United States Patent [19]

Hoge

[11] **3,848,750**

[45] **Nov. 19, 1974**

[54] **CRANE TIP ALARM**

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[52] **U.S. Cl.**..... **212/69,** 212/39 MS, 116/124 F, 340/190, 340/267 C

[51] **Int. Cl.**..... **B66c 23/84,** G08c 21/00

[58] **Field of Search**..... 212/39 MS, 69; 340/188 R, 340/188 CH, 190, 267 C; 116/124 F; 222/55

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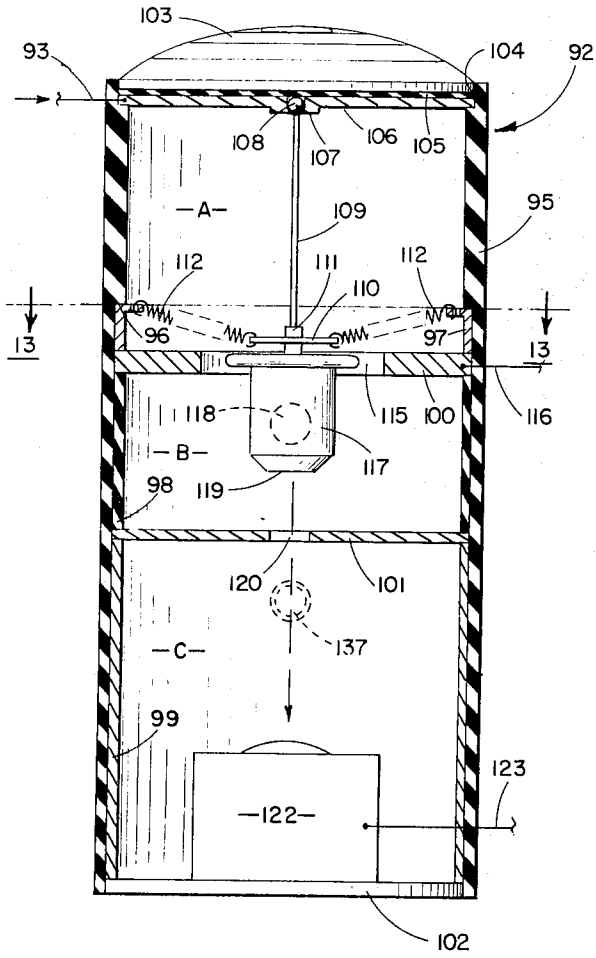
Primary Examiner—Robert B. Reeves
Assistant Examiner—H. S. Lane
Attorney, Agent, or Firm—Howard L. Johnson

[57] **ABSTRACT**

The invention provides several tilt indication/warning devices for use on equipment or vehicles having a rotating, angularly upstanding boom such as fire-fighting and rescue apparatus and particularly mobile cranes such as used to shift containerized cargo between the holds of ships and land carriers.

A prospective topple condition caused by movement of the weight carrying boom is monitored with a multi-stage warning by a gimbal-mounted light-carrying pendulum gravitationally suspendable above the chassis with its vertically descending beam displaceable over a plurality of arcuate photoelectric receivers arranged in a circle. Intermediate its length, the pendulum also carries an electric-conducting ring which on swinging contacts an electrically-conducting arcuate segment in the direction of chassis-tilt thus giving a subsequent stage alarm which may be connected to inactivate the boom-lowering mechanism as well as effecting a final audio-visual alert in the cab.

