APPARATUS AND METHOD FOR HANDLING A COUNTERWEIGHT

A lift crane having enhanced lifting capability includes a self-installing counterweight system which utilizes actuators (142) forming part of a counterweight the rear of the crane. A pair of slidable counterweight beams (34) are slidably supported within main frame members forming part of the upper works of the crane and have their outer ends attached to the counterweight (32). Fluid pressure operated actuator (126) within the frame members extend and retract the beam (34) in order to move the counterweight (32) rearwardly with respect to the rear of the crane. The upperworks (10) also includes spaced-apart, parallel frame members each having spaced-apart vertical side plates (86, 88) with integral flange sections (110, 112) extending upwardly. The flanged sections (110, 112) include mounting locations (110a, 112a) for hoist machinery which utilize pins for easily mounting and dismounting the equipment. Drip pans (80, 82) including drain plugs (80a, 82a) are provided and located below machinery components that are likely to discharge fluid.
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Apparatus and method for handling a counterweight

Technical Field

The present invention relates generally to lift cranes and, in particular, to a new and improved mobile lift crane having enhanced lift capability and enhanced serviceability.

Background Art

Conventional lift cranes include a upper body or upper works which is typically rotatable about a vertical axis with respect to a lower works or carbody. The upper works typically supports a boom or mast and carries lift machinery for raising and lowering the boom as well as machinery for operating the lifting hoist. The carbody in mobile cranes, typically includes a crawler-type drive system including a pair of track assemblies driven by a suitable drive motor or motors.

The lifting capacity of a crane is determined at least in part by the geometry of the base, since all of the compression and tilting loads must act through the base which is in contact with the ground. The need for increased crane capacity has been partly met by larger sized cranes having bigger carbodies, both for more strength and to further space the fulcrum or tipping point of the crane from the counterweight effective line of action. Larger cranes have also been provided with increasing amounts of counterweight carried on the rotatable upper works which resist the overturning moment of larger loads.

Cranes having auxiliary counterweights and/or movable counterweight mechanisms have been suggested in the past. U.S. Patent No. 5,035,337 illustrates an example of a crane having auxiliary counterweights which are used in order to lift heavy loads. U.S. Patent No. 4,557,390 illustrates a suspended counterweight system in which a separate counterweight is supported by a separate counterweight boom.

U.S. Patent Nos. 4,729,486 and 4,953,722 illustrate mechanisms for providing a counterweight that is movable along a beam extending from the rear of
the upper works. In the '486 patent, an actuator operating a chain drive is provided for selectively moving the counterweight along the beam is disclosed.

Large capacity mobile cranes often have to be disassembled in order to transport the crane to a job site. In some instances, the upper works is separated from the cabody and the individual units are transported to the job site and reassembled. In at least some large capacity cranes, the counterweight is also separately transported and is installed onto the upper works at the job site. Attempts have been made to simplify the installation of the counterweight. U.S. Patent No. 4,081,081 illustrates an example of a crane in which provision has been made for mounting and demounting a counterweight.

Disclosure of the Invention

The present invention provides a new and improved lift crane having enhanced lift capability and enhanced serviceability. According to the invention, the crane includes a self installing counterweight system which includes a counterweight assembly having a weighted counterweight and at least one fluid pressure operated actuator forming part of the counterweight assembly.

During installation, a source of pressurized fluid is communicated to the counterweight assembly in order to provide a means for extending and retracting the actuator with respect to the counterweight. In the illustrated embodiment, during installation, the actuator is extended upwardly and coupled to the crane. The actuator is then retracted to raise the counterweight from ground level to a position in alignment with a counterweight support forming part of the crane. Once in position, the counterweight is attached to the crane and the actuator is then decoupled from the crane.

In the preferred and illustrated embodiment, the counterweight assembly is attached to a laterally extendable support which in the preferred embodiment comprises a pair of extendable beams forming part of the crane. When the counterweight is raised to its operative position, the support beams are extended into a predetermined position with respect to the counterweight, whereupon the actuator is extended to lower the counterweight onto the
support beams. In the exemplary embodiment, the counterweight includes downwardly depending lugs that are received in apertures formed in the counterweight support beams. Locking bolts are then used to secure the counterweight assembly to the beams.

In the preferred embodiment, two actuators are used in the counterweight assembly and operate in unison. According to a feature of the invention, the actuators perform a dual function. During installation, they are extended upwardly to engage structure on the crane by which the counterweight is raised to its operative position. Once installed, upper parts of the actuators are locked as by pins, to the counterweight to prevent movement. Lower ends or rods of the actuators are uncoupled from the counterweight so that energization of the actuator produces downward movement in the lower end of the actuators. The lower end of the actuators are in turn attached to a stabilization foot so that under predetermined operating conditions, the operating foot is extended in order to provide support for the crane, should a load condition be encountered (such as a cable failure) in which the crane would otherwise tip rearwardly.

