

- [54] **PROXIMITY DIFFERENTIAL CONTROL**
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[22] Filed: **Nov. 2, 1973**
[21] Appl. No.: **412,163**

Related U.S. Application Data

- [63] Continuation-in-part of Ser. No. 240,359, April 3, 1972, abandoned.
[52] U.S. Cl. **340/267 C**, 212/39 P, 317/DIG. 2, 340/248 A
[51] Int. Cl. **G08b 21/00**
[58] Field of Search 340/267 C, 258 D, 258 C, 340/419, 282, 248 A; 317/DIG. 2; 212/39 P, 86

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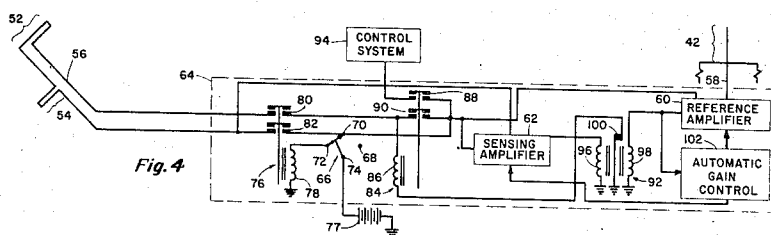
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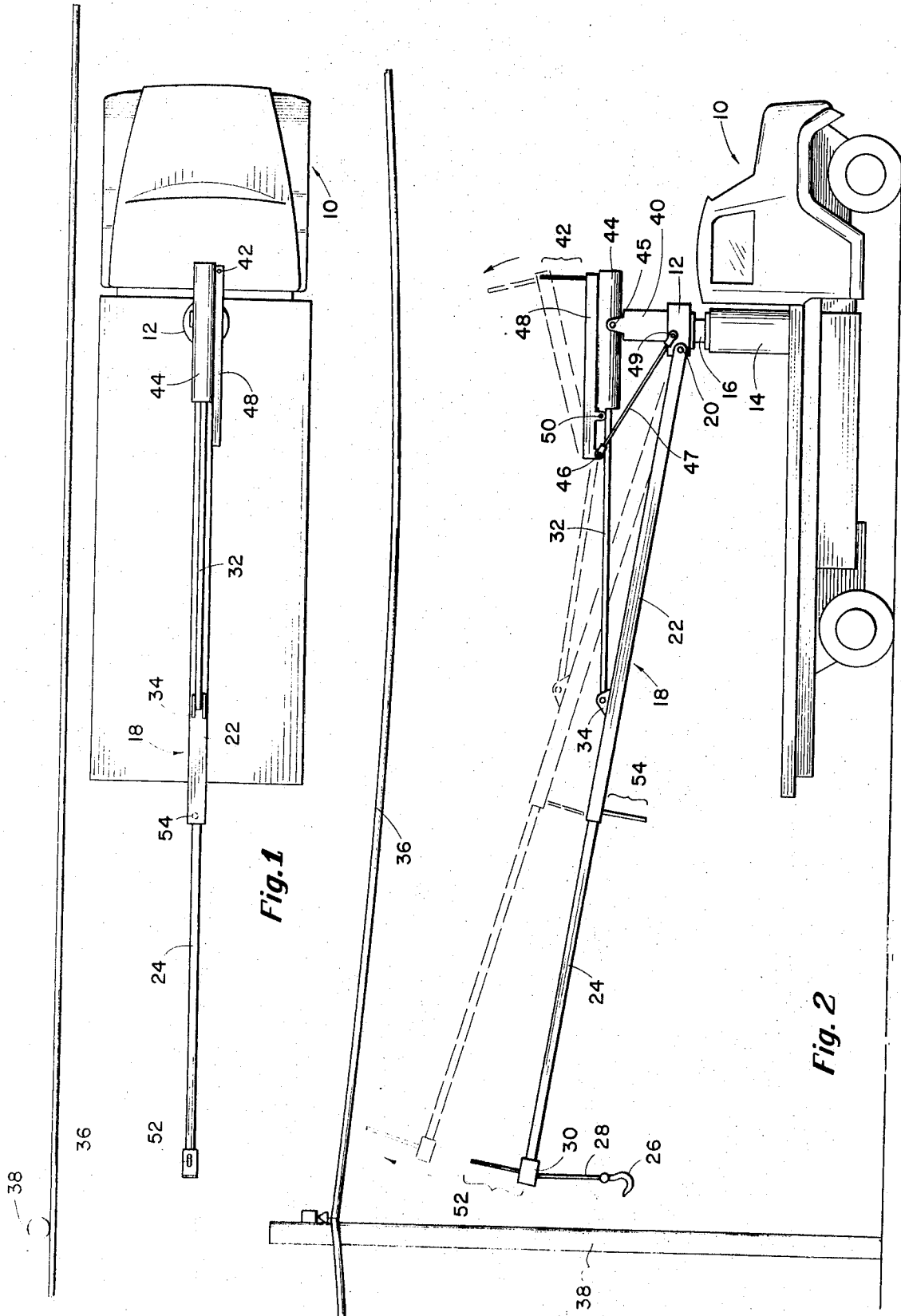
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[57] **ABSTRACT**