9 Claims, 21 Drawing Figures



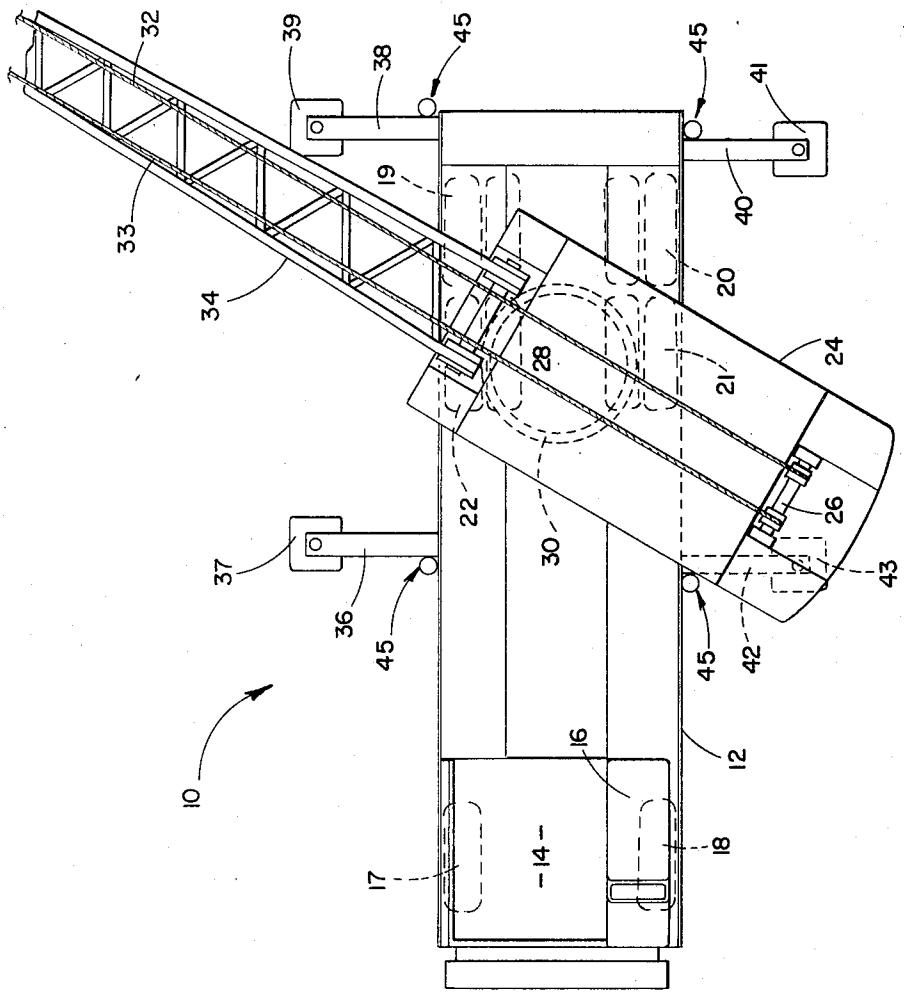

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FIG. 1

FIG. 2

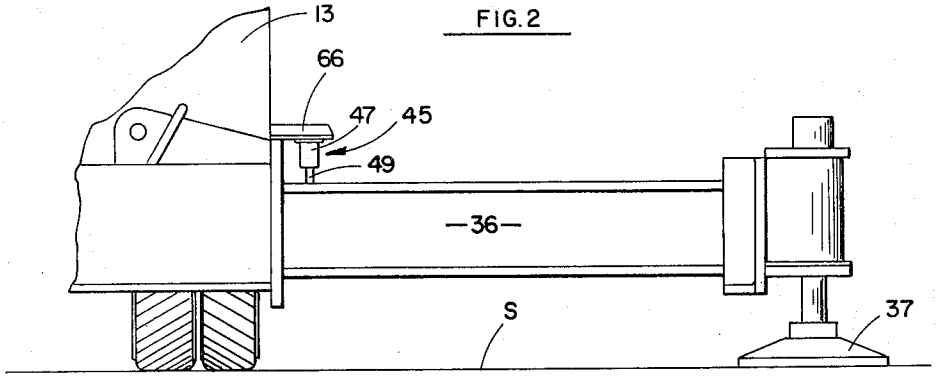


FIG. 3

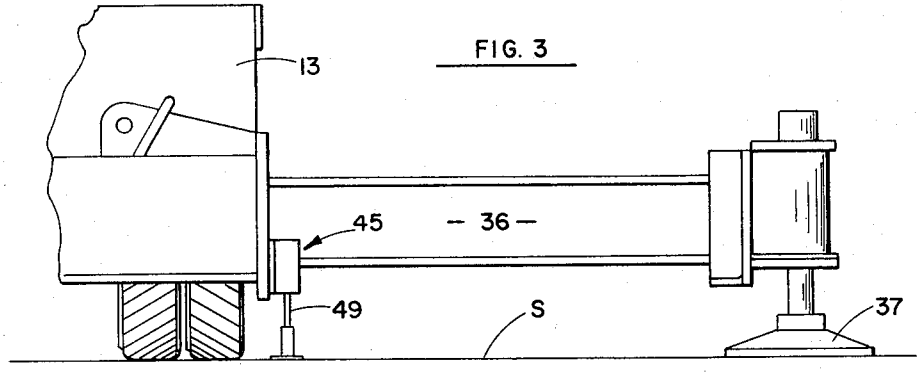
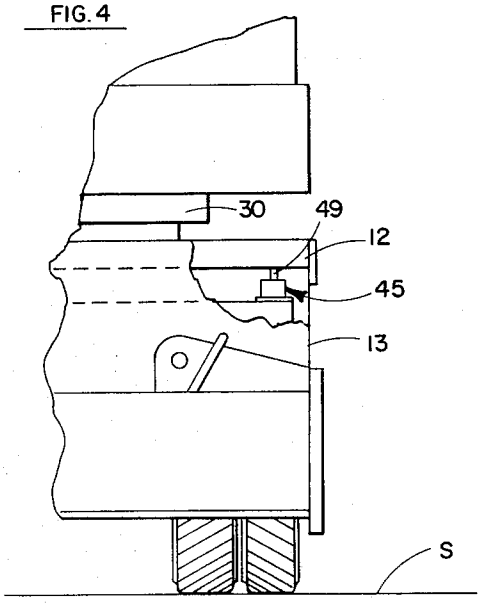