According to another feature of the crane, a pair of spaced apart frame members form the load bearing structure to which hoist machinery and the crane boom are attached. In the preferred embodiment, each frame member includes at least one vertical side plate including an integral flange section extending upwardly above a general plane of the frame member, to which the machinery is releasably attached. In the illustrated embodiment, each frame member includes a pair of spaced apart side plates each having upwardly extending flange sections. Stanchions forming part of the crane machinery are coupled to the flange sections using easily removable pins. With this feature of the invention, machinery can be easily removed for replacement and/or when repair or service is necessary.

According to another feature of the invention, the main frame members are square or rectangular in cross-section and define housings for receiving the counterweight support beams. In particular, the counterweight support beams are slidably supported within the frame members. Fluid
pressure operated counterweight extension actuators are also mounted within the frame members and are reciprocally moveable in order to extend and retract the beams and hence, the counterweight assembly.

According to a feature of the invention, the supply of pressurized fluid for extending and retracting the counterweight extension actuators, is at least partially controlled by a load moment indicator which monitors the load and configuration, i.e., boom angle and boom out radius, of the crane. The load moment indicator inhibits the supply of pressurized fluid to either retract or extend the counterweight extension actuators under certain operating conditions that would produce instability in the crane. Movement of the counterweight assembly towards and away from the rear of the crane is effected by the operator in connection with a display panel mounted within the operator cab that includes a load indicator.

According to another feature of the invention, the machinery deck includes drip pans extending laterally from the main frame members which collect fluid discharge by components located within the upperworks of the crane. The drip pans include drains which are used to discharge collected fluid under controlled conditions.

Additional features of the invention will become apparent and a full understanding obtained by reading the following detailed description made in connection with the accompanying drawings:

**Brief Description of the Drawings**

Figure 1 is a side elevational view of a mobile lift crane constructed in accordance with the preferred embodiment of the invention;

Figure 2 is a fragmentary side view, partly in cross-section, of the crane shown in Figure 1 with a counterweight shown in a partly installed condition;

Figure 3 is fragmentary side view, partly in cross-section, of the crane shown in Figure 1 illustrating an operative position for a support foot forming part of the counterweight shown in Figure 2;

Figure 4 is an isometric view of a machinery compartment forming part of the crane shown in Figure 1;

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Figure 5 is an isometric view of the machinery compartment, with components removed to show additional details;

Figure 6 is a side elevational view of the machinery deck shown in Figure 4;

Figure 7 is a top plan view of the machinery deck;

Figure 8 is a front view of the machinery deck shown in Figure 4;

Figure 9 illustrates somewhat schematically the counterweight extension mechanism and control system therefor;

Figure 10A illustrates, somewhat schematically, the display panel of a load moment indicator forming part of the crane control system; and

Figures 10B-10D illustrate various conditions of a load indicator forming part of the load moment display shown in Figure 10A.

**Best Mode for Carrying Out the Invention**

Figure 1 illustrates a mobile crane constructed in accordance with the preferred embodiment of the invention. As is conventional, the crane includes a rotatable upper works 10 and a lower works or carbody 12. The upper works is rotatably connected to the carbody through a coupling indicated generally by the reference character 14 which includes a large rotary bearing that mounts a bull gear.

The carbody 12 includes a crawler type drive mechanism (not shown in detail) for driving a pair of tracks 16 (only one of which is shown) to effect movement in the crane when desired. The carbody 12 is considered conventional and does not form part of the present invention.

The upper works 10 includes an operator cab 18 mounted ahead of and to one side of a machinery compartment 20. A boom 22 is pivotally attached to the upper works and is raised and lowered using cables 23 that are extended or retracted by machinery located within the machinery housing 20. For purposes of explanation, only a partial boom is shown in the Figures. It should be understood, that a more conventional, elongate boom would more typically be mounted to the upper works. A lift or hoist assembly 24 is used to lift and lower loads. The hoist machinery within the machinery compartment extends
and retracts cabling 25 in order to raise and lower the load attached to the hoist.

In accordance to one preferred embodiment of the invention, a pair of counterweight support arms 30 (only one is shown) extend upwardly and rearwardly from the upper works and are used to install a counterweight assembly 32 onto the rear of the crane. In the preferred embodiment, the counterweight 32 is removable to facilitate transport of the crane to a job site.

In the preferred embodiment, the counterweight assembly 32 is attached to a pair of extendable beams 34 (shown best in Figure 4) which are used to move the counterweight 32 rearwardly in order to enhance the lifting capability of the crane. By extending the counterweight rearwardly, the boom 22 can be boomed outwardly a greater distance for a given load. When the enhanced lifting capability is not needed, the counterweight is retracted so that it is adjacent the rear of the crane.

