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Sarrell

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[45] **Dec. 2, 1975**

[54] **BOOM LENGTH SENSING SYSTEM WITH TWO-BLOCK CONDITION SENSING**

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[73] Assignee: **Koehring Company,** Milwaukee, Wis.

[22] Filed: **Dec. 11, 1974**

[21] Appl. No.: **531,707**

[52] **U.S. Cl.** ..... **33/125 R;** 33/138; 33/185 V; 116/124 F; 212/39 A; 340/267 C

[51] **Int. Cl.²** **G08B 21/00**

[58] **Field of Search** ..... 33/125 R, 185 V, 138; 340/267 C; 212/39 A; 116/124 F

[56] **References Cited**

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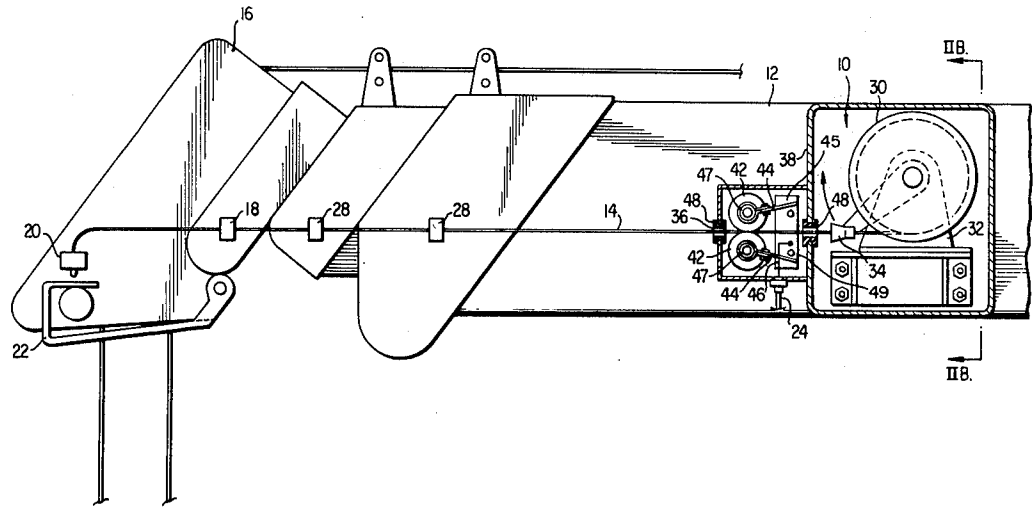
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Primary Examiner—William D. Martin, Jr.
Attorney, Agent, or Firm—Andrew J. Beck

[57] **ABSTRACT**

The disclosure relates to a system for sensing the length of an extendible boom of a crane and for sensing the impending occurrence of a two-block condition through the use of a single electrically conductive cable mounted on the boom of the crane. The cable is wound on a spring-biased reel mounted for rotation on a non-extending portion of the crane boom with one end of the cable secured to and electrically connected to the uppermost movable section of the crane boom. A constant current is supplied to the cable through an electrical contactor arranged to permit movement of the cable as the boom is varied in length. The constant current is also supplied to a circuit in parallel with the cable and the circuit senses a resistance value for the length of the cable between the contactor and the end secured to the movable section of the crane boom in response to the current flowing through the cable. In the preferred embodiment of the invention, the cable is connected to the upper-most movable section of the crane boom through a normally closed switch. An arm pivotally mounted to the peak of the crane boom cooperates with the switch and opens the switch in response to an impending two-block condition. The circuit in parallel with the cable senses an open condition of the normally closed switch, thus providing a manifestation of an impending two-block condition. To insure accurate sensing of boom length, the contactor and cable are preferably fabricated from different electrically conductive metals which produce a predetermined thermal EMF characteristic at the contact point therebetween. The thermal EMF characteristic is selected such that the thermal EMF tends to cancel thermal effects from the resistance of the cable due to temperature variations. A system for calculating boom load limit values in response to boom length and boom angle values is also disclosed.