FIG. 4



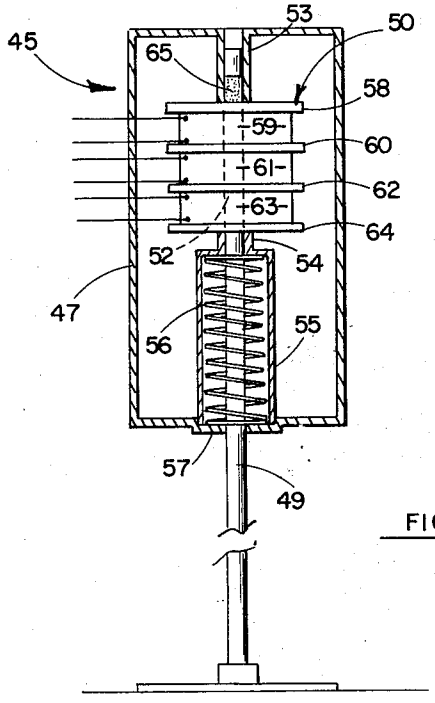


FIG. 5

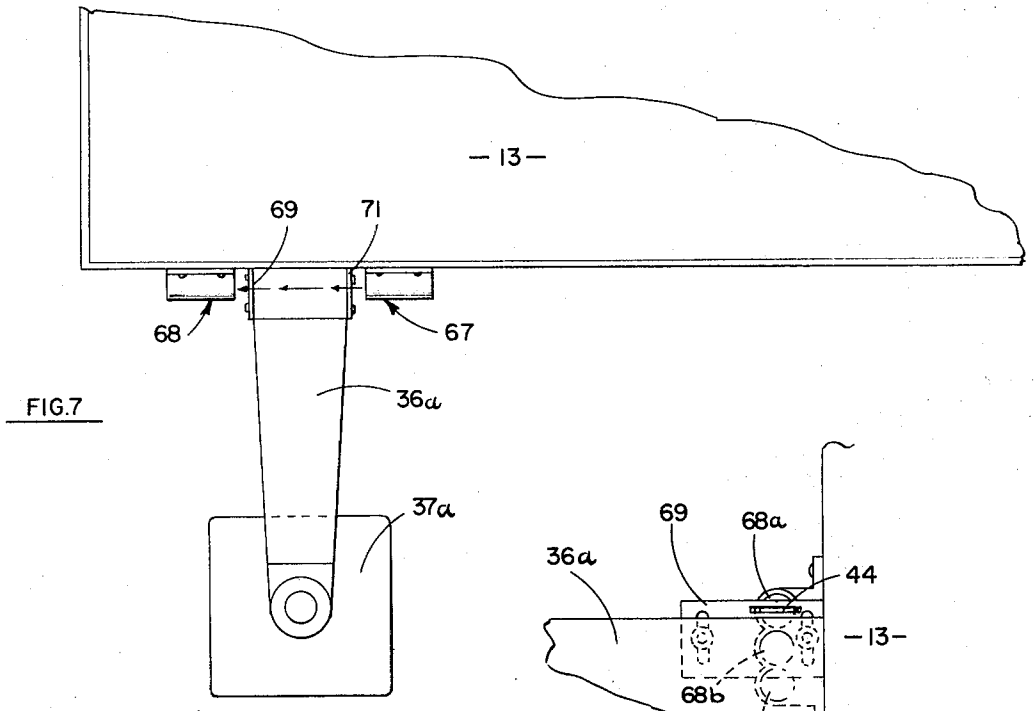


FIG.7

FIG. 8

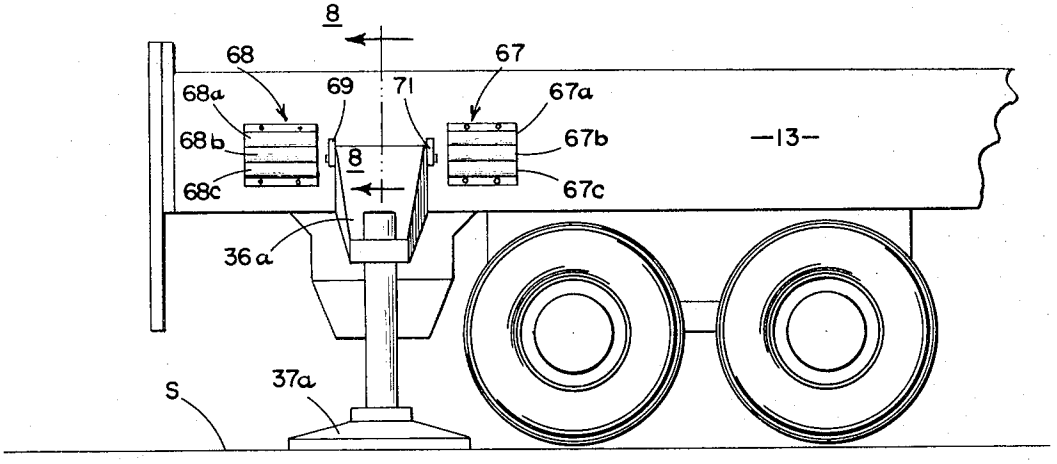


FIG. 6

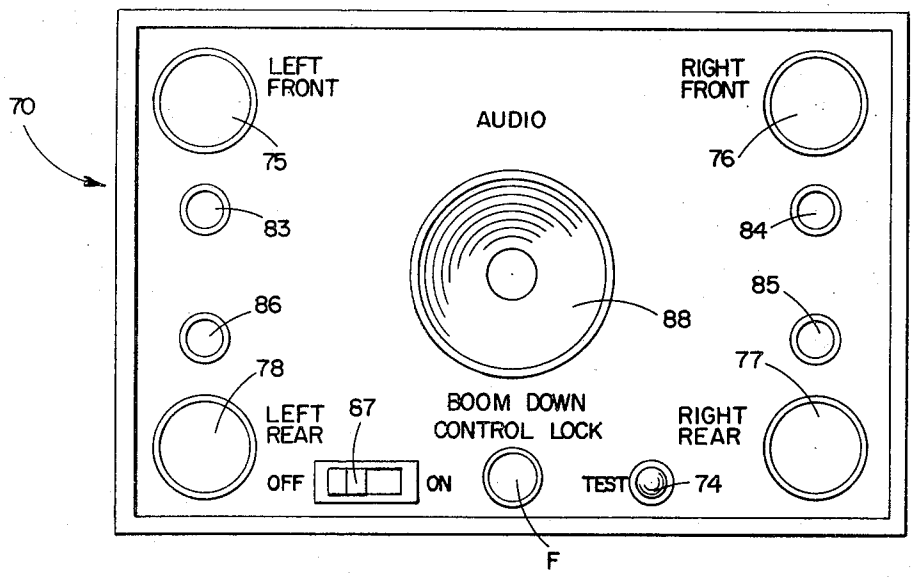

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LEFT FRONT
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AUDIO
RIGHT FRONT
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LEFT REAR
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BOOM DOWN CONTROL LOCK
RIGHT REAR
OFF
ON
TEST
74
F