Turning now to Figures 4-8, the internal construction of the upper works is illustrated. In particular, Figure 4 illustrates the machinery housed within the upper works whereas Figure 5 provides details of the frame and other support structure forming part of the upper works.

As seen best in Figure 4, the upper works mounts two hoisting drums 40, 42 onto which hoist cabling 25 (see Figure 1) is wound and unwound. As is known, for some applications only one load hoisting drum is required. Typically the crane would require an additional hoisting drum (not shown) which is used to lower or raise the boom 22 via cable 23.

In the illustrated embodiment, the hoisting drums are driven by hydraulic motors 44, 46. A ratchet 48 forms part of each hoisting drum and provides a mechanical stop to lock the drums against rotation in the unwinding direction. The hoisting drums would also include conventional friction brakes. A pulley assembly 50 controls movement and maintains alignment of the various cables that control movement in the boom 22 and the load hoist 24.

Referring also to Figure 5, the upper works includes a machinery deck indicated generally by the reference character 60 to which components are mounted as well as a pair of frame members 62, 64 to which the hoist
machinery 40, 42 and boom 22 are mounted. The frame members 62, 64 are substantially similar and may be identified. The deck and/or frame members mount a conventional diesel engine 70 which is operatively connected to a hydraulic pump (not shown) that provides the necessary pressurized fluid for the hydraulic motors 44, 46 and other hydraulic components and drive motors not shown. A radiator 76 provides cooling for the engine 70. A hydraulic system cooler or radiator 72 is also provided to cool the hydraulic fluid.

According to a feature of the invention, the machinery deck includes integral drip pans 80, 82 mounted below components that are likely to emit or leak fluids. As seen best in Figure 4, the drip pan 80 is mounted below the diesel engine 70 and hydraulic pump and contains anything that drips or leaks from these components. Drains 80a, 82a are opened periodically in order to drain collected fluids into a suitable container. With the disclosed drip pan construction, uncontrolled release of fluids onto a job site is inhibited. The drip pan 82 catches and contains any fluid leak by the hydraulic motors 44, 46.

According another feature of the invention, the primary load supporting structure comprises the spaced-apart, box-like frame members 62, 64 which are interconnected by stand-offs 92. In accordance with the preferred construction, each frame member 62, 64 comprises a pair of side plates 86, 88 welded to upper and lower cross pieces 90 (only the upper cross piece is shown). As seen best in Figure 5, the side plates 86, 88 define upwardly extending, parallel, integral flanges to which the hoist and other machinery is mounted. With the disclosed construction, assembly of the machinery to the machinery deck is greatly facilitated and moreover, service and replacement of the components are easily effected rendering a very serviceable crane.

Referring also to Figure 7, the forward hoist assembly 42 is secured to flange sections 110, 112 formed on the side plates 86, 88 of both frame members 62, 64. The flange sections 110, 112 define bores 110a, 112a (shown best in Figure 5 which serve as mounting points for hoist assembly stanchion 42a (shown best in Figure 7). To further facilitate installation or removal, pin connections may be provided for securing the hoist drum stanchions to the flange sections 110, 112. The stanchion 40a of the rear hoist drum assembly 40
are secured to flange sections 114, 112 and, in particular, via mounting holes 114a, 112b. Similarly, stanchion 50a that support the hoist pulley assembly 50 are mounted to flange section 116 which includes mounting holes 116a.

At the forward end of each beam 62, 64, the side plates 86, 88 define boom mounting flanges 120, including mounting holes 120a, 120b for receiving pins that interconnect the boom 22 to the frame members 62, 64. A pair of mounting plates 122 (only one is shown in Figure 5) are provided on the machinery deck and serve as an anchoring point for a floating mast 124 (shown in Figure 1).

According to another feature of this construction, the frame members 62, 64 also form support housings for extendable beams 34 that are used to extend and retract the counterweight 32 with respect to the rear of the crane. Referring also to Figures 6, 7 and 9, the counterweight extension beams 34 are formed by box channels which are sized to fit within the frame members. A hydraulic actuator 126 (shown best in Figure 9) in each frame member 62, 64 includes a rod end pinned to the extension beam 34. The cylinder end of each actuator 126 is fixed to the machinery deck by a pin/plate arrangement 125. Extension of the actuators 126 extends the beams 34 and vice versa.

The counterweight extension beams 34 are slidably supported within the main frame members. As seen best in Figure 9, an anti-friction pad 127 is fixed to the rear end of each frame member and slidably supports the underside of the associated extension beam 34. A corresponding anti-friction pad 129 is fixed to the forward end of each extension beam 34 and slides along the underside of the cross piece 90 forming part of each frame member.

Additional lubrication for the anti-friction pads 127, 129 may also be provided.

