CRANE AND THE LIKE LOAD LIFTING APPARATUS

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This invention relates to cranes and the like load lifting apparatuses. More particularly, the invention pertains to an automatic safety counterbalancing mechanism for preventing toppling of such apparatuses.

The prime object of my invention is to provide a mechanism of the character described which is efficient and fool-proof in use, and can be depended upon to remove the overturning hazards heretofore present in the operation of such apparatuses.

A secondary, but important, object of the invention is to provide a practical mechanism of the character described which, by automatically removing the overturning hazards, greatly increases the capacity of such an apparatus.

Another object of the invention is to provide a mechanism of the character described which will act faster than the load can be changed on the apparatus with which it is used, whereby toppling is prevented upon occurrences of sudden changes in load.

A further object of the invention is to provide a mechanism of the character described which will lend itself readily to incorporation in existing crane and the like designs and which can be added as an improvement to such apparatuses in the field.

An additional object of the invention is to provide a mechanism of the character described which will freeze all apparatus controls having to do with movement of a load when a predetermined danger point leading to the toppling of the apparatus is reached, but which permits manual nullification of frozen controls for raising or lowering the load in order to stabilize the apparatus.

Still another object of my invention is to provide a mechanism of the character described which comprises relatively few and simple parts, which is economical to manufacture and install, and which is simple in operation and highly efficient in use.

Other objects of this invention will in part be obvious and in part hereinafter pointed out.

The invention accordingly consists in the features of construction, combinations of elements, and arrangement of parts which will be exemplified in the construction hereinafter described, and of which the scope of application will be indicated in the claims.

In the accompanying drawings, in which is shown one of the various possible embodiments of this invention.

Fig. 1 is a side elevational view of a crane having my invention incorporated therein;

Fig. 2 is an enlarged sectional view taken substantially along the line 2—2 of Fig. 1;

Figs. 3 and 4 are highly enlarged sectional views taken substantially along the lines 3—3 and 4—4, respectively, of Fig. 2; and

Fig. 5 is a partially schematic diagram of the control and actuating circuits employed in my invention.

Referring to the drawings, I have there shown a gantry crane 10 of conventional design, comprising a trestle section 12 having a plurality of wheels 14 at its base. Certain of the wheels, as is well known, are power-operated for traction. These wheels may ride on steel rails 16, securely mounted upon a permanent foundation. A cab 18, supported by the trestle section 12, is arranged to rotate relative thereto by means of a conventional turntable 20. A suitable driving mechanism, such as a gear and pinion, may be provided to turn the cab. A boom 22 is pivotally mounted upon the bed of the cab and carries at its free end a plurality of sheaves 24, 26 adapted to support various lifting mechanisms such as a multiple sheave 28 or a weighted lifting hook 30. Winches 32, 34 may be provided to actuate the cables controlling the lifting mechanisms 28, 30 and to lift the boom.

The crane, as thus far described, is wholly conventional, and it will be apparent as the description proceeds that cranes and mechanisms of similar types are as well adapted to be used in conjunction with my invention. It will, therefore, be understood that the foregoing description is in no sense limiting and that the invention can be employed, without departing from the spirit of my invention, in all types of cranes as for example, crawler cranes, locomotive cranes, automotive cranes, boat cranes, derrieks, stationary cranes, and, generally, in devices having a boom which rotates about a horizontal axis and which is adapted to lift or release a load. The problem common to all of these devices is that because of the aforesaid angular movement of the boom, loads of the same weight may be disposed at different distances from the pivot point of the boom and therefore will apply different overturning torques or moments. As is well known, the load and its horizontal distance from the pivot point determine the value of this torque and since the two often vary rapidly and without close control of an operator, it is difficult for an operator to prevent the torque from rising to an
overturning value. In practice therefore, cranes have often overturned.