FIG. 9

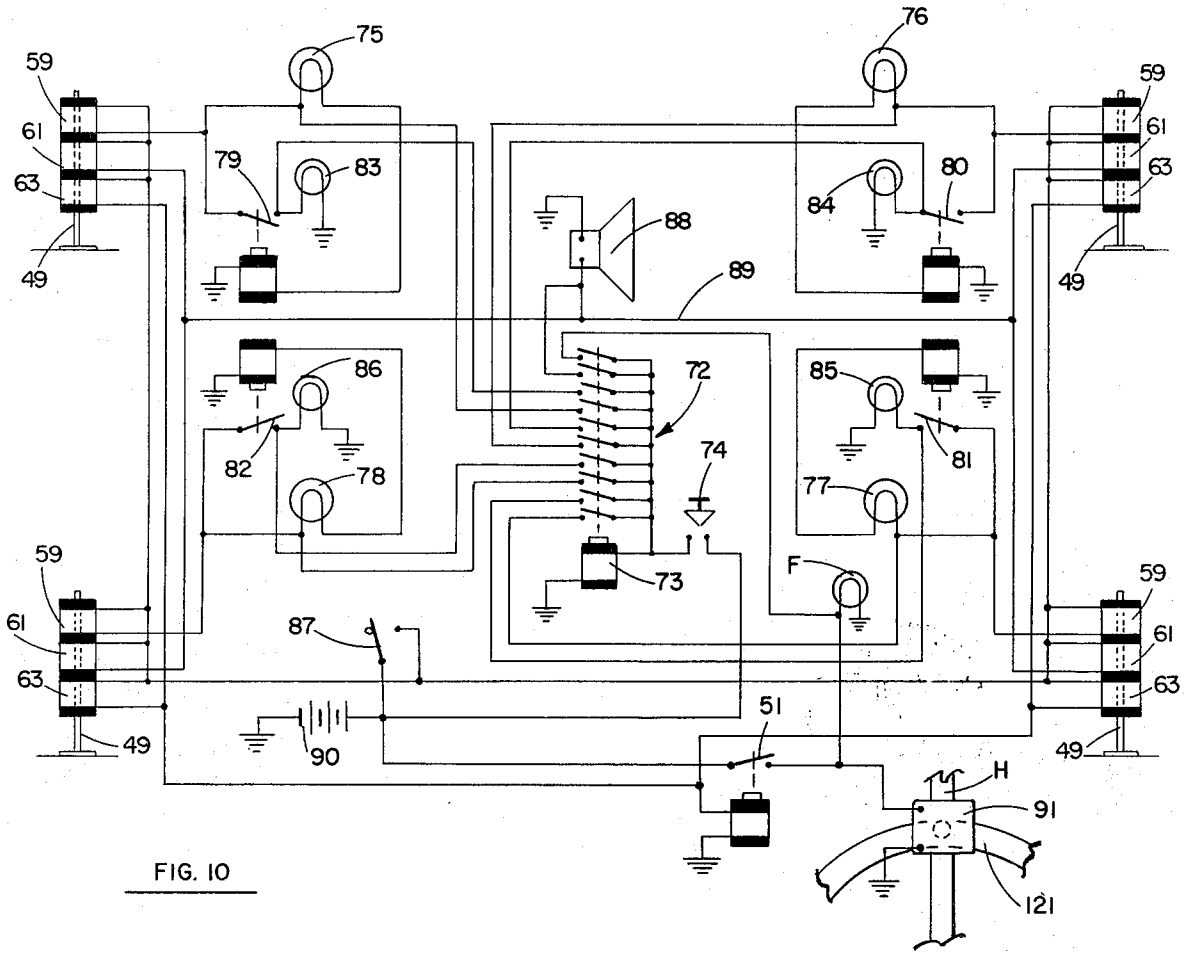

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FIG. 10

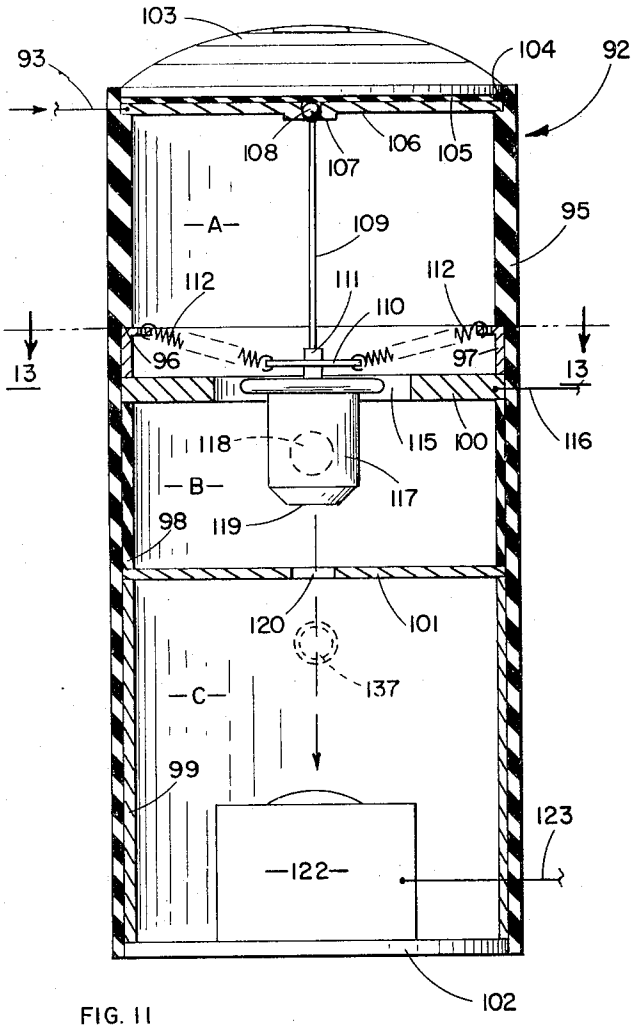


FIG. 11

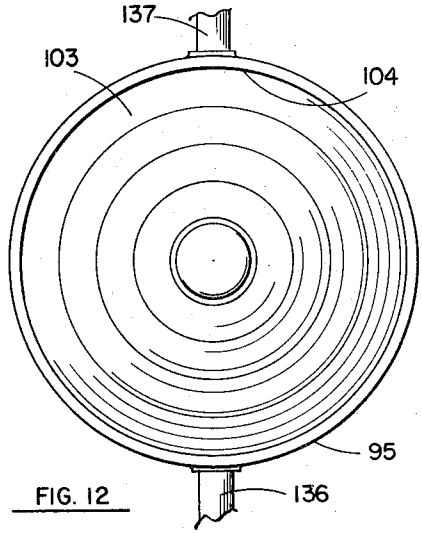


FIG. 12

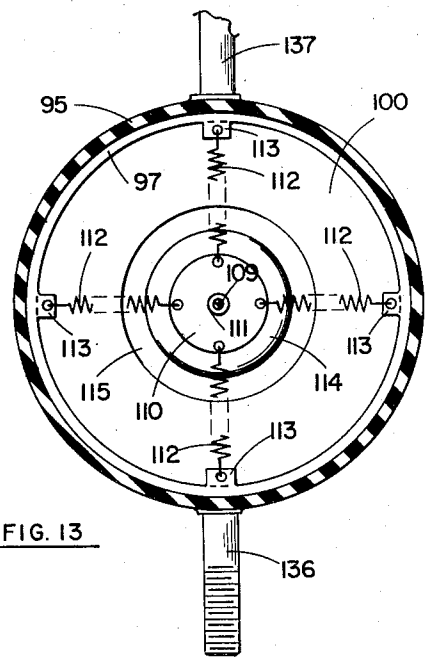


FIG. 13

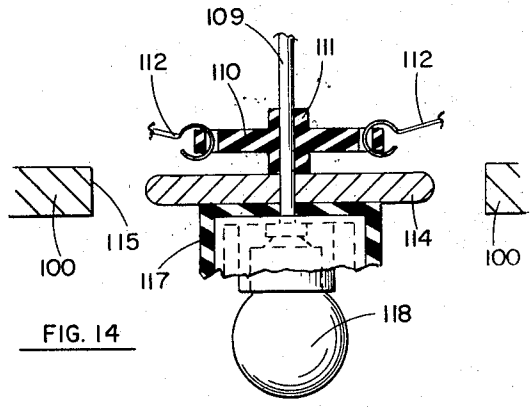


FIG. 14

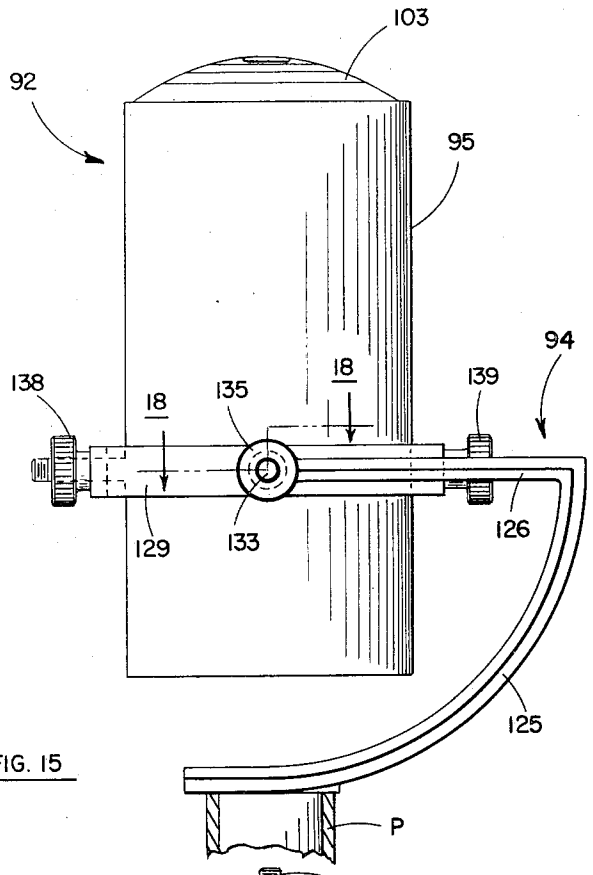


FIG. 15

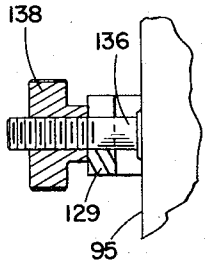


FIG. 17

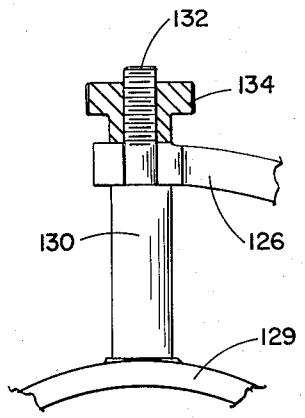


FIG. 18

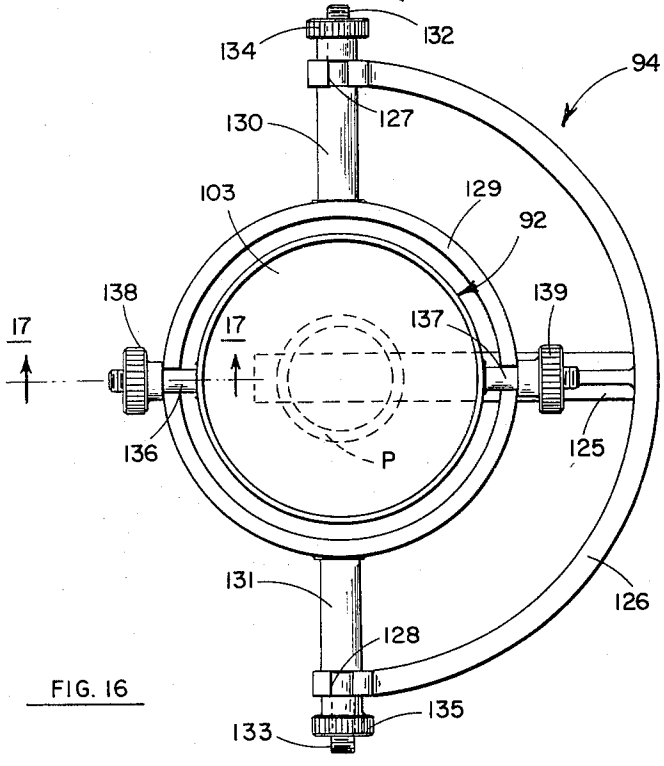


FIG. 16

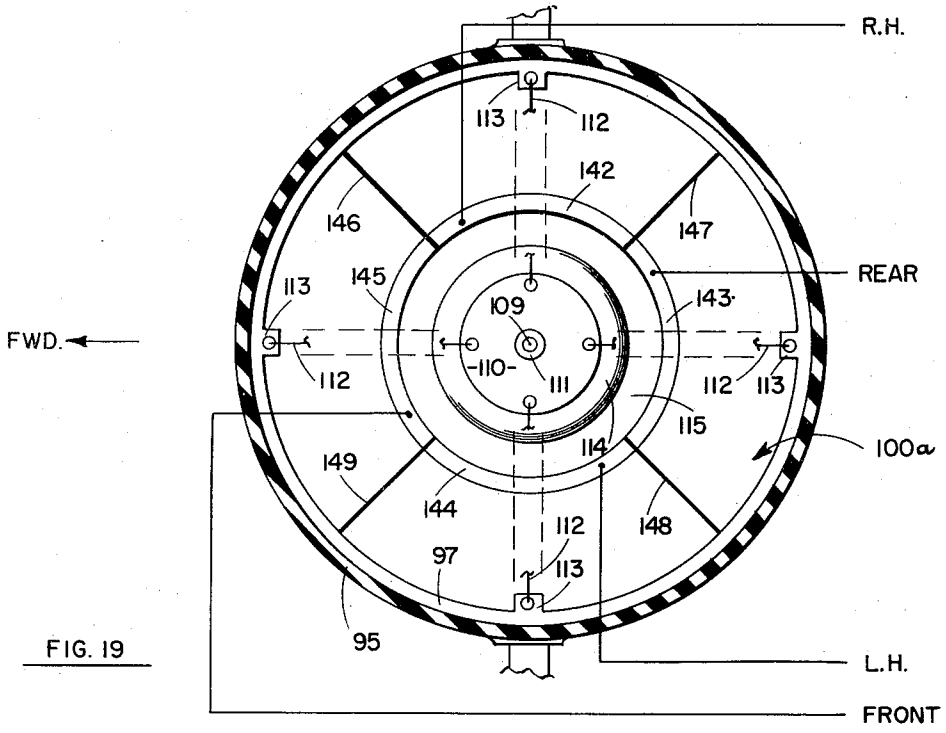


FIG. 19

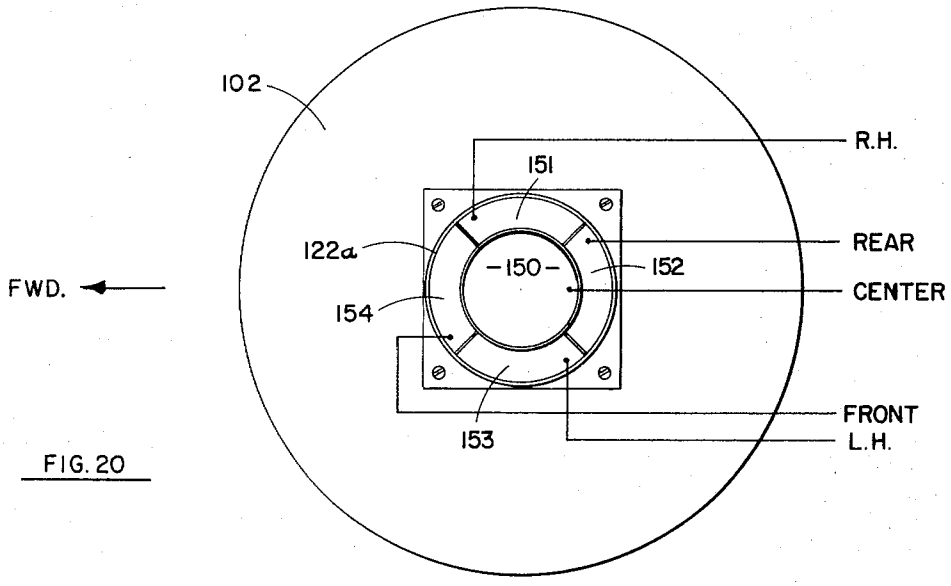


FIG. 20

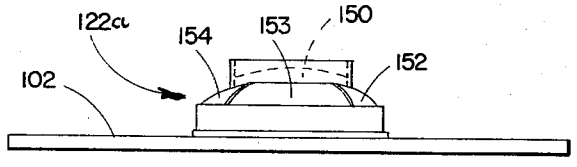


FIG. 21

CRANE TIP ALARM

BACKGROUND OF THE INVENTION

This invention relates to progressive tilt-monitoring or upset-warning devices for equipment such as cargo-moving cranes and the like, which cranes are characterized by a plurality of angularly articulated, extension arms which are ground-supported to achieve positional stability which may be threatened by a rotationally swinging and vertically-angled boom which terminally is adapted to lift and move heavy cargo. Such heavy duty cranes typically are used to shift containerized cargo.between holds of ships and land carriers. As technology has resulted in heavier and larger containerized packages, the booms required to handle them have become longer, and the vehicular operating base to which the boom is attached has become more top-heavy. Overturn of the total assembly has occurred in some instances, producing loss of the operator's life as well as destruction of equipment and cargo, especially when the whole tumbles into the ocean.