Hydraulic pressure under the control of an operator control 130 is applied to the cylinder end 126a of each actuator in order to effect concurrent extension of the counterweight support beams whereas pressure supplied to the rod end 126b of each cylinder effects retraction of the beams 34 and hence, movement of the counterweight 32 towards the rear of the crane. Returning now to Figures 1-3, features regarding the counterweight assembly 32 are illustrated. As indicated above, the counterweight 32 is removable to facilitate
transportation of the crane to a job site. As seen in Figure 1, the counterweight 32 to be installed is positioned adjacent the rear of the crane. It should be noted that the crane itself can be used to initially position the counterweight and to unload it off the transportation vehicle. Once in position, hydraulic and electrical connections indicated generally by the reference character 140 are made to the counterweight 32. As seen in Figures 2 and 3, the counterweight includes a pair of hydraulic actuators 142. The connections made between the crane and the counterweight 32 provide the necessary pressurized fluid for the actuators 142 whereas an electrical connection provides the power for controlling the application of pressurized fluid to the actuators via solenoid control valves (not shown). A control box indicated generally by the reference character 144 (shown only in Figure 1) includes controls for individually activating the hydraulic cylinders 142 mounted within the counterweight 32.

As seen best in Figure 2, each actuator 142 can be pinned or locked to the upper end of the counterweight 32 or the lower end of the counterweight, or both. Referring also to Figure 1, the upper end of the cylinder 142b of the actuator 142 includes a trunion 148, including a pair of trunion plates 148a. Referring to Figure 3, when the cylinder end 142a of the actuator 142 is in a lower position, the trunion plates 148a which include aligned apertures (not shown) are also aligned with apertured locking tabs 149 forming part of the counterweight 32 and located in a recess near the top of the counterweight. A pin 160 is installed through the aligned apertures in order to lock the upper end 142b of the actuator 142 to the top of the counterweight 32. When locked in the position shown in Figure 3, the application of fluid pressure to the actuator 142 does not produce upward movement in the actuator.

To install the counterweight, the pins 160 are removed and the actuators 142 are extended upwardly (as seen in Figure 1). In the illustrated arrangement, the actuators are oriented with the rod ends down. To raise the actuators the top ends or cylinder ends of the actuators 142 are pressurized. The top end of the actuators are coupled to the respective counterweight support arms 30 using suitable pins or alternately bolts. Referring to Figure 2,
the actuators 142 are then retracted (by pressurizing the rod ends of the actuators), which, in effect, causes the counterweight 32 to be pulled upwardly towards the counterweight support arms 30. Upon reaching a predetermined height, the counterweight extension beams 34 are extended rearwardly to the position shown in Figure 2. In this position each beam 34 enters a recess 32a formed within the counterweight 32 and is aligned with a mounting lug 150. Each extension beam 34 includes an aperture 152 for receiving the associated mounting lug 150. After the counterweight 32 and extensions beams 34 are properly aligned, the actuators 142 are extended to lower the counterweight 32 so that the mounting lug 150 enters the lug opening 152 defined in each extension beam 34. Engagement of the mounting lug 150 with the lug aperture 152 is shown in Figure 3. The counterweight is then secured in position by a bolt 154 which extends through tabs 156 formed on the counterweight 32 and through an aperture 159 shown in Figure 1 formed in each extension beam 34.

The bolt 154 restrains the counterweight 32 from upward movement which would otherwise dislodge the connection between the lug 150 and the associated lug aperture 152 formed in each extension beam 34.

According to the preferred construction, the actuators 142 provide a mechanism for providing a stabilization foot for the counterweight 32 to inhibit rearward tipping of the crane when the counterweight is extended and a load is released unexpectedly, such as occurs upon failure of a cable. According to this feature, the upper part of each actuator 142 is locked to the counterweight 32 by the pin arrangement 160 (described above and shown in Figure 3), indicated generally by the reference character.

A second pin arrangement 158 is also provided for releasably locking the lower ends or rods 142a of the actuators 142 to the base of the counterweight 32. In the illustrated embodiment, a pin 158a is used to releasably lock the rods 142a of the actuator 142 to the base of the counterweight 32. The rods 142a of the actuators 142 (as seen best in Figure 3) are normally locked or pinned to the counterweight 32 during the installation process and in conditions when the counterweight is not to be extended by the beams 34. When the counterweight 32 is to be extended, the
rods 142a of the actuators 142 are released, allowing them to extend downwardly when pressurized fluid is communicated to the cylinder ends of the actuators 142.

In the preferred embodiment, a support foot 162 is mounted to the end of the actuators 142. Energization of the actuators 142 causes the foot 162 to move towards ground level (provided that the pins 158c are removed). In the preferred operational method, the foot 162 is extended to a predetermined distance above ground level, and as indicated above, acts as an abutment or stop to restrain the crane from tipping excessively should an unexpected load change occur when the counterweight is extended.