A proximity differential control for use with construction equipment and sepcifically cranes operating in the near proximity to an energized electrical power line comprises a reference antenna positioned at substantially the closest desired distance of operation from an electrical power line, at least one substantially identical sensing antenna positioned on the movable equipment, substantially identical receiving and amplifying means for each of the said antennas, and control means for comparing the relative strength of electrical fields around each of the antennas, and for shutting down the movable equipment when one of the sensing antennas moves into an area having a greater electrical field strength than that of the reference antenna.

8 Claims, 4 Drawing Figures





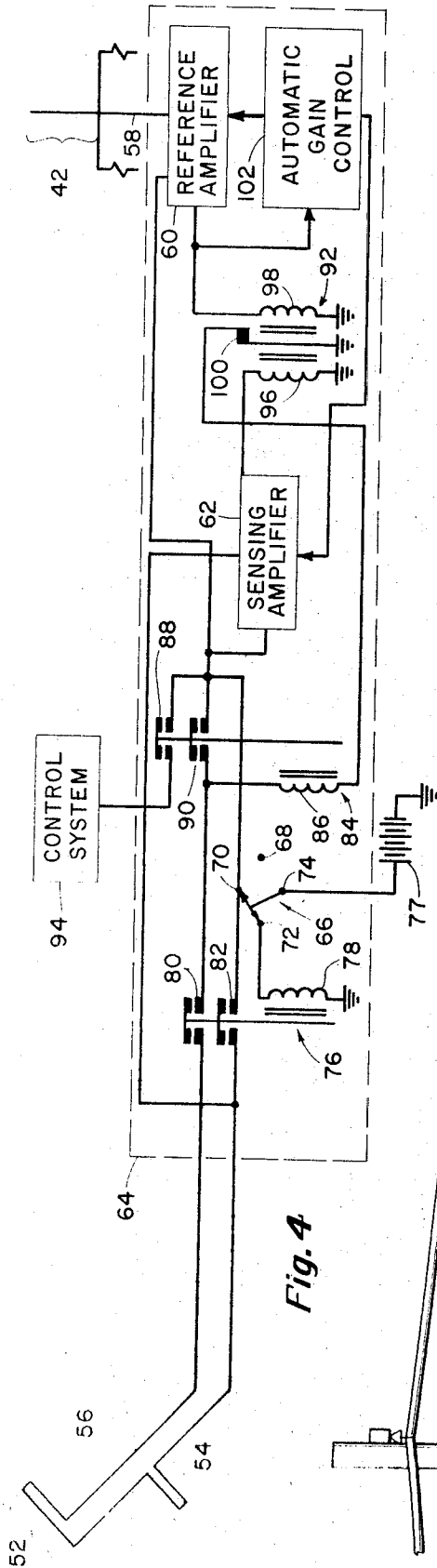


Fig. 4

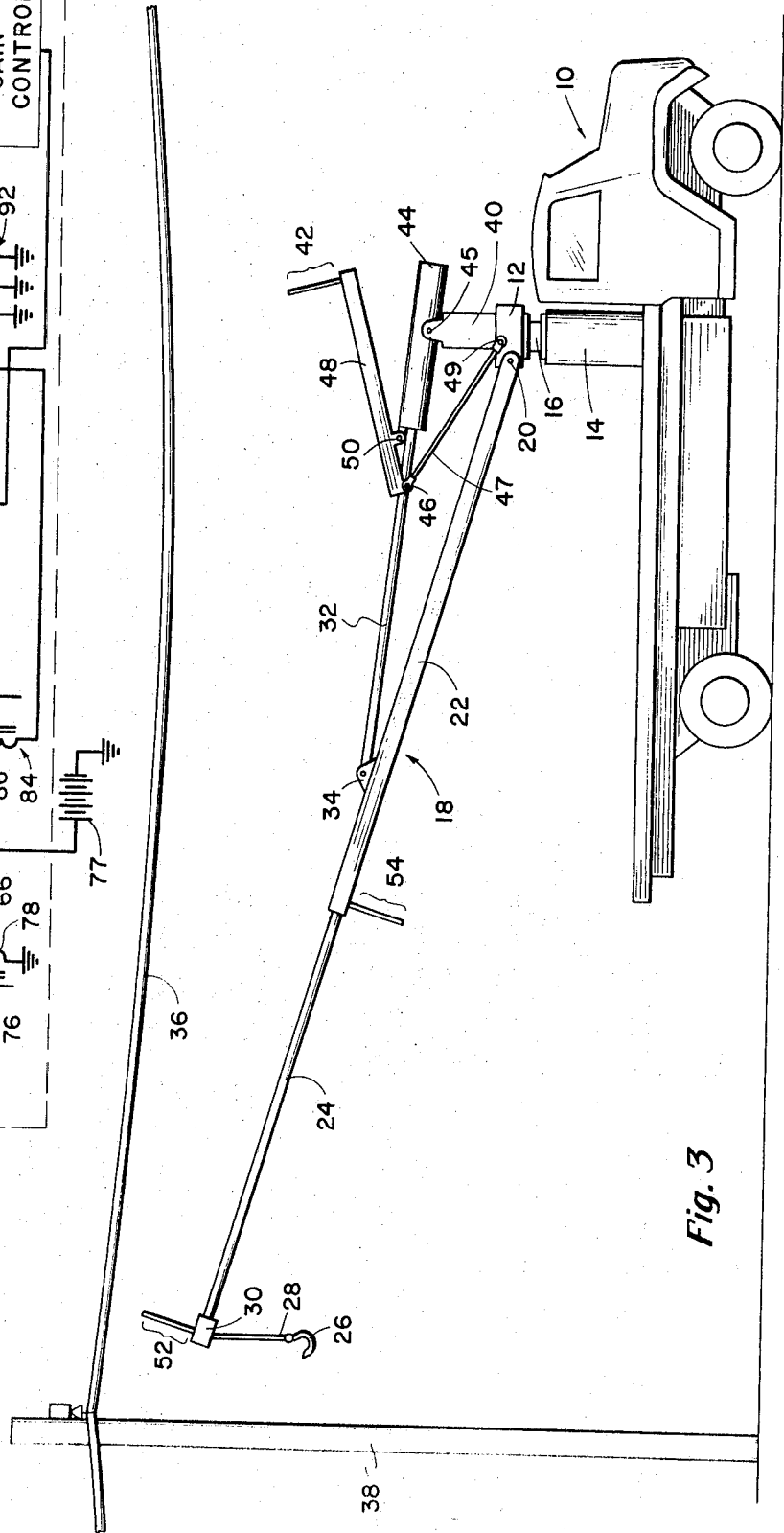


Fig. 3

PROXIMITY DIFFERENTIAL CONTROL

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation-in-part of my prior copending application Ser. No. 240,359 filed Apr. 3, 1972 for "Proximity Differential Control", and now abandoned.