In accordance with the present invention, I provide a counterbalance and an automatic mechanism for varying the position thereof relative to the cab, such that very small angular deviations of the crane from its normal or horizontal position will cause the counterbalance to move and increase the stability of the crane by reducing such deviation. Such mechanism is particularly useful in connection with the present invention, I...
"retracting" solenoid. Said means also includes a second solenoid 84 whose actuation will cause the weight 36 to be moved away from the cab 18 and which will hereinafter be referred to as the "thrusting" solenoid. The movable armatures of these two solenoids are connected to each other by a shaft 66. Said shaft carries a pin 68 which rides in a slot 80 in the valve handle 86. The handle is normally maintained in a neutral position intermediate the two extremes of the actuating positions of the valve by means of a centering device, comprising a bifurcated yoke 82 which is pivoted at 84 and straddles the pin 68 on opposite sides of the connecting shaft 66. A short spring 88, connected at one end to a stationary post and at the other end to the yoke 92, biases said yoke to a normally vertical position and therefore normally maintains the connecting shaft 88 centralised between the thrusting and retracting solenoids with the valve handle 86 in neutral position. Power for the two solenoids 82, 84 is derived from electric supply lines 98, 100. The solenoid 82 is connected to said lines by wires 102, 104, and 106 through the fixed contact 108 and normally open armature 110 of relay 112. The solenoid 84 is connected to said lines by wires 114, 116, and 118 through the fixed contact 120 and normally open armature 122 of relay 124.

The electric actuating means for the brake 60 comprises a pair of brake solenoids 126, 128, whose armatures are harnessed together so that either solenoid upon actuation will pull the brake lever 78 against the spring 80 to release the brake 68. These solenoids also derive their power from the lines 98, 100. The solenoid 126 is connected thereto through wires 130, 132 and 106 as well as through the armature of the relay 112. The solenoid 128 is connected to said lines through wires 134, 136, and 118 as well as through the armature of the relay 124.

The electric control means for governing the operation of the foregoing electric actuating means is responsive to angular deviation of the cab 18 or trestle 12, or both, depending upon where it is desired to control such deviation from normal or horizontal position, that is, the control means will, when the crane structure supports it in a predetermined angular deviation, become operable, and will become inoperative when said crane structure returns to a smaller angle, as for example back to normal or horizontal position. Said means, furthermore, is preferably responsive to tilting in the plane including the boom 22 and counterweight 36. Accordingly, the control means is usually mounted upon the structural element, as for example the cab 18, which revolves with or supports the boom 22 during turning thereof about a vertical axis and is so oriented as to be responsive to tilting in said plane. Further, said means must be selectively sensitive to tipping of the said supporting structure in either a clockwise or counter-clockwise direction. In other words, it must so control the operation of the means for moving the counterweight 36 towards or away from the cab that said counterweight will move toward the cab when its extended position tends to topple the crane, or away from the cab when the moment of the load carried by the boom tends to topple the crane.

The electric control means for the retracting solenoid 82 comprises a mercury tilt switch 138, including a glass envelope 140 having a pool of mercury 142 contained therein. One end of said envelope supports a pair of spaced contacts 144 which are adapted to close the energizing circuit for the solenoid 146 of the relay 112 from the supply lines 98, 100 through wires 148, 150, and 152. The envelope 140 is supported in a pivot clamp 154 at one end and caugnt at the other end between the tips of screws 156. These screws are so adjusted that when the cab 18 is in a horizontal position the envelope is inclined to the horizontal at a predetermined angle which it is desired not to have the crane exceed when releasing a load. In a gantry crane, as illustrated, the angle of permissible tippling should be kept very small, as for example about three degrees. The mercury tilt switch 142 is so arranged that when this angle is reached or very slightly exceeded, the pool 140 will submerge the contacts 144 wherein to complete the control circuit for the relay 112. The mercury tends to adhere to said contacts 144 and will not leave the same until movement of the counterbalance causes the crane to assume a lesser angle, as for example to become restored to substantially normal or horizontal position. The tendency of the pool of mercury to adhere to the contacts 144 may be increased or decreased by varying the space between said contacts, so that where substantially different degrees of angular inclination are to be permitted prior to actuation of the counterweight 36 or where it is desired to vary the angular inclination at which the control means is rendered inoperable, mercury relays 138 having different spacings between the contacts 144 may be employed.