Safety regulations now require warning signal devices which correlate the angular position of the boom with the weight of the suspended load; if the latter exceeds a preset limit, it may act to cancel the pick-up. However, once the cargo-piece is hung from the boom and the latter starts to slant downward, rotate and/or extend longitudinally, the stability of the base of the crane may become extremely precarious and suddenly fail, dependent upon how the moving cargo-piece is progressively deployed relative to the ground anchorage of the vehicle.

With a mobile crane, after being wheeled to an operating site, outriggers are extended from the chassis along both sides so as to form four corners of a theoretical rectangle with the ground-supported outriggers vertically articulated to the chassis and with the vehicular wheels usually remaining on the ground. Weight-shift thereafter caused by the swinging boom-carrying-cargo may then tilt the chassis and lift wheels off the ground along one side or the other. While a minimum amount of such tilt is familiar to and tolerated by crane operators, it is when this condition approaches a "topple-point" that they need to be immediately aware of it so as to avert calamity. However, because the rotating operator's cab normally exhibits appreciable wobble, by his own senses the operator cannot accurately gage to what extent the chassis is tilted beneath him, that is, how much an edge of the vehicle (or its wheels) may be raised off the ground.

In relation to this situation it has been proposed that in cranes having hydraulic-operated outriggers, when all wheels have been thereby raised off the ground (to obtain an operative position), the fluid pressure of the several outrigger rams be balanced against a preset standard of variance so as to actuate an on-off type alarm (U.S. Pat. No. 3,680,714).

BRIEF STATEMENT OF THE INVENTION

By the present invention, the state of stability or threathened instability of the crane assembly is continuously monitored by evaluation of the tilting or change of the planar disposition of the chassis relative to other elements of the assembly such as the outrigger stabilizer arms or the vehicle bed, or to the plane of the ground support. This may be done directly by ground

contact of a chassis-mounted plunger, but more conveniently this is effected by such a plunger disposed in contact with each outrigger arm; such a tactile plunger has a short induction mass carried by its proximate length which passes axially and progressively through successive electrical coils secured to the chassis, whereby warning signals of increasing danger are sent to a panel in the operator's cab so as to activate successive alarms with increasing amount of tilt. In place of the multiple coil, induction plunger, an electric eye monitoring device may be used at each outrigger. Alternately or in addition, there is provided a chassis supported pendulum-type unit which by progressive amounts of tilt, activates successive alarms in response to progressive tilt of the chassis; only a single such unit need be used for an assembly and it is initially suspended perpendicular to the horizon even though the chassis itself may be positioned at an angle. With any of these forms of multi-stage alarm, the last stage may also be connected to cancel or override a selected crane-operating element which accentuates topple-risk, such as the boom-lowering mechanism.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a top plan view of a mobile crane with a tilt-warning device mounted at each outrigger.

FIGS. **2** and **3** are elevational segmental views of an outrigger laterally extending from the chassis of the crane, with the chassis mounted warning device shown making contact respectively with an outrigger arm, and with the ground support surface.

FIG. **4** is a similar view with the overlying bed of the crane contacted by a chassis-mounted plunger.

FIG. **5** is a vertical sectional view through the warning device with portions of the contact plunger and surrounding coils appearing in elevation.

FIG. **6** is an elevational view of an outrigger projecting from the chassis which carries an alternate electric eye form of tilt-warning device.

FIG. **7** is a top plan view of the construction of FIG. **6.**

FIG. **8** is a transverse sectional view taken along line **8—8** of FIG. **6.**

FIG. **9** is a semi-schematic elevational view of the indicator and control panel in the operator's cab of the crane.

FIG. **10** is an electrical wiring diagram showing connection of four tilt-warning devices to the panel elements of FIG. **9.**

FIG. **11** is a vertical axial sectional view through the cylindrical housing of another tilt-warning device which is particularly adapted to be mounted on the chassis of a crane or other tiltable assembly.

FIG. **12** is a top plan view of the same.

FIG. **13** is a horizontal sectional view taken along line **13-13** of FIG. **11.**

FIG. **14** is an enlarged vertical sectional view of a portion of the pendulum mount of FIG. **11.**

FIG. **15** is an elevational view of the tilt-warning device of FIG. **11** held in leveling mount for attachment to the chassis.

FIG. **16** is a top plan view of the leveling mount and tilt-warning device of FIG. **15.**

FIG. **17** is a sectional view taken along line **17—17** of FIG. **16.**

FIG. **18** is a horizontal sectional view taken along the line **18—18** of FIG. **15.**

FIG. 19 is an enlarged horizontal sectional view similar to FIG. 13 but showing a modified conductive disk formed of four insulated quadrants.

FIG. 20 is a top plan view of the composite photoreceiver used with the construction of FIG. 19.

FIG. 21 is a side elevational view of the photoreceiver of FIG. 20.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

A typical mobile crane **10** illustrated in FIG. **1** has an elongated bed or body **12** juxtaposed above a chassis **13** (FIG. **4**) which at its forward end supports a vehicle motor **14** and driver's compartment **16** situated above a pair of steering wheels **17, 18.** The rear body portion is carried upon four dual wheels **19, 20, 21, 22** which are relatively clustered together so as to support the main portion of the weight when the crane is in operation. A rotary platform bearing an operator's cab **24** plus mutually parallel cable drum **26** and horizontal boom axle **28** is disposed atop a power-operated turntable **30.** A pair of cables **32, 33** extends forward lengthwise along the boom **34** to terminal cargo-attachment means (not shown). Extensible and retractable from the sides of the chassis (upon the vehicle being parked) are four outriggers, each consisting of a transverse stabilizer arm **36, 38, 40, 42,** with a terminal, flared ground-support pad **37, 39, 41, 43.** The contact pads are generally spaced outward in four directions from the approximate center of the turntable in order to try to evenly distribute the load at the turntable. Obviously, the weakest position for boom stability would be midway between two corners of the rectangle formed by the outrigger pads.

In operation, a load suspended from the end of the boom may be found to be swinging back and forth more-or-less in a line parallel to the boom, and on its outward swing it is evident that such movement can jeopardise the stability of the whole assembly. To suppress this swing, the operator may try simultaneously to lower the boom and reel up the cargo in order to bring the two together. In such a critical situation however, too great a lowering of the weighted boom may move the center of gravity sufficiently outward so as to cause the whole to suddenly topple. In addition, at this critical time, watching the ship rise and fall in the water rhythmically may deaden the operator's own sense of balance.