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to improvements in safety devices for sensing hazardous conditions when operating in the proximity of an energized electrical power line, and more particularly, but not by way of limitation, to a proximity differential control which will function consistently when in the proximity of an electrical power line regardless of the voltage and current being transmitted by the power line and without the necessity of manual adjustment or tuning in order to compensate for varying voltages and current in the electrical power line.

2. Description of the Prior Art

It is often necessary for construction vehicles, such as cranes, with extendable booms, to operate in the near proximity to energized electrical power lines. The danger to the operator of such vehicles and to the electrical distribution system is often great if the boom apparatus or protruding part of construction equipment comes into contact with these high voltage lines. High voltage sensors and proximity alarms presently available for use with construction vehicles having extendable booms are normally of a single antenna type such as disclosed in the patent to Winters, U.S. Pat. No. 2,789,282, issued Apr. 16, 1957, and entitled "Automatic Approach Alarm," and the patent to Volberg, No. 3,168,729, issued Feb. 2, 1965, and entitled "Proximity Alarm." However, these type of high voltage proximity alarm systems have certain disadvantages in that the system has to be tuned to the particular high voltage line about which it is operating. This is due to the fact that many high voltage lines are operating at different voltage levels which would require the system to be moved to the site, the antenna to be placed to the nearest desired proximity to the high voltage lines, and to tune the system to sound the alarm when the antenna mounted on the boom structure comes closer to the high voltage line than the preset distance for which the system is tuned. It is therefore obvious that the danger of the equipment coming into contact with the high voltage lines may still be present if first the operator makes a mistake in tuning the system, and second, if the voltage on the lines was changed during the operation of the equipment. The presently available systems also have the disadvantage of time lost on the site in having to manually adjust the system each time the construction equipment is set up near a high voltage line.

SUMMARY OF THE INVENTION

The present invention contemplates a novel proximity differential which overcomes the above disadvantages. The present invention is provided with a reference antenna which is positioned near the electrical power line, and at least one remote sensing antenna which is positioned on the movable equipment, and providing an amplifying means for each of the said an-

tennas. The system is also provided with control means for comparing the relative strength of electrical fields around the sensing antennas and the reference antenna so that when the sensing antenna moves into an area having a greater electrical field strength than the reference antenna the equipment is automatically shut down, thereby preventing the said equipment from coming into contact with the high voltage lines. It is therefore obvious that the present invention does not require tuning when operating in the proximity of an electrical power line regardless of the voltage being carried on that power line since the system operates on relative electrical field strength rather than a direct measurement of the field strength around the high voltage line. The present invention is also provided with safety means by which the operator thereof cannot put the equipment into operation without having the proximity differential control mechanism turned on and operating, thereby virtually eliminating any operator error. It is also obvious that if, while the construction is being carried out, the voltage level being carried on the high voltage lines changes, the system will continue to operate normally, since, as hereinbefore stated, the system operates on relative field strength rather than on a direct measurement of the field strength.

Other and further advantageous features of the present invention will hereinafter more fully appear in connection with a detailed description of the drawings in which:

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a plan view of a vehicle having an extendable boom structure mounted thereon and positioned adjacent to an electrical high voltage line, the said vehicle and boom structure being provided with a proximity differential control system embodying the invention.

FIG. 2 is an elevational view of the vehicle, boom structure and proximity differential control system as shown in FIG. 1.

FIG. 3 is an elevational view similar to FIG. 2 but showing the boom and reference antenna in a more elevated position.

FIG. 4 is an electrical schematic diagram of the proximity differential control system.