The thrusting solenoid is controlled by another mercury tilting relay 154 which is connected to the supply lines by wires 156, 158, and 106. Said relay is in all respects similar in its construction and mounting to the relay 138, but is inclined at an opposite angle to the horizontal so as to energize the thrusting solenoid 154 when the boom is subjected to too great a moment. Obviously the angles of the two relays 138, 154, although opposite, need not be of identical absolute values. It will be seen that when either of the mercury tilting switches 138, 154 is closed the solenoid of its associated relay 112, 124 is energized to close the corresponding contact 108, 120 against the fixed contact 110, 122; this action, in addition to energizing the proper solenoid 82, 84, will also energize one of the brake solenoids 126, 128 to release the brake 98 when the valve handle 68 is turned. Normally the brake, because of its lighter mass, will respond more quickly to actuation than the counterweight 36. If, however, the counterweight tends to move before the brake is released, any standard type of electric or mechanical delay may be interposed in the mechanism for controlling or actuating movement of the counterweight 36. Such mechanisms may include dash-pot relays, thermal-delay relays, chokes, or the like.

Since a crane or similar load lifting apparatus equipped with my automatically operating counterweight 36 would be handled with less caution by a crane control man than is now exercised, and since it is possible for a mechanical or electrical defect to appear in either the control or actuating mechanisms, it is important that in connection with the various means for automatically controlling the operating said counterweight there also be provided safety means for stopping all normal crane manually controlled operations if the deviation of the crane from the horizontal substantially
exceeds the deviation at which the mercury tilt switches 138, 154 are supposed to initiate operation of the counterweight 36. This necessity for this safety means may be due either to defective control mechanism or to the fact that the crane has picked up too heavy a load, for which even the counterweight 36 cannot compensate. Such safety means comprises a mercury tilt control switch 162 which includes a glass envelope 184 whose two ends are oppositely inclined. The relative angular relationship between these two ends of envelope 184 is equal to twice the permissible safe angular deviation of the crane from the horizontal. Said envelope is mounted in the cab with the two ends thereof in the plane of the boom 122 and counterweight 36 and, when the cab is in normal or horizontal position, inclined at equal angles to the horizontal. The envelope contains a pool of mercury and the two ends have pairs of contacts 168 connected therein and extending into the envelope 184. It will thus be apparent that, when the crane tips in either direction beyond a predetermined safe deviation from the horizontal, the mercury pool 166 will close the space between one of the pairs of contacts 168.

The control circuit governed by said switch 162 includes a relay 170 whose solenoid 171 is connected to the supply line 100 by wire 172. The other end of the solenoid 171 is connected by wires 174, 176 to one contact of each pair of contacts 168. The other contacts of said pair of contacts 168 are connected by wires 178, 180, and 162 to the supply line 98.

The actuating circuit governed by the aforesaid safety control comprises a turntable control 184, a traction control 186 for the wheels 14, a boom control 188, that is a control for the angular position of the boom 122, and a winch control 190. The foregoing controls are connected by wires 192—212, fixed contact 214 of relay 170, and normally closed armature 216 of the power supply line 98, 100. The wires connecting the traction control and turntable control 184, 186 to the source of power include a double-pole, single-throw switch 219 which in the normal operation of the crane is closed.

It will be seen that when closing of the tilt switch 162 energizes the solenoid 171 and attracts the armature 216, the source of power is removed from the winch, boom, turntable and traction controls, thus freezing all operation of the crane which is liable to further add to the overturning moment. Of course, when these operations are frozen the crane man will recognize that danger is imminent, or if desired, a horn or some similar danger signal may be energized by movement of the armature 216.