17 Claims, 7 Drawing Figures



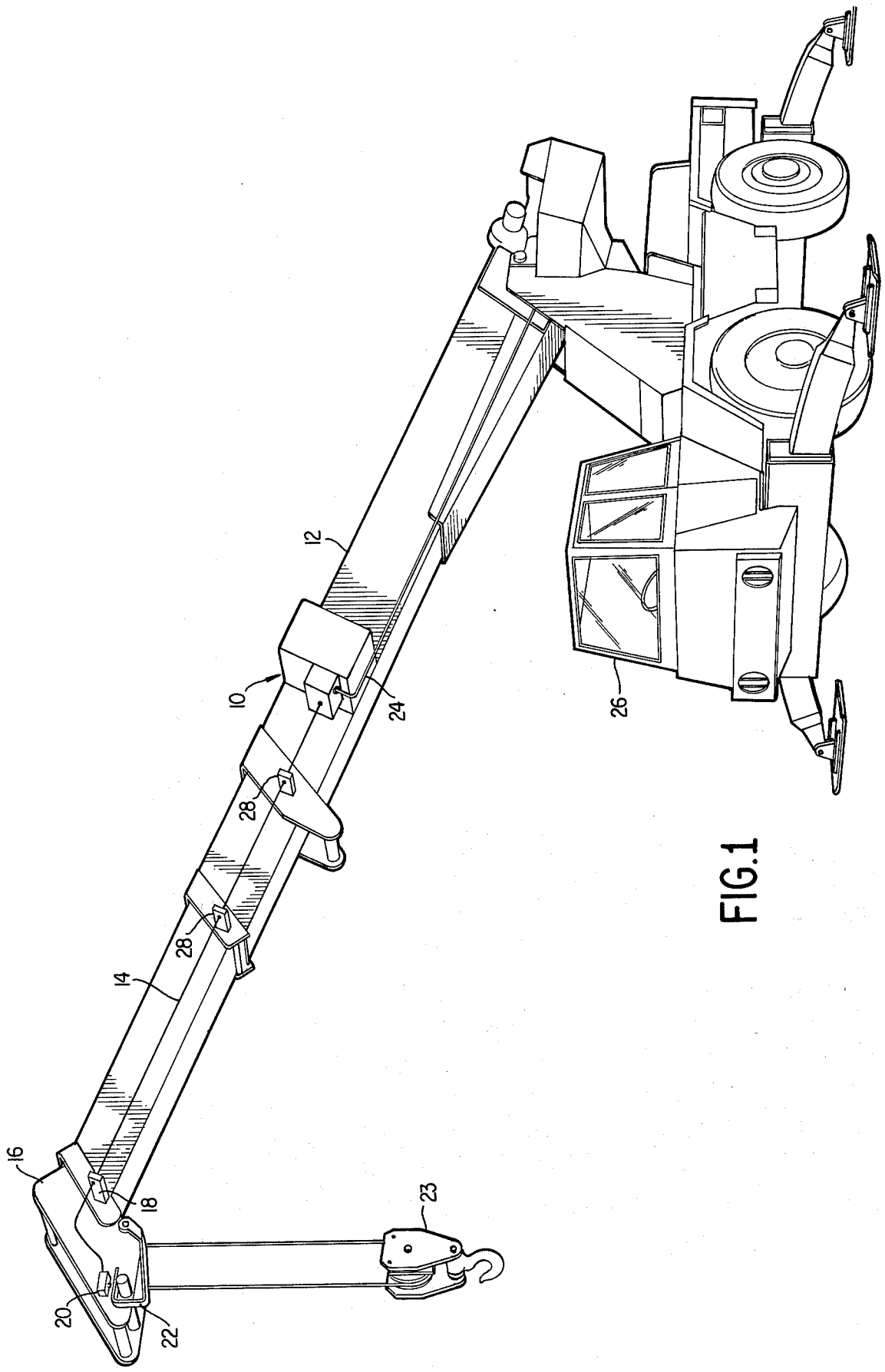


FIG.1

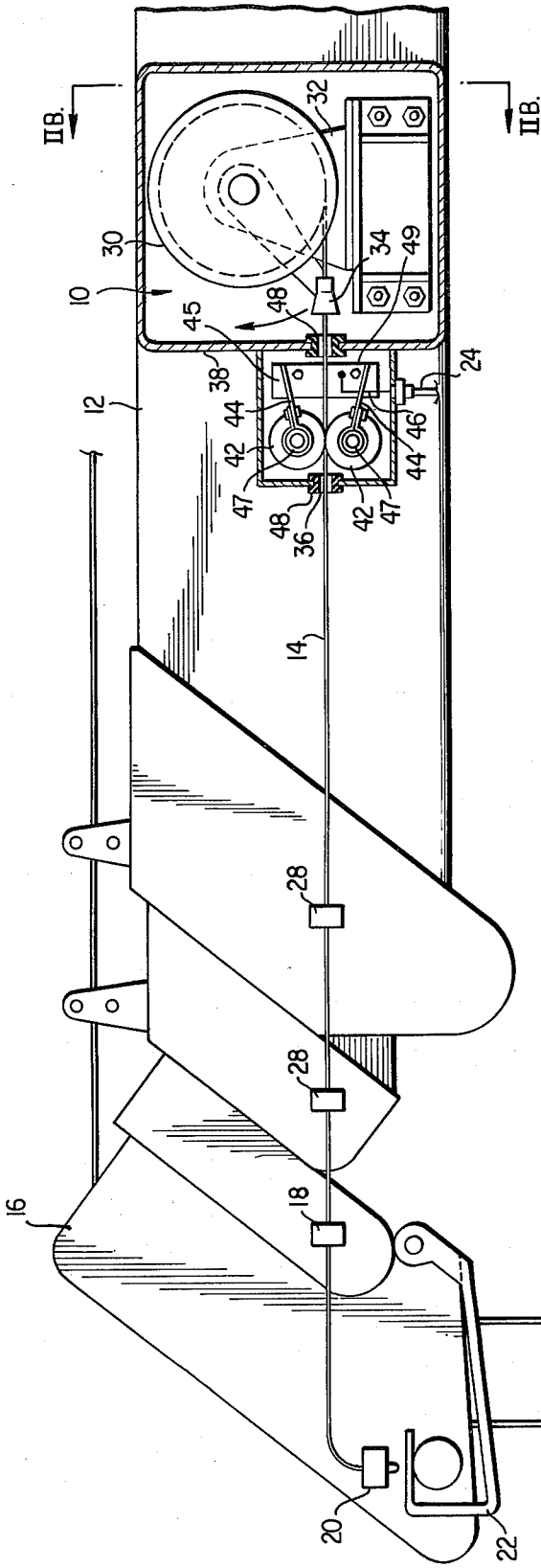

IIB.
IIB.
32
30
34
49
10
48
45
24
38
12
44