DETAILED DESCRIPTION OF THE DRAWINGS

Referring to the drawings in detail, reference character 10 generally indicates a self-propelled vehicle or truck having a crane 12 rotatably mounted thereon. The crane 12 comprises a vertically disposed pedestal 16 rigidly secured to the vehicle support 14, a shaft (not shown) journaled within the pedestal 16, and a boom 18 rotatably secured to the crane 12 by a suitable hinge pin 20 to effect rotation of the boom 18 in a vertical plane about the hinge pin 20. The boom 18 comprises an elongated sleeve member 22 having one end thereof hingedly secured to the crane 12 by the aforementioned hinge pin 20. The opposite end of the sleeve member 22 is provided with an extendable boom member 24 slidably disposed therein. The outer end of the extendable boom member 24 is provided with a load hook 26 which is attached to a load cable 28. The load cable 28 extends from the hook 26 over a suitable pulley 30 (diagrammatically shown) located at the outer end of the extendable boom member 24 and back along the said boom 18 to a power controlled winch unit (not shown) located on the crane 12. The boom member 18

is vertically rotated about the hinge pin 20 by the use of a power controlled jib screw 32 which extends substantially horizontally from a hinge point 34 at the upper portion of the crane 12 into a power cylinder 44. The power cylinder 44 has internal means (not shown) 5 rotatably engageable with the inner end of the jib screw 32 for extending or retracting the jib screw outwardly from, or inwardly into, the power cylinder. The power cylinder is pivotally connected at point 45 to an upper pedestal extension 40. The rotation of the crane 12 and 10 its associated boom member 18 horizontally within the pedestal 16 is accomplished by a power unit (not shown) located in the crane unit 12. Hence, the boom member 18 has two degrees of freedom of movement; that is, a horizontal rotational movement about the vertically disposed pedestal 16, and vertical movement about the hinge pin 20. The outer end of the boom member 18 may be elongated by extending the extendable boom member 24.

Referring now to FIGS. 1 and 2, it is easy to see how the extendable boom member 18 could be inadvertently swung into contact with an adjacent power line 36 being supported by poles 38 thereby causing extensive damage to the crane 12 and possibly resulting in injury to the operator thereof. To prevent this occurrence, the present invention provides a proximity differential control system (later to be described), the electrical components of which can be mounted, if desired, within the upper pedestal extension 40. The proximity differential control system includes, first of all, a reference antenna 42 which is at the right hand end of an elongated antenna mount 48. The antenna mount is hingedly secured to the power cylinder 44 at the hinge point 50 located at the left hand end of the power cylinder. The antenna mount 48 extends past hinge point 50 to an anchor point 46 where the anchor rod 47 attached to the point 46 at one end, the opposite end thereof being attached to the crane 12 at a point 49 adjacent to the boom hinge point 20. Therefore, when the boom 18 is raised to the position shown in FIG. 3 and also as shown by the broken lines of FIG. 2, the anchor rod 47 attached to the end of the antenna mount 48 will cause the said mount 48 to be rotated about the anchor point 46 thereby automatically elevating the reference antenna 42. The reference antenna 42 is vertically mounted on the antenna mount 48 at the opposite end from the anchor point 46 so that the said reference antenna 42 may be raised and lowered about the anchor point 46 as the hinge point 50 rises with the power cylinder 44.

The proximity differential control system also comprises a first sensing antenna 52 which is vertically mounted on the outer end of the extendable boom 24 directly above the load hook pulley 30 and a second substantially identical sensing antenna 54 which is located on the bottom side of the boom sleeve member 22 and at the outer end thereof.

Referring now to FIG. 4 which shows the electrical circuitry, it will appear that the sensing antennas 52 and 54 are series-connected by antenna lines 56 for a purpose that will be hereinafter set forth. The reference antenna 42 is operably connected by a suitable antenna line 58 to a reference amplifier 60. Likewise, the sensing antennas 52 and 54 are operably connected to a substantially identical amplifier 62. The amplifiers and associated control circuitry are disposed within a control box 64 which, as indicated heretofore, can be con-

veniently mounted within the upper pedestal extension 40. A three-position toggle control switch 66 is mounted in the control box 64 in any well known manner (not shown). The switch 66 is provided with an "off" position 68, and "on" position 70, and a "momentary on" position 72 for purposes that will be hereinafter set forth. The toggle pole 74 of the switch 66 is operably connected to a direct current power supply 77 located externally to the control box 64. It is to be noted that this direct current power supply may be provided by a battery means or by connection with the vehicle normal DC power source. It is further noted that when the switch 66 is in the "momentary on" position (as shown), the power is provided by the DC power source 77 to both the contacts 70 and 72 of the switch 66, and when the switch 66 is moved to the "on" position, then power is supplied only to the contact 70.