When the armature 216 is opened, the crane operator opens the switch 216 which is designed to leave all controls open which cannot be readily manipulated to reduce overturning momentum. He then closes a switch 220 which is open during normal crane operation. Closing of this switch again supplies current to the winch and boom controls from the supply line 98, 100 through auxiliary feed wires 222, 224, and 226, so that the operator can manipulate either the winch or boom to reduce the overturning moment and restore the crane to stable equilibrium.

It may be mentioned that the foregoing winch, boom, turntable, and turntable controls may be the operating rheostats for these elements of the crane if the crane is electrically powered, and in this event, the controls represent the means for varying the speed and direction of operation of said elements. In addition controls of this type, i.e., the controls in electrically powered cranes, include brakes of conventional character which are normally held in inoperative position but which, when electric power is cut off by action of solenoid 170, become operative to prevent movement of the boom, truss, winch, turntable, etc. Thus, controls of this type, i.e., the controls in electrically powered cranes, also include a locking function. Where the crane or load-lifting apparatus is operated by other sources of power, as for example, steam, the winch, the boom, truss, and turntable controls may take other forms, as for example, of electrically controlled clutches and latches, or motors which, after operation of the various crane elements, under normal conditions, are held in proper position for this effect by suitable means, as for example, solenoids which are energized when the mercury tilt switch 162 is open and whose actuating members are spring pressed to stop and lock movement of the several crane operating elements when the tilt switch 162 is closed.

It will be understood, of course, that the specific crane operating elements mentioned need not be the crane elements governed by the safety means and that any crane elements whose operation might affect the turning moment should be included in the above circuit and thus rendered inoperative when the tilt switch 162 is closed.

It will thus be seen that there is provided a device which achieves the several objects of this invention and which is well adapted to meet the conditions of practical use.

As various possible embodiments might be made of the above invention and as various changes might be made in the embodiment above set forth, it is to be understood that all matter shown in the accompanying drawings is to be interpreted as illustrative and not in a limiting sense.

Having thus described my invention, I claim as new and desire to secure by Letters Patent:

1. For use with a device having a load handling boom which turns about a horizontal axis and which is supported by a structure: the combination of a counterweight supported for movement relative to said structure, means to move said counterweight towards and away from said structure, and electric control means operable in response to a predetermined deviation of said structure from normal to render said last named means effective while said structure is at least so deviated.

2. For use with a device having a load handling boom which turns about a horizontal axis and which is supported by a structure: the combination of a counterweight supported for movement relative to said structure, means to move said counterweight towards and away from said structure, and electric control means operable in response to a predetermined deviation of said structure from normal to render said last named means effective while said structure is at least so deviated.

3. For use with a device having a load handling boom which turns about a horizontal axis and which is supported by a structure: the combination of a counterweight supported for movement relative to said structure, means to move said counterweight towards and away from said structure, and electric control means operable in re-
response to a predetermined deviation of said structure from normal horizontal position to render said last named means effective, said control means being rendered inoperable, whereby said counterweight actuating means is rendered ineffective, when said structure returns substantially to normal horizontal position.

4. For use with the device having a load handling boom which turns about a horizontal axis and which is supported by a structure: the combination of a counterweight supported for movement relative to said structure, means to move said counterweight towards and away from said structure, electric control means operable in response to a predetermined deviation of said structure from normal horizontal position to render said last named means effective, said control means being rendered inoperable, whereby said counterweight actuating means is rendered ineffective, when movement of said counterweight causes said structure to assume a lesser deviation from the horizontal, and braking means to maintain said counterweight stationary when said control means is inoperable.