The tilt sensing device **45** detailed in FIG. **5** consists of a cylindrical tubular housing **47** having a contact piston **49** projecting partway from one end thereof. Axially centered within the housing is a spool **50** formed with a central longitudinal channel **52** which receives an inner length of the piston thus disposed for limited reciprocal movement therealong. Endwise in both directions from the spool, the axial channel is continued by short tube lengths **53, 54,** the latter length joining an intermediate-diameter tubular housing **55** which holds a coil spring **56** biased to resist compression. One end of the spring abuts an annular plate **57** carried by the plunger which is thus normally urged outward from the housed position of FIG. **5.**

The spool **50** carries a series of axially spaced insulating disks **58, 60, 62, 64,** the spool lengths therebetween being wound with electrically conducting wire so as to form separate coils **59, 61, 63.** The length of the piston rod **47** which is within the spool is formed of non-conducting material such as porcelain, wood, synthetic plastic, etc. and near its inner end it carries a concentration of magnetisable material **65** such as nickel-steel or other ferrous material. As progressive extension of the rod **47** brings the induction charge **65** within each coil **59, 61, 63,** a current is induced in the respective coil which registers on the monitoring panel **70** in the cab.

As seen particularly in FIG. **2,** the housing **47** may be secured to the chassis by a narrow mounting bracket **66** so that the distal end of the plunger **49** rests atop the outrigger arm **36.** Alternately (or in addition) the chassis-connected housing **47** can dispose the contact plunger **49** against the overlying body **12** (FIG. **4**) or directly against the ground support S (FIG. **3**). In the latter case, the device **45** must be set for ground contact each time the mobile crane is moved to a new location. However, the other two mounting locations remain continuously functional without intermittent adjustment. The chassis-to-body mounted plunger of FIG. **4** does not produce as much movement of the plunger **49** as the ground connection (FIG. **3**) or connection to an articulated outrigger arm (FIG. **2**), but is useful in situations where the outriggers cannot be extended onto a stable area because of absence of firm ground support; for example, when the crane must be parked on a narrow causeway or alongside wet sand or mud in which the support pad **37** would sink.

In the construction shown in FIGS. **6-8,** progressive tilting of the outrigger arm **36***a* is indicated by interruption of successive beams of (visible or invisible) radiation linearly directed from a bank of emitters **67***a-b-c* to corresponding receivers **68***a-b-c* so as to pass through aligned slots **44** of a pair of scanning plates **69, 71** which are attached to opposite sides of the stabilizer arm **36***a*. Thus the closely adjacent series of emitter/-receivers is aligned to monitor successive tilt positions of each stabilizer arm and the several units are connected to the indicators on panel **70** similar to the stacked coil device **45.**

Circuit integration of the four tilt-warning devices **45** into a composite warning or alarm assembly is shown in FIG. **10.** It will be understood that four of the composite electric eye units of FIGS. **6–8** can be similarly connected. The first activated coil **59** of each of the units **45** is connected to a corresponding warning lamp **75, 76, 77, 78** which typically may be a flashing red light which by its position on the panel **70** designates the particular area of tilt corresponding to a specific outrigger stabilizer arm **36, 38, 40, 42.** If a primary warning light **75, 76, 77,** or **78** burns out, loss of ground circuit through the lamp element causes the corresponding solenoid **79, 80, 81** or **82** (which is in series with the primary lamp) to become de-energised, allowing the normally open contact to close and thereby complete a circuit through a respective standby lamp **83, 84, 85** or **86.** Successive movement of the induction mass **65** into the intermediate coil **61** energises the second stage alert **88** which may be a siren or buzzer. As the piston and its activating mass **65** descend into the lowermost coil **63,** a climactic or "panic" signal is energised, closing the solenoid switch **51** which energises the final (lamp or sound) signal F and also locks the Boom-down Control Handle H by means of a solenoid **91** which magnetically attaches and holds the handle against the metallic sidewall **121** of its guideway. Such selective locking action of just the boom-lowering

function (in contrast, for example, to rendering all winch action inoperative) leaves the operator free to take immediate defensive action, as grabbing the "Boom-up" lever. A test system provides multiple normally-open switches **72** which are closed by any current flow through the solenoid relay **73.** Energization is effected by pressing the test button **74.** An ON-OFF switch **87** and current source **90,** plus ground connections complete the assembly.

FIGS. **11-18** show a single multi-stage or progressively monitoring tilt alarm **92** and self-leveling mount **94** therefor, which in place of the previous quadruple units of FIGS. **5** and **6** (or in addition thereto if desired) can be chassis-attached so as to suspend a pendulum-type unit, the swinging movement of which is registered on a monitoring panel in the cab **24** so as to show the change of tilt or inclination of the chassis (and hence of the whole mobile crane). A cylindrical tubular housing **95** is formed of insulating material with the inner surface inset at **96** so as to receive bottom-inserted sleeves **97, 98, 99** which are separated by transverse, centrally apertured disks **100, 101** which thus delineate internal chambers A, B, C. The housing is closed by a bottom disk **102** and a dome-shaped cap **103** which is lodged in an annular recess **104**; the recess additionally supports a juxtaposed pair of disks **105, 106** of which the latter is electrically conducting and connected to an external cable **93.** A dependent central boss **107** of the lower disk is formed with a spherical socket which houses a ball-shaped head **108** of a thus suspended pendulum rod **109,** both formed of electrically conducting material. An insulating disk **110** having an axially-projecting apertured boss **111** embracing the rod, is peripherally attached to four stabilizing springs **112** which extend to respective anchorage tabs **113** which project radially inward from the positioning sleeve **97.** Spaced beneath the stabilizing disk **110** is a larger, electrically conducting, annular plate **114** which is normally centered within a larger central aperture **115** of the conductive disk **100**; the latter by a cable **116** is connected to an alarm device in the cab **24.**

A dependent shield **117** of insulating material houses an electric lamp **118,** the light from which is directed downward through a restricted bottom aperture **119.** Light passing through the outlet **119** is directed to traverse an axial aperture **120** of the lower disk **101** (thus passing from compartment B to compartment C) so as to enter a photo-receiver **122** which by a conductor **123** is connected to another alarm device on the panel **70.** It will be seen that an initial or minimum displacement of the light beam moving through the aperture **119** onto the receiver **122** will signal a first stage alert such as by activation of one of the panel indicators **75–78.** If subsequently the conductor ring **114** makes contact with the metal plate **100,** the audio **88** or "panic" alarm F is activated (whichever is connected).