A circuit continuity test relay 76 having an actuating coil 78 and two normally open relay contacts 80 and 82 is operably connected to the switch 66. The actuating coil 78 has one end thereof connected to the "momentary on" contact point 72 and the other end of said coil being grounded whereby, when the switch 66 is moved to the "momentary on" position, DC power is supplied through the actuating coil 78 thereby closing the contacts 80 and 82. At this point, electrical power is also being provided to the switch position 70 and through the relay contact 82. The opposite side of the relay contact 82 is serially connected with the antennas 54 and 52 and back to the relay contact 80. A second relay 84 having an actuating coil 86 and two normally open contacts 88 and 90 is provided in the system as will be hereinafter set forth.

One side of the actuating coil 86 is operably connected to the contact 80 of the relay 76 and the opposite end of the coil 86 is operably connected to a differential system 92, as below described. One side of the contact 88 of the relay 84 is connected to the control system 94 of the crane, the opposite side of the contact 88 being connected on the "on" position 70 of the switch 66. One side of the contact 90 is operably connected to the contact 80 of the relay 76, the opposite side of the contact 90 being connected to the "on" position 70 of the switch 66. The amplifiers 60 and 62 are also operably connected to the "on" position 70 of the switch 66.

The differential relay 92 comprises a first coil member 96, a second opposing coil member 98, and one set of normally closed contact points 100. One side of the coil 96 is operably connected to the output of the amplifier 62 and the other side thereof is connected to ground. Likewise, the coil 98 has one side thereof connected to output of the amplifier 60 and the other side connected to ground. One side of the contact 100 is connected to the actuating coil 86 of the relay 84, while the other side of the contact 100 is connected to ground. An automatic gain control unit 102 is operably connected to the output of the reference amplifier 60, the output of the automatic gain control being provided to both amplifiers 60 and 62 for automatically balancing the gain of the two amplifiers 60 and 62.

In operation, when the switch 66 is moved to the "momentary on" position, power from the direct current power source 77 is provided to the switch position points 70 and 72. Therefore, electrical power is provided through the actuating coil 78 of the relay 76 thereby closing the contacts 80 and 82 thereof. While

the switch 66 is still in the "momentary on" position, power is simultaneously provided to the amplifiers 60 and 62, and to one side of the contacts 88 and 90 of the relay 84. Simultaneously, power is provided through the contact 82 of the relay 76 and thence through the antennas 54 and 52, back through the contact 80 of the relay 76 to both the contact 90 of the relay 84 and through the actuating coil 86 of the relay 84 and to ground through the contact 100 of the differential relay 92. If continuity exists through the sensing antenna system comprising antennas 54 and 52, then the contacts 88 and 90 of the relay 84 will close thereby providing electrical power from the power unit 77 through the contact 88 of the relay 84 to the control system 94 for the crane. Simultaneously, power will also be provided through the contact 90 to one side of the actuating coil 86 of the relay 84. Therefore, the relay 84 becomes a self-latching relay and will remain closed when the switch 66 is moved to the "on" position 70. When the switch 66 is moved from the "momentary on" position 72 to the "on" position 70, the power is taken away from the coil 78 of the relay 76 and the contact points 80 and 82 of the relay 76 will open, thereby isolating the antennas 52 and 54. At this point, the sensing antennas 52 and 54 are connected only to the input of the sensing amplifier 62.

