44 downward out of contact with micro switch 41 to a position in between the micro switches 41, 42. Solenoids 36, 37 thereby both being deenergized, valve 29 is returned to its neutral position and the fluid in cylinder 25 is rendered immobile. Thus, since piston 24 is locked against further movement in either direction, the counterweight is maintained in the proper position of extension.

With the counterweight extended rearwardly as described hereinabove the center of gravity of the vehicle is effectively shifted rearwardly to compensate for the additional weight of load 80 supported forwardly of the front wheels 3. It is to be observed in Figure 4 that when the counterweight is fully extended it is not only extended rearwardly of the frame, but it is also lowered to a level substantially below its normal rest position on the frame. This lowered position effectively lowers the center of gravity of the vehicle and thereby stabilizes the latter to an even greater degree.

It will be understood that when the counterweight is fully extended, as shown in dotted outline in Figure 4, arm 21 contacts and opens limit switch 39. Thus, the circuit of solenoid 36 is opened and valve 29 is returned to neutral position. In this manner the fluid pump 34 is relieved of unnecessary work in holding the counterweight in its extended position.

The operator now manipulates the proper controls which first tilts the mast 7 rearwardly and then elevates the load to a position on the mast at which the center of gravity of the vehicle is shifted rearwardly a distance sufficient to cause the rearward end of the vehicle frame 1 to be lowered against the compression of spring 63 until the pivot support 45 of switch arm 44 is lowered to a point at which the forward end 43 of said arm is moved downwardly from its intermediate position into contact with micro switch 42. The closing of micro switch 42 energizes solenoid 37 which moves fluid valve 29 to a position at which fluid lines 32, 27 and 28 are in respective communication. Thus, fluid pressure from pump 34 is injected into the left-hand end of cylinder 25 to drive the piston 24 rearwardly (to the right in Figure 3). Shaft 16 thereupon rotates counterclockwise, moving the assembly of lever arms 17, links 18, 19, support arms 14 and counterweight 11 to the left in Figure 4 to the position of rest shown in full lines. The vehicle is now ready to transport the load.

In returning the counterweight to retracted position it is to be noted that as shaft 12 glides forwardly beyond the vertical plane of shafts 15 no further fluid pressure is required because the weight of the counterweight is sufficient to complete its own retraction from that stage to its final position of rest upon frame 1. In this position limit switch 46 is opened, solenoid 37 is deenergized and valve 29 is returned to its normal position.

From the foregoing it is seen that the counterweight functions by extending rearwardly of the vehicle automatically and to the proper extent to counterbalance the vehicle during the preliminary stages of lifting and tilting the particular load. Then, when the load is elevated rearwardly on the mast to a point of stability, the fluid pressure is returned automatically, thereby reducing the length of the vehicle to its minimum dimension shown in Figure 2 for most efficient maneuverability during transportation of the load.

Further, it is apparent that the counterweight extends and retracts automatically as the vehicle travels over uneven paths and inclined surfaces which are of sufficient magnitude to cause movement of the switch arm 44 alternately into contact with micro switches 41 and 42. Thus, proper balance of the vehicle is maintained automatically under all of the usual adverse conditions of travel, and the counterweight is actuated with such speed that balance is maintained even when the center of gravity of the truck is shifted rapidly.

The arrangement of the shafts 12 and 15 with respect to the supporting arms 14 for the counterweight 11 is of particular advantage in the present invention. In the initial stage of extension, the counterweight is required to be lifted vertically as it moves rearwardly until shaft 12 passes the vertical plane of shafts 15. Fluid power is required to effect this movement only, thereby reducing the power requirements to a minimum and effecting extension of the counterweight with maximum speed. Moreover, since the weight of the counterweight resists its own elevation during this initial stage, the counterweight functions to prevent its own accidental extension while in its retracted position of rest upon the vehicle frame.