5. For use with a device having a load handling boom which turns about a horizontal axis and which is supported by a structure: the combination of a counterweight supported for movement relative to said structure, means to move said counterweight towards and away from said structure, electric control means operable in response to a predetermined deviation of said structure from normal horizontal position to render said last named means effective, said control means being rendered inoperable, whereby said counterweight actuating means is rendered ineffective, when movement of said counterweight causes said structure to assume a lesser deviation from the horizontal, and braking means to maintain said counterweight stationary when said control means is inoperable.

6. For use with a device having a load handling boom which turns about a horizontal axis and which is supported by a structure: the combination of a counterweight supported for movement relative to said structure, means to move said counterweight towards and away from said structure, electric control means operable in response to a predetermined deviation of said structure from normal horizontal position to render said last named means effective, said control means being rendered inoperable, whereby said counterweight actuating means is rendered ineffective, when movement of said counterweight causes said structure to assume a lesser deviation from the horizontal, and braking means to maintain said counterweight stationary when said control means is inoperable.

7. For use with a device having a load handling boom which turns about a horizontal axis and which is supported by a structure: the combination of a counterweight supported for movement relative to said structure, means to move said counterweight towards and away from said structure, electric control means operable in response to a predetermined deviation of said structure from normal horizontal position to render said last named means effective, said control means being rendered inoperable, whereby said counterweight actuating means is rendered ineffective, when movement of said counterweight causes said structure to assume a lesser deviation from the horizontal, and means to selectively vary said predetermined deviation.

8. For use with a device having a load handling boom which turns about a horizontal axis and which is supported by a structure: the combination of a counterweight supported for movement relative to said structure, means to move said counterweight towards and away from said structure, electric control means operable in response to a predetermined deviation of said structure from normal horizontal position to render said last named means effective, said control means being rendered inoperable, whereby said counterweight actuating means is rendered ineffective, when movement of said counterweight causes said structure to assume a lesser deviation from the horizontal, and braking means to maintain said counterweight stationary when said control means is inoperable.

9. For use with a device having a load handling boom which turns about a horizontal axis and which is supported by a structure: the combination of a counterweight supported for movement relative to said structure, means to move said counterweight towards and away from said structure, electric control means operable in response to a predetermined deviation of said structure from normal horizontal position to render said last named means effective, said control means being rendered inoperable, whereby said counterweight actuating means is rendered ineffective, when movement of said counterweight causes said structure to assume a lesser deviation from the horizontal, and braking means to maintain said counterweight stationary when said control means is inoperable.

10. For use with a device having a load handling boom which turns about a horizontal axis and which is supported by a structure: the combination of a counterweight supported for movement relative to said structure, means to move said counterweight towards and away from said structure, electric control means operable in response to a predetermined deviation of said structure from normal horizontal position to render said last named means effective, said control means being rendered inoperable, whereby said counterweight actuating means is rendered ineffective, when movement of said counterweight causes said structure to assume a lesser deviation from the horizontal, and means to maintain said control means operable in response to a predetermined deviation of said structure from normal horizontal position to render said last named means effective, said control means being rendered inoperable, whereby said counterweight actuating means is rendered ineffective, when movement of said counterweight causes said structure to assume a lesser deviation from the horizontal, and braking means to maintain said counterweight stationary when said control means is inoperable.

11. In combination, a load handling boom which turns about a horizontal axis and which is supported by a structure, means to turn said boom about said axis, means independent of said load means to turn said boom about a vertical axis, a counterweight supported for movement relative to said structure, means to move said counterweight towards and away from said structure, electric control means operable in response to a predetermined deviation of said structure from normal horizontal position to render said last named means effective, said control means being rendered inoperable, whereby said counterweight actuating means is rendered ineffective, when movement of said counterweight causes said structure to assume a lesser deviation from the horizontal, a plurality of separate control means for said means for turning said boom about a
vertical axis, for said means for turning said boom about a horizontal axis and for said means for independently raising a load, and electrically actuated means operable in response to a larger predetermined deviation of said structure from normal horizontal position to cause said second named control means to render the means controlled thereby inoperable.