The rods 142a of the actuators 142 may include a trunion similar to the trunion 148 mounted at the upper end of the actuator cylinder 142b to provide the pinning feature. Alternately, the foot 162 may include locking tabs (not shown) having apertures through which the pin or pins 158a extend in order to restrain the rods 142b and hence the foot 162 from moving either upwardly or downwardly. By installing the upper pins 160 and removing the pins 158a, energization of the actuators 142 moves the foot 162 downwardly towards ground level.

In the preferred embodiment, controls for extending and retracting the counterweight 32 are interconnected with a load moment indicator/monitoring system. In particular, the control system for extending the counterweight 32 is only enabled if a sufficient moment force is being exerted by the boom 22. As is known, the moment force applied by the boom 22 is determined by the load being lifted, as well as the position of the boom. The further the boom is boomed outwardly, the greater the moment force for a given load. In accordance with this feature, controls for the hoisting the load and for positioning the boom are also interconnected with the counterweight control system such that hoist operation, which would produce a moment force that is too low, is inhibited when the counterweight is extended. Under these conditions, operation of the hoist or boom position control equipment is inhibited until the counterweight 32 is retracted.
Figure 9 illustrates, schematically, a control system for extending and retracting the counterweight 32 with respect to the rear of the crane. In the preferred embodiment, control of the actuators 126 is effected by the operator using a control valve 130 and based on information displayed on a panel in the operator's cab. Figure 10A illustrates a display panel 180 which is at least partly controlled by a load moment indicator 182 (shown in Figure 9). The panel 180 includes an illuminated display 184 which displays the current crane configuration. Immediately below, the configuration display 184 is a load indicator panel 188 which displays the percent of rated load that is currently being experienced by the crane. This indicator 188 is automatically changed by the load moment indicator control 182 system as a function of the position of the counterweight 32.

Immediately below the load indicator is a panel 190 that displays current crane-loading conditions. For example, in the panel 190 shown in Figure 10A, the load currently being lifted by the crane is 25,700 pounds. The boom is angled at 43° and the radius of the load with respect to the center line of rotation of the crane is 43 feet. The crane is capable of lifting 35,200 pounds with the boom at 43°.

A panel 192 immediately below the load panel 190 is a conventional function control panel.

The percent of rated capacity is determined by the length of the boom and the boom angle. The load is determined by monitoring the load placed on the boom suspension. It should be apparent that the percent of rated capacity will change depending on the position of the counterweight assembly with respect to the crane. Referring to Figure 9, sensors 194, 196 sense the forward and rear positions of the counterweight. As seen in Figure 9, the sensors 194, 196 are interconnected with the load moment indicator 182 so that the display 188 will reflect the percent of rated load at a given counterweight position.

Since extension of the counterweight from the crane can produce instability in the crane if a sufficient load is not placed on the boom, the control system inhibits operation of the actuators 126 if sufficient load is not present. In the preferred embodiment, the communication of pressurized fluid
from a supply 198 to the operator control 130 is controlled by a solenoid-operated control valve 200. The electrical signal for energizing or de-energizing the valve 200 is controlled by the load moment indicator.

The load moment indicator 182 provides an electrical signal to the solenoid controlled valve 200 under predetermined operating conditions. For example, with the counterweight in a retracted position, the load moment indicator de-activates the solenoid valve until the crane reaches 60% of its capacity (as measured by the load moment indicator and associated hardware).

In the illustrated embodiment, the load indicator 188 is a color display that is divided into red, green, blue, yellow and red sections as seen in Figures 10B-10D. The extent of load is indicated by a lighted bar which moves rightwardly as viewed in Figures 10B-10D as the load increases. With the disclosed control, when the crane is at 60% capacity with the counterweight retracted, the indicator illuminates into the blue area (as seen in Figure 10B).

As this point, the load moment indicator 182 activates the solenoid valve 200 which will enable the operator to use the control 130 to extend the actuators 126. By moving the control 130 towards the left (as viewed in Figure 9), pressurized fluid is communicated from the hydraulic supply 188 to the rod end 126b of the cylinder 126 which, in turn, extends the rod, thereby moving the counterweight assembly 32 rearwardly, i.e., away from the crane. When the counterweight reaches its extended position as sensed by the rear position sensor 196, the load moment indicator 182 changes the bar display to the condition illustrated in Figure 10C where the green section of the indicator is illuminated. With the counterweight 32 extended, the capacity of the crane is enhanced and thus the percent of rated load capable of being lifted by the crane with the counterweight extended is greater. This is reflected in the bar indicator 188 by virtue of illuminating only a portion of the green section.