Of further advantage is the arrangement of fulcrum rod 71 at the axial center of the pivot of the steerable wheel unit 4. This rod, being mounted upon axle 52, provides a fixed base for the rearward end of switch arm 44, with respect to the vertically movable frame 1, while accommodating rotation of the wheel unit 4 about the vertical axis in response to controlled movement of the steering wheel 5.

Many practical advantages result from the lift truck construction embodying the features of this invention. Among these is the reduction of axle width in warehouses and other storage spaces, thereby effectively enlarging the storage capacity of a given area. A further advantage is the virtue of the ability of the lift truck to be extended in length while lifting a heavy load and then to be reduced to minimum length for transporting the load. Further, a substantially greater range of load weights and bulk may be transported on one size of lift truck than has been afforded heretofore. Heavier and bulkier pay loads may be hauled on a lift truck of substantially
smaller gross weight and size than has been accomplished heretofore. The low center of gravity of the lift truck provides additional stability and safety, reducing hazards of operation and spillage to a minimum. In addition, the increased traction and precise control of the counterweight automatically in response to the load requirements enable heavy loads to be transported with maximum speed, facility and safety, thereby saving considerable time in the loading and unloading operations. A still further advantage resides in the automatic control of the lift in response to the load, for in this manner the operator is relieved of all responsibility in determining the condition of maximum stability and safety.

It will be apparent to those skilled in the art that various changes in the structural details described hereinbefore may be made without departing from the scope and spirit of the present invention. Accordingly, it is to be understood that the foregoing description is merely illustrative and is not to be construed in a limiting sense.

Having now described our invention and the manner in which the same may be used, what we claim as new and desire to secure by Letters Patent is:

1. A lift truck comprising a frame, rearwardly tiltable load-supporting means on the forward end of the frame, a front wheel and axle unit supporting the frame, a rear wheel and axle unit supporting the frame and secured pivotally on the frame for rotation about a vertical axis, rod means mounted at its lower end on the rear axle and extending upwardly therefrom freely through the vertical axis of rotation of the rear wheel and axle unit, spring means resiliently interconnecting the frame and rear axle whereby the frame and rod means are movable vertically with respect to each other, a counterweight, support means mounted pivotally at its lower end upon the rearward end of the frame, pivot means suspending the counterweight from the upper end of the support means, the axis of the counterweight pivot means being displaced alternately on opposite sides of the plane of the pivotal mounting of the support means, which plane extends normal to the plane of the frame, when the counterweight is in retracted and extended positions, lever means mounted pivotally on the frame forwardly of the counterweight, link means pivotally connecting the lever means with the support means and the counterweight, respectively, electrically actuated reversible power means connected to the lever means for moving the latter, switch means in the respective electrical circuits of the forward and reverse power-actuating means, and switch-actuating arm means mounted pivotally on the frame forwardly of the counterweight, pivot means suspending the counterweight from the upper end of the support means, the axis of the counterweight pivot means being displaced alternately on opposite sides of the plane of the pivotal mounting of the support means, which plane extends normal to the plane of the frame, when the counterweight is in retracted and extended positions, lever means mounted pivotally on the frame forwardly of the counterweight, link means pivotally connecting the lever means with the support means and the counterweight, respectively, electrically actuated reversible power means connected to the lever means for moving the latter, electric circuits for the actuating means, switch means in the respective electrical circuits of the forward and reverse power-actuating means, and switch-actuating means mounted on the frame and operated by the rod means in response to changes in relative vertical displacement of the frame and rod means by longitudinal tilting of the frame.