When it is necessary to operate the construction equipment in the near proximity to high voltage power lines, the vehicle 10 is stationed near the power line thereby positioning the reference antenna 42 at the closest desired horizontal distance from the said power line. The sequence of operation, then, is as follows. The switch 66 is moved to the "momentary on" position 72 which will provide power simultaneously to the relay 76 and to the reference amplifier 60 and the sensing amplifier 62. The current from the power unit 77 will then flow through the actuating coil 78 of the relay 76 thereby closing the contacts 80 and 82. Upon closure of the contacts 80 and 82, current will flow through the contact 82 and subsequently through the antennas 52 and 54. The current then flows through the conductor 56 back through the contact 80 of the relay 76 and subsequently through the actuating coil 86 of the relay 84. The current then flows from the coil 86 through the closed contacts 100 of the differential relay 92 and then to ground. If there is continuity throughout the sensing antenna system, the passage of the current through the actuating coil 86 will cause the closure of the contacts 88 and 90 of the relay 84. Thus, the relay 84 becomes a self-latching relay, as indicated above, since, upon closure of the contact 90, power is provided through the contact 90 and back through the actuating coil 86 and subsequently through the differential relay 92 to ground. At this point, the switch 66 is moved back to the "on" position 70. This will remove power from the actuating coil 78 of the relay 76 and the contacts 80 and 82 will open, thereby isolating the antennas 52 and 54, the latter being connected only to the input of the sensing amplifier 62. The closure of the contact 88 of the relay 84 also provides power directly through the said contact 88 to the control system 94 for the crane.

At this point, the crane is fully operable, the amplifiers 60 and 62 are operating and are maintaining an equal gain balance due to the actuation of the automatic gain control 102 by the output of the reference amplifier 60. The field intensity as experienced by the

reference antenna 42 is being provided as an input to the reference amplifier 60. The output of the reference amplifier 60 is being provided through the actuating coil 98 of the differential relay 92 thereby holding the contacts 100 of the said relay 92 in a closed position. Simultaneously, the field intensity experienced by the sensing antennas 52 and 54 is being provided as an input to the sensing amplifier 62. The output of the sensing amplifier 62 is being provided through the actuating coil 96 of the relay 92 and to ground. It is obvious now that as the sensing antennas 52 or 54 move into a closer proximity to the electrical power line 36 than the reference antenna 42, thereby experiencing a stronger field intensity, the outputs of the sensing antennas 52 and 54 will be stronger than the output of the reference antenna 42. At this point, the output of the sensing amplifier 62 will be strong enough so that the actuating coil 96 of the relay 92 will overcome the strength of the coil 98 and thereby open the contacts 100 of the relay 92. When the contacts 100 of the coil 92 are opened, the current flow through the actuating coil 86 of the relay 84 will be disrupted thereby disengaging the contacts 88 and 90 of the relay 84. When the relay 84 is de-energized, the power through the contact 88 to the control system 94 of the crane will be deactivated, and the crane will thereby be shut down.

Therefore, the crane 12 will be able to operate so long as the sensing antennas 52 and 54 are in an electrical field of no greater intensity than that of the reference antenna 42. This will permit the operator of the vehicle 10 to park the said vehicle near an electrical power line and operate the unit so long as the boom 18 of the crane 12 swings away from the power line.

From the foregoing it will be apparent that the present invention provides a proximity differential control particularly designed and constructed for providing safe, virtually fail-proof protection for equipment and equipment operators while working in the near proximity of a high voltage electrical power line.

Whereas, the present invention has been described in particular relation to the drawings attached hereto, it should be understood that other and further modifications, apart from those shown or suggested herein, may be made within the spirit and scope of this invention.

What is claimed is:

1. A proximity differential control for use with construction equipment having movable equipment associated therewith operating in the near proximity of high voltage power lines, said differential control comprising a reference antenna which is positioned below said lines at the closest desired horizontal distance of the movable equipment from said lines, a sensing antenna substantially identical to said reference antenna and positioned on the movable equipment, receiving and amplifying means operably connected to the reference antenna, a separate and substantially identical receiving and amplifying means operably connected to said sensing antenna, and control means for comparing the relative strength of the electrical field surrounding the reference antenna and the field surrounding the sensing antenna and for electrically shutting down the movable equipment when said sensing antenna moves into an area having a greater electrical field strength than that of said reference antenna.

2. A proximity differential control for use with construction equipment operating in the near proximity of

high voltage power lines as set forth in claim 1 wherein means are provided to raise and lower the reference antenna.