Once the load is at the required location, the operator may set the load in place. Because the counterweight is in the extended position, the load can only be partially set in place since totally unloading the boom would result in instability since the counterweight is in the extended position. Partially setting the load is reflected in Figure 10D where the bar indicator has moved further
towards the left red area. If the operator does not stop before reaching the red area, the load moment indicator 182 energizes the main hoist brake to prevent lowering of the load and the boom up function is rendered inoperative. In order to fully lower the load, the operator must fully retract the counterweight as sensed by the forward position sensor 194. Once the counterweight 32 is fully retracted, the main hoist brake is released and the boom up function is enabled, allowing the load to be fully released by the crane. During the retraction process, the control system automatically retracts the actuators 142 in order to move the stabilization foot 162 into the counterweight assembly, i.e., the position shown in Figure 2.

With the disclosed control arrangement, the enhanced lifting capability of the crane can be easily manipulated by the operator. Instances of unstable conditions are reduced by the load moment indicator 182 which functions to disable or inhibit operation of certain components such as the counterweight extension actuators 126 if extension of the actuators would produce instability in the crane.

Returning now to Figure 9, as described above, the counterweight assembly 32 is self installing in that it includes actuators 142 which interact with the crane in order to position and mount the counterweight onto the counterweight extension arms 34. During the counterweight installation process, the separate tethered control box 144 is used by a crane installer/operator to control the extension and retraction of the actuators 142. During actual crane operation, however, the extension and retraction of the actuators 142 in order to effect lowering of the foot 162 is controlled by a crane mounted control system. The control box 144 is disabled during normal crane operation and would typically be stowed in a compartment forming part of the counterweight of assembly 32 or alternately removed. During crane operation, when the counterweight 32 is to remain adjacent the rear of the crane, it is preferred that the control system for lowering or raising the foot 162 be disabled.

In the preferred and illustrated embodiment, the counterweight assembly 32 includes a multi-position switch which is shown schematically and
indicated by the reference character 210. As described above, prior to
installing the counterweight assembly 32, a connection 140 is made between the
counterweight 32 and the rear of the crane. The connection 140 include both
hydraulic and electrical conduits and cables. The cable 140 may be routed
through one of the counterweight support beams 34. A conventional cable
take-up mechanism or spool may be used to maintain control of the cable as
the beams 34 are extended.

The switch 210 may be either an electrical or hydraulic or combination
switch. During actual counterweight installation, the switch is moved to the
lower position 210a which activates the control box 144. In this position, the
control box 144 is used to control the application of pressurized fluid from the
cable/conduit 140 to the actuators 142. After installation, the switch is
normally moved to the center position 210b which disables the actuators 142 so
they cannot be extended or retracted either by the control box 144 or by a
control system forming part of the crane.

If the crane is to be operated with the counterweight extended, the
switch 210 is moved to the upper position 210c which then allows the actuators
142 to be operated by the crane mounted control system which, as shown in
Figure 9, may include the load moment indicator 182. In the preferred
embodiment, whenever the counterweight is extended (as permitted and
controlled by the load moment indicator 182), the actuators 142 are energized
automatically to lower the foot 162 when the beams 34 have been extended
rearwardly, a predetermined distance, i.e., only after the foot has cleared the
barbody 12. Conversely, the foot 162 is automatically retracted whenever the
counterweight is withdrawn.

Although the invention has been described with a certain degree of par-
ticularly, it should be understood that those skilled in the art can make various
changes to it without departing from the spirit or scope of the invention as
hereinafter claimed.
CLAIMS

1. A frame structure for a load-lifting crane, comprising:
   a) a pair of spaced apart, longitudinal frame members;
   b) each of said frame members including at least one substantially vertical side plate defining an upwardly extending flange section; and
   c) said flange sections of associated frame members defining spaced apart mounting locations for crane hoist machinery, said crane hoist machinery spanning a region between said frame members.

2. The apparatus of Claim 1 wherein said mounting locations are defined by apertures formed in said flange sections which are adapted to receive pin members for interconnecting said hoist machinery with said apertures.

3. The apparatus of Claim 1 wherein each frame member includes a pair of spaced apart, substantially vertical side plates, each of said side plates defining upwardly extending flange sections, said flange sections of each frame member adapted to mount and support one side of said hoist machinery.

4. The apparatus of Claim 3 wherein said frame members are substantially rectangular in cross section and include a pair of spaced apart lateral cross pieces extending between said side plates.

5. The apparatus of Claim 1 including drip pans extending laterally from said frame members and positioned below drive machinery for said crane, said drip pans configured to contain fluids discharged by crane machinery.

6. The apparatus of Claim 5 further including drain members for draining fluids collected by said drip pans.
7. The apparatus of Claim 1 further comprising:
   a) extendable beams slidably supported within said frame members;
   b) actuating means for extending and retracting said beams with respect to said frame members; and
   c) a counterweight assembly attached to ends of said beam such that extension of said beams moves said counterweight away from a rear section of said crane.

8. The apparatus of Claim 7 including fluid pressure-operated counterweight actuators forming part of said counterweight assembly and operative to engage a rear portion of said crane and further operative to raise said counterweight assembly to an operative level with respect to said rear section of said crane during an installation process.