12. In combination, a load handling boom which turns about a horizontal axis and which is supported by a structure, means to turn said boom about said axis, means independent of said last named means for raising a load, a plurality of separate control means for said means for turning said boom about a horizontal axis and for said means for independently raising a load, and means operable in response to a predetermined deviation of said structure from normal horizontal position to cause said control means to render the means controlled thereby inoperable.

13. In combination, a load handling boom which turns about a horizontal axis and which is supported by a structure, means to turn said boom about said axis, means independent of said last named means for raising a load, means to turn said boom about a vertical axis, a plurality of separate control means for said means for turning said boom about a vertical axis, for said means for turning said boom about a horizontal axis and for said means for independently raising a load, and electrically actuated means operable in response to a predetermined deviation of said structure from normal horizontal position to cause said control means to render the means controlled thereby inoperable.

14. In combination, a load handling boom which turns about a horizontal axis and which is supported by a structure, means to turn said boom about said axis, means independent of said last named means for raising a load, means to turn said boom about a vertical axis, a plurality of separate control means for said means for turning said boom about a vertical axis, for said means for turning said boom about a horizontal axis and for said means for independently raising a load, and electrically actuated means operable in response to a larger predetermined deviation of said structure from normal horizontal position to cause said control means to render the means controlled thereby inoperable.

15. In combination, a load handling boom which turns about a horizontal axis and which is supported by a structure, means to turn said boom about said axis, means independent of said last named means for raising a load, means to turn said boom about a vertical axis, a plurality of separate control means for said means for turning said boom about a vertical axis, for said means for turning said boom about a horizontal axis and for said means for independently raising a load, and means operable in response to a larger predetermined deviation of said structure from normal horizontal position to cause said control means to render the means controlled thereby inoperable.

16. In combination, a load handling boom which turns about a horizontal axis and which is supported by a structure, means to turn said boom about said axis, means independent of said last named means for raising a load, means to turn said boom about a vertical axis, a counterweight supported for movement relative to said structure, means to move said counterweight towards and away from said structure to counterbalance deviations of a predetermined degree of said structure from normal horizontal position, a plurality of separate control means for said means for turning said boom about a vertical axis, for said means for turning said boom about a horizontal axis and for said means for independently raising a load, and means operable in response to a larger predetermined deviation of such structure from normal horizontal position to cause said control means to render the means controlled thereby inoperable.

17. In combination, a load handling boom which turns about a horizontal axis and which is supported by a structure, means to turn said boom about said axis, means independent of said last named means for raising a load, means to turn said boom about a vertical axis, a counterweight supported for movement relative to said structure, means to move said counterweight towards and away from said structure to counterbalance deviations of a predetermined degree of said structure from normal horizontal position, a plurality of separate control means for said means for turning said boom about a vertical axis, for said means for turning said boom about a horizontal axis and for said means for independently raising a load, and electrically actuated means operable in response to a larger predetermined deviation of said structure from normal horizontal position to cause said control means to render the means controlled thereby inoperable, and manually manipulative means to render the means for turning said boom about a horizontal axis or the means for independently handling a load operable after they have been rendered inoperable by the control means.

18. In combination, a load handling boom which turns about a horizontal axis and which is supported by a structure, means to turn said boom about said axis, means independent of said last named means for raising a load, means to turn said boom about a vertical axis, a counterweight supported for movement relative to said structure, means to move said counterweight towards and away from said structure to counterbalance deviations of a predetermined degree of said structure from normal horizontal position, a plurality of separate control means for said means for turning said boom about a horizontal axis and for said means for independently raising a load, and electrically actuated means operable in response to a larger predetermined deviation of said structure from normal horizontal position to cause said control means to render the means controlled thereby inoperable, and manually manipulative means to render the means for turning said boom about a horizontal axis and the means for independently handling a load operable after they have been rendered inoperable by the control means.

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