3. A proximity differential control for use with construction equipment operating in the near proximity of high voltage power lines as set forth in claim 2 wherein the means for raising and lowering the reference antenna comprises an elongated antenna mount hingedly secured to the construction equipment along the mid portion thereof, one end of the said antenna mount being secured to the reference antenna and the opposite end thereof being operably connected to the movable equipment whereby the said reference antenna is automatically raised when the movable equipment is raised and automatically lowered when the movable equipment is lowered by rotation of the elongated antenna mount.

4. A proximity differential control for use with construction equipment operating in the near proximity of high voltage power lines as set forth in claim 1 wherein a single automatic gain control unit is provided having its input operably connected to the output of the reference receiving and amplifying means, and having its output operably connected to both of the receiving and amplifying means for the sensing antenna and reference antenna for balancing and controlling the gain of each of said amplifying means.

5. A proximity differential control for use with cranes having booms operating in the proximity of high voltage power lines, said proximity differential control comprising a reference antenna which is positioned below said lines at the closest desired horizontal distance of said boom from said lines, a sensing antenna substantially identical to said reference antenna and positioned on the movable equipment, receiving and amplifying means operably connected to said reference antenna, separate and substantially identical receiving and amplifying means operably connected to said sensing antenna, and control means for comparing the relative strength of the electrical field surrounding said reference antenna and the field surrounding said sensing antenna for electrically shutting down the movable equipment when said sensing antenna moves into an area having a greater electrical field strength than that of said reference antenna, and wherein said control means comprises a coil operated self-latching relay for controlling power to the crane, a multiple coil differential control relay having a set of contacts operably connected to the coil of the self-latching relay and having a first coil operably connected to the output of the receiving and amplifying means for the reference antenna which tends to keep the contacts of the differential control closed, the differential control relay also having a separate opposing coil operably connected to the receiving and amplifying means for the sensing antenna so that when the output from the receiving and amplifying means for the sensing antenna becomes greater than the output from the receiving and amplifying

means for the reference antenna, the contacts for the first differential control relay will open thereby de-energizing the first-mentioned relay which, in turn, removes power from the crane boom.

6. A proximity differential control for use with construction equipment operating in the near proximity of high voltage power lines as set forth in claim 5 wherein the proximity differential control also comprises sensing antenna continuity testing means, said testing means comprising a coil actuated test relay operably connected to the sensing antenna and switching means connected to the test relay for actuating said test relay said test relay being connected such that power is supplied to the control system of the crane only if the sensing antenna exhibits continuity when the test relay is actuated.

7. A proximity differential control system for use with movable cranes having pedestal mounted boom structures operating in the proximity of high voltage electrical power lines, said differential control system comprising a reference antenna which is positioned above the boom pedestal, said pedestal being positioned at the closest desired horizontal distance from said lines, a sensing antenna substantially identical to said reference antenna and positioned on the boom structure of the crane, receiving and amplifying means operably connected to the reference antenna, separate and substantially identical receiving and amplifying means for said sensing antenna, and control means for comparing the relative electrical field strength surrounding the reference antenna and the field surrounding the sensing antenna for electrically shutting down the boom operation when said sensing antenna moves into an area having a greater electrical field strength than that of the reference antenna.

8. A proximity differential control system for use with movable cranes having a pedestal mounted boom operating in the near proximity to high voltage electrical power lines, the said differential control system comprising a reference antenna which is movably positioned above the horizontal boom pedestal, the said reference antenna being positioned at substantially the closest desired horizontal distance from the high voltage power line, a first sensing antenna located on the top of the outer end of the boom and a second substantially identical sensing antenna secured substantially mid-way out on the bottom of the boom so that when one of the sensing antennas is hidden from the electrical power line by the boom structure the other will be exposed thereto, receiving and amplifying means operably connected to the reference antenna, substantially identical receiving and amplifying means operably connected to the sensing antennas and control means for comparing the relative electrical field strength surrounding the sensing antennas to that of the reference antenna.

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