9. The apparatus of Claim 8 further comprising stabilization means, including a fluid pressure-operated stabilization foot extendable downwardly with respect to said counterweight assembly when said counterweight assembly is moved to an extended position with respect to said rear section of said crane.

10. The apparatus of Claim 1 further including additional flange structure on said side plates for pivotally mounting a boom.

11. A self-installing counterweight system for enhancing the lift capability of a lifting crane having a pivotally mounted boom, comprising:
    a) a counterweight assembly, including a counterweight;
    b) at least one fluid pressure-operated actuator forming part of said counterweight assembly;
    c) means for communicating pressurized fluid to extend and retract said actuator forming part of said counterweight assembly;
d) means for releasably coupling said actuator to a portion of said crane;

e) means for energizing said actuator to raise said counterweight assembly to a position at least partially aligned with a counterweight support forming part of an upper body of said lifting crane; and

f) at least one securement member for securing said counterweight assembly to said counterweight support in order to maintain the position of said counterweight assembly after said actuator is decoupled from said crane.

12. The apparatus of Claim 11 wherein said counterweight assembly includes a pair of fluid pressure operated actuators.

13. The apparatus of Claim 12 further including a first removable locking means for locking a lower end of said actuators to said counterweight assembly whereby said actuators extend above said counterweight assembly upon energization.

14. The apparatus of Claim 12 further including a second removable locking means for locking an upper end of said actuators to said counterweight assembly to enable said actuators to distend below said actuators upon energization after said first locking means is removed.

15. The apparatus of Claim 12 further including actuator control means forming part of said counterweight assembly by which said actuators are extended and retracted during an installation process.

16. The apparatus of Claim 12 wherein said means for communicating pressurized fluid to said actuators comprises fluid conduits extending from a source of pressurized fluid carried by said lift crane to said counterweight assembly, said conduits operative to communicate pressurized fluid from a crane-mounted fluid pressure system to said actuators.
17. The apparatus of Claim 12 further comprising a stabilization foot attached to a lower end of said actuators which is lowered by energizing said actuators under predetermined operating conditions.

18. The apparatus of Claim 12 wherein said counterweight support comprises a pair of extendable beams slidably mounted by said crane.

19. The apparatus of Claim 18 further comprising beam actuation means for extending said beams in order to move said counterweight assembly towards an extended position spaced from a rear portion of said crane.

20. The apparatus of Claim 19 further comprising sensors for sensing extended and retracted positions of said counterweight assembly.

21. The apparatus of Claim 20 further comprising control means including a load moment indicator and a display means for displaying a load condition experienced by said crane as a function of the position of said counterweight assembly.

22. The apparatus of Claim 21 wherein said display means includes a load indicator that displays information relating to a safe working load that is a function of the position of said counterweight assembly.

23. The apparatus of Claim 22 wherein said control system includes a valve for controlling the communication of pressurized fluid to said counterweight position actuator that is enabled only under certain predetermined operating conditions.

24. The apparatus of Claim 23 wherein said predetermined operating conditions are determined at least in part by the position of the counterweight assembly with respect to a rear section of said crane.
25. A method for installing a counterweight onto a lift crane, comprising the steps of:
   a) providing at least one fluid pressure operated actuator orientated vertically within said counterweight assembly;
   b) positioning said counterweight assembly adjacent a rear section of said crane;
   c) coupling a source of pressurized fluid to said counterweight assembly;
   d) pressurizing said actuator in order to extend said actuator upwardly towards a crane mounted counterweight support arm;
   e) coupling said actuator to said arm;
   f) retracting said actuator whereby said counterweight is moved upwardly toward said arm;
   g) securing said counterweight assembly to a counterweight support forming part of said crane.

26. The method claim 25, wherein said step of securing said counterweight to said support comprises the steps of:
   a) retracting said actuator until said counterweight assembly is at a level above a normal operating position with respect to said crane;
   b) extending said crane mounted support towards said counterweight until securing structure formed on said support is in alignment with companion securing structure forming part of said counterweight assembly;
   c) lowering said counterweight by extending said actuator until said crane mounted and counterweight assembly mounted securing structure engage.

27. The method of claim 26, further comprising the step of securing said counterweight to said crane support using removable fasteners.
28. The method of claim 27, further comprising the step of providing said counterweight assembly with a first locking means for releasably locking a top of said actuator to a top of said counterweight and a second locking means for releasably locking a lower end of said actuator with a lower end of said counterweight assembly.

29. The method of claim 28, further comprising the step of removing said second locking means in order to allow said actuator to extend downwardly towards ground level under predetermined operating conditions, whereby a stabilization foot is provided.