46
42
44
47
48
36
42
47
14
28
28
18
16
20
22

FIG.2A

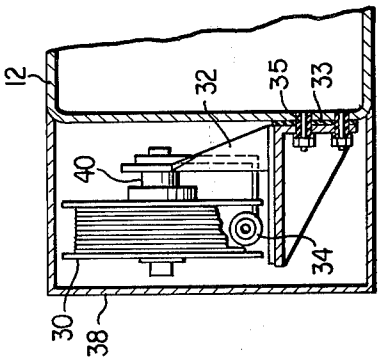

12
32
35
33
40
34
30
38

FIG.2B

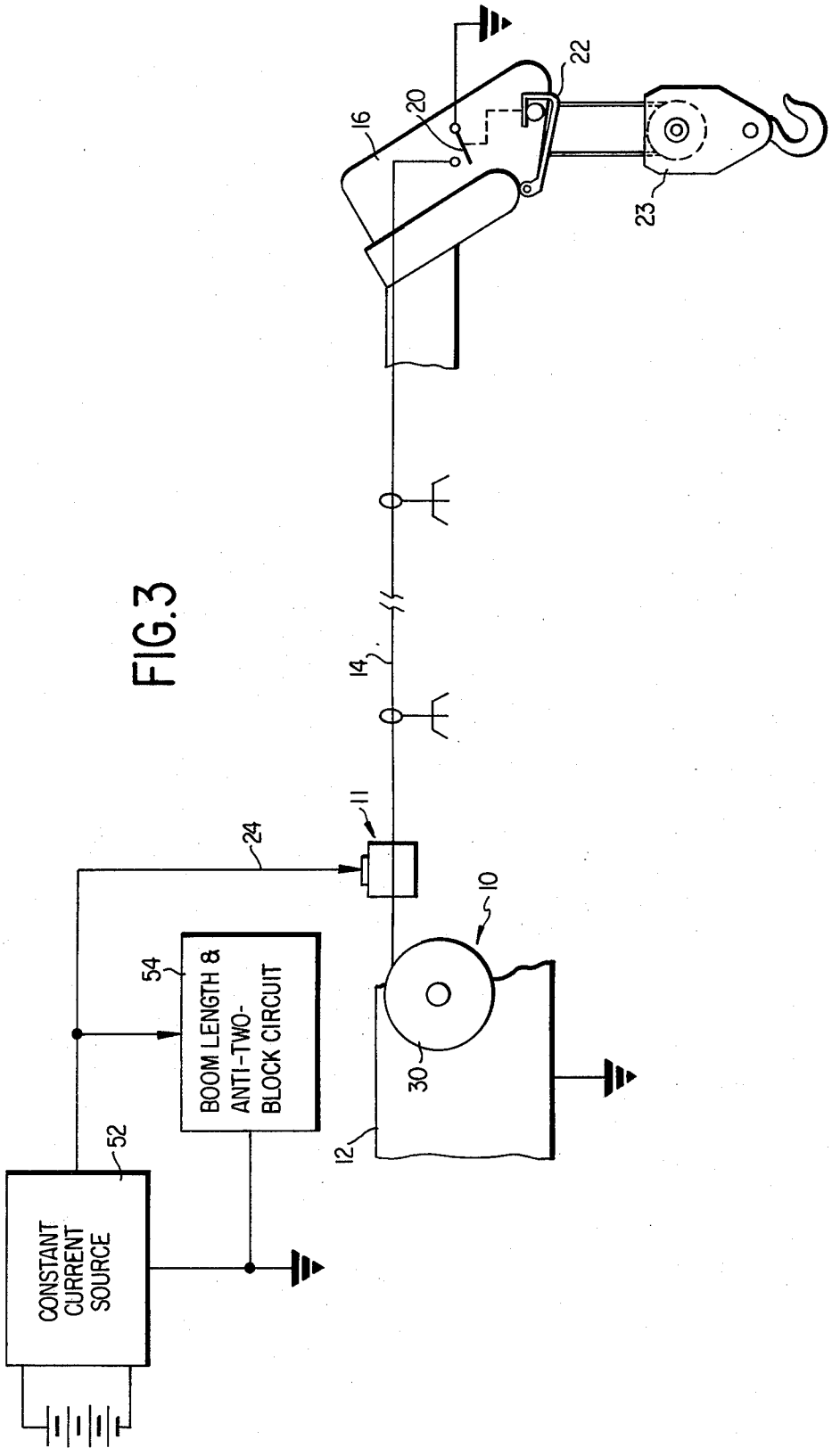