The gimbal mount **94** (FIGS. **15-18**) is adapted to initially dispose the tilt-alarm unit **92** in a gravitationally perpendicular position when attached to the crane chassis, as by a pedestal P, even though the chassis itself may be restingly slanted (or the mounted pedestal may be inclined). A laterally outward and upwardly curved arm **125** with its bottom end supported atop the pedestal, distally supports a transverse semicircular bow **126,** the two ends of which are formed with mutually-aligned open-top grooves **127, 128.** A suspension ring **129** is formed with an opposing pair of diagonally outward extending arms **130, 131,** each having a radially restricted axle projecting therefrom and journalled in one of said grooves, and with a terminally threaded extension **132, 133** carrying a lock nut **134, 135** which thus can fasten the ring **129** and arms **130, 131** relative to the bow **126.** The alarm unit **92** is held by an opposing pair of diametrically aligned pivot pins **136, 137** journalled in grooves of the ring **129** and having terminally threaded ends carrying lock nuts **138, 139** for tightening against the ring **129.** It will be appreciated that by these four lock nuts, the unit **94** and its contained pendulum are set in a "plumb line" position prior to use of the unit.

The pendulum construction of FIGS. **19–21** modifies the form of FIGS. **11–14** so as to yield two successive sets of tilt indications, both of which are directional. Either directional set by itself can be substituted in the form of FIGS. **11–14** so as to provide an assembly with just one directional set of indicators but still having a two stage alarm. In FIGS. **19–21** the prior disk **101** and its focussing aperture **120** are eliminated and a directional first stage alert is provided by the photoreceiver **122*a*** being formed with a ring made by four separate, arcuate shaped, photoreceivers **151, 152, 153, 154,** each electrically connected to a different tilt-warning indicator in the cab **24.** Cab indication of light transmitted to the central area **150** shows when the chassis is approximately level and also serves as a continuous indicator that the circuitry is functioning.

The upper indicator disk **100*a*** has its inner edge formed by four arcuate shaped, conductor segments **142, 143, 144, 145** separated by radially directed, insulator strips **146, 147, 148, 149** with each segment electrically connected to a different second stage, directional tilt indicator on the panel **70.** The crane operator can thus learn at once with which quadrant the swinging plate **114** of the pendulum has made contact, that is, which area of the inclined chassis is "down." This may be in a different quadrant from which the first stage alert was monitored due to swinging of the cargo and/or rotation of the crane. The second stage signals from the pendulum may also be connected to lock the Boom-down handle as earlier explained.

In this connection it should be realized that with the mount **94** of FIGS. **15–18,** the tilt warning device **92** can be itself set initially tilted so as to produce a final alarm by a lesser tilt in one direction than in another. Thus it can be set to compensate for an inclined ground support on which the mobile crane may be parked. This is the case when the ground support slants downward in the direction of the boom; obviously the chassis is already partway inclined toward an upset condition and less additional tilt would be required to topple it. The easy adjustability of the pendulum mount **94** in such event is a very considerable advantage.

While the invention has been particularly described and illustrated herein by reference to its use with a mobile crane which employs a cargo-carrying boom, it will be clear that such tilt-warning devices can be advantageously employed with other equipment having a rotatable angularly-adjustably-upstanding weight-carrying booms, such as the "cherry-pickers" used by fire departments to rescue persons from high places; the tilt-warning devices can be used on the type of building wrecking equipment which swings a heavy ball against walls to demolish them; such tilt-warning devices can

likewise be used on earth clearing heavy equipment which has to operate on the sides of steep hills, etc. It is also adapted to floating cranes and marine salvage equipment.

I claim:

1. A device for indicating tilting of a structure on which it is mounted, said device comprising photoelectric emitting means suspended by a pendulum swingable over an annular area above vertically aligned photoelectric receiving means electrically connected to a first signaling device, said pendulum also carrying an annular electrical conducting element spacedly disposed within a larger surrounding annular electrical conducting element, contiguity between the two annular elements serving to make a circuit to a second tilt signaling device, whereby the two tilt signaling devices indicate progressive amounts of tilt of said structure.

2. A device according to claim **1** wherein said photoelectric receiving means comprises a plurality of photoelectric receivers arranged in a generally annular pattern and individually connected to separate tilt signaling devices whereby the direction of tilt of said structure is thus indicated.

3. A device according to claim **2** wherein said annular electrical conducting element comprises separate arcuate segments individually connected to separate second tilt signaling devices.

4. A device according to claim **1** wherein said annular electrical conducting element comprises separate arcuate segments individually connected to separate second tilt signaling devices.

5. A device according to claim **1** in combination with a gimbal mount having means for suspending said device with said photoelectric receiving means disposed selectively horizontal or deliberately slanted therefrom, regardless of the initial inclination of said structure.

6. A device according to claim **1** in combination with a crane or the like having a rotary platform normally tiltable by reason of an upstanding angularly adjustable boom extending therefrom with means for distally lifting and carrying a heavy article with rotation of the platform, said device being functionally mounted adjacent said rotary platform for indicating directional tilt thereof caused by movement of such boom and heavy article.

7. In a mobile crane or the like having a rotary platform from which an angularly adjustable boom extends with means for distally lifting and carrying a heavy article with rotation of the platform, and a plurality of outriggers selectively extensible from a chassis of the crane and adapted for articulated support thereof at tilted positions of the chassis which are variable with the immediate spacial location of the heavy article held by the boom,

the improvement of first means connected to the chassis for progressively monitoring a tilting condition of the chassis by continuously measuring change of its angular position relative to the ground or to a chassis-connected structure having ultimate ground support, and a plurality of warning devices having means for successively activating same in response to increasing tilt measured by said first means,

said first means comprising photoelectric emitting means suspended by a pendulum above vertically aligned photoelectric receiving means and electrically connected to a first tilt signaling device, said pendulum also carrying an annular electrical conducting element spacedly disposed within a larger surrounding annular electrical conducting element and both electrically connected to a second tilt signaling device energisable by contiguity between the two annular elements upon swinging of the pendulum whereby said first and second tilt signaling devices will indicate progressive amounts of tilt of a structure upon which said first means is mounted.

said photoelectric receiving means comprising a plurality of photoelectric receivers arranged in a generally annular pattern are individually connected to separate first tilt signaling devices whereby the direction of tilt is thus indicated.

8. A mobile crane according to claim **7** wherein said annular electrical conducting element comprises separate arcuate segments individually connected to separate second tilt signaling devices.

9. A movable vehicle having a chassis-carried rotary platform with an angularly extending weight-carrying boom rotatable therewith, and

a tilt indicating means carried by the vehicle chassis and adapted to indicate successive tilt positions in a plurality of directions as changed by movement of said boom and weight, means comprising photoelectric emitting means suspended by a pendulum carried by the chassis and swingable over an annular area above a plurality of discrete photoelectric receiving means, said last mentioned means being electrically connected to said indicating means.

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