30. The method of claim 29, further comprising the steps of:
   a) providing means for slidably mounting said counterweight support; and,
   b) providing extension actuator means for extending and retracting said support whereby said counterweight assembly is moved towards and away from a rear section of said crane.

31. The method of claim 30, further comprising the step of activating said counterweight mounted actuator to extend downwardly when said counterweight assembly is moved rearwardly a predetermined distance by said counterweight extension actuator means.
### A. CLASSIFICATION OF SUBJECT MATTER

<table>
<thead>
<tr>
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<td>B66C 23/72; B66C 13/18; B60P 1/04</td>
<td>414/786,467,719; 212/156, 178.270</td>
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### B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

- U.S. : Please See Extra Sheet.

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic database consulted during the international search (name of database and, where practicable, search terms used)

### C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category*</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>X</td>
<td>US,A, 1,718,434 (Ronk) 25 June 1929 Figs. 4-5</td>
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<td>X</td>
<td>US,A, 3,779,330 (Longpre) 18 December 1973 Members 15-19</td>
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<td>US,A, 4,953,722 (Becker) 04 September 1990 Figs. 2-4, 12-13, 9-10</td>
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<td>Y</td>
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**X** Further documents are listed in the continuation of Box C.  
**□** See patent family annex.

* * Special categories of cited documents:
  - **A** document defining the general state of the art which is not considered to be of particular relevance
  - **E** earlier document published on or after the international filing date
  - **L** document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
  - **O** document referring to an oral disclosure, use, exhibition or other means
  - **P** document published prior to the international filing date but later than the priority date claimed
  - **T** later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
  - **X** document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
  - **Y** document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
  - **&** document member of the same patent family

Date of the actual completion of the international search: 22 JUNE 1994

Date of mailing of the international search report: **JUN 23 1994**

Name and mailing address of the ISA/US  
Commissioner of Patents and Trademarks  
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Form PCT/ISA/210 (second sheet) (July 1992)*
### INTERNATIONAL SEARCH REPORT

**C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT**

<table>
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<td>Y</td>
<td>US, A, 4,363,412 (Patel) 14 December 1982 Figs. 1-2, 8-10</td>
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<tr>
<td>Y</td>
<td>US, A, 3,726,416 (Pottorff) 10 April 1973 Fig. 11 (29,31,45,54), Figs. 8-10</td>
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<td>US, A, 3,924,753 (Lamer) 09 December 1975 (24,30,30,52)</td>
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<td>US, A, 2,368,268 (Spiegel) 30 January 1945 Figs. 2-5</td>
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<td>Y</td>
<td>US, A, 4,557,390 (Mick) 10 December 1985 Figs. 3-5, column 3-5</td>
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<td>US, A, 4,516,116 (White) 07 May 1985 Figs. 1a-2</td>
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<td>US, A, 3,866,939 (Fanslow) 18 February 1975 Figs. 1,2</td>
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<td>US, A, 4,494,906 (Brocklebank) 22 January 1985 Figs. 1,2</td>
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<td>US, A, 4,518,305 (Stuhrmann) 21 May 1985 Figs. 1-5</td>
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Form PCT/ISA/210 (continuation of second sheet)(July 1992)*
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<th>Relevant to claim No.</th>
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<tr>
<td>Y</td>
<td>GB 964,154 (Veb SS. Mokirow) 28 May 1962 members 5, 12, 13, 16</td>
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<td>GB 2,159,122 (Veb. S. Takraf) 27 November 1985 Figs. 1, 4, 6</td>
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<tr>
<td>A</td>
<td>JP 26494 (-- ) 18 February 1984 Figs. 2-4</td>
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**INTERNATIONAL SEARCH REPORT**

**Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)**

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. □ Claims Nos.:
   - because they relate to subject matter not required to be searched by this Authority, namely:

2. □ Claims Nos.:
   - because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. □ Claims Nos.:
   - because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. □ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. X As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. □ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. □ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

□ The additional search fees were accompanied by the applicant's protest.

□ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet(1))(July 1992)
B. FIELDS SEARCHED
Minimum documentation searched
Classification System: U.S.

414/467,475,477,478,486,566,543,602,673,698,699,719,786; 212/156,178,174,191,195-198,270; 188/69.1;
280/107,790,797,800; 364/463,464;
340/438,389,440,525,706,685,686,984

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

I Claims 1-10 (apparatus)
II Claims 11-31 (Apparatus and method)

In making the above restriction requirement the Examiner is fully cognizant that the instant application was filed under 35 USC 371. However, in the instant application it is noted that:

a). The process/method of independent claim 25 is not specifically adapted or capable of being performed by the apparatus of independent claim 1 or claims dependent therefrom, e.g. Claims 2-8 and 10. There is no claimed technical relationship between the claimed apparatus (claim 1) and process (claim 25). The contribution of the apparatus (claim 1) does not correspond to the contribution offered by the method/process relative to the prior art.