2. A lift truck comprising a frame, a front wheel and axle unit supporting the frame, a rear wheel and axle unit supporting the frame, rod means mounted at its lower end on the rear axle and extending upwardly therefrom freely through the frame, spring means resiliently interconnecting the frame and rear axle whereby the frame and rod means are movable vertically with respect to each other, a counterweight, support means mounted pivotally at its lower end upon the rearward end of the frame, pivot means suspending the counterweight from the upper end of the support means, the axis of the counterweight pivot means being displaced alternately on opposite sides of the plane of the pivotal mounting of the support means, which plane extends normal to the plane of the frame, when the counterweight is in retracted and extended positions, lever means mounted pivotally on the frame forwardly of the counterweight, link means pivotally connecting the lever means with the support means and the counterweight, respectively, electrically actuated reversible power means connected to the lever means for moving the latter, electric circuits for the actuating means, switch means in the respective electrical circuits of the forward and reverse power-actuating means, and switch-actuating means mounted on the frame and operated by the rod means in response to changes in relative vertical displacement of the frame and rod means by longitudinal tilting of the frame.

3. A lift truck comprising a frame, a front wheel and axle unit supporting the frame, a rear wheel and axle unit supporting the frame and secured pivotally to the frame for rotation about a vertical axis, rod means mounted at its lower end on the rear axle and extending upwardly therefrom freely through the vertical axis of rotation of the rear wheel and axle unit, spring means resiliently interconnecting the frame and rear axle whereby the frame and rod means are movable vertically with respect to each other, a counterweight supported on the rearward end of the frame for movement rearwardly
thereof, electrically actuated reversible power means connected to the counterweight for moving the latter, electric circuits for the actuating means, switch means in the respective electrical circuits of the forward and reverse power-actuating means, and switch-actuating arm means mounted pivotally on the frame, one end of the arm means being positioned to contact the switch means alternately, the opposite end of the arm means being positioned in contact with the upper end of the rod means, whereby the arm means is pivoted in response to longitudinal tilting of the frame.

6. A lift truck comprising a frame, a front wheel and axle unit supporting the frame, a rear wheel and axle unit supporting the frame, rod means mounted at its lower end on the rear axle and extending upwardly therefrom freely through the frame, spring means resiliently interconnecting the frame and rear axle whereby the frame and rod means are movable vertically with respect to each other, a counterweight supported on the rearward end of the frame for movement rearwardly thereof, electrically actuated reversible power means connected to the counterweight for moving the latter, electric circuits for the actuating means, switch means in the respective electrical circuits of the forward and reverse power-actuating means, and switch-actuating arm means mounted pivotally on the frame, one end of the arm means being positioned to contact the switch means alternately, the opposite end of the arm means being positioned in contact with the upper end of the rod means, whereby the arm means is pivoted in response to longitudinal tilting of the frame.

7. A lift truck comprising a frame, front and rear wheel and axle units supporting the frame and secured pivotally to the frame for rotation about a vertical axis, rod means mounted at its lower end on the rear axle and extending upwardly therefrom freely through the vertical axis of rotation of the rear wheel and axle unit, spring means resiliently interconnecting the frame and rear axle whereby the frame and rod means are movable vertically with respect to each other, a counterweight supported on the rearward end of the frame for movement rearwardly thereof, electrically actuated reversible power means connected to the counterweight for moving the latter, electric circuits for the actuating means, switch means in the respective electrical circuits of the forward and reverse power-actuating means, and switch-actuating arm means mounted on the frame and operated by the rod means in response to changes in relative vertical displacement of the frame and rod means by longitudinal tilting of the frame.

8. A lift truck comprising a frame, a front wheel and axle unit supporting the frame, a rear wheel and axle unit supporting the frame, rod means mounted at its lower end on the rear axle and extending upwardly therefrom freely through the frame, spring means resiliently interconnecting the frame and rear axle whereby the frame and rod means are movable vertically with respect to each other, a counterweight supported on the rearward end of the frame for movement rearwardly thereof, electrically actuated reversible power means connected to the counterweight for moving the latter, electric circuits for the actuating means, switch means in the respective electrical circuits of the forward and reverse power-actuating means, and switch-actuating means mounted on the frame and operated by the rod means in response to changes in relative vertical displacement of the frame and rod means by longitudinal tilting of the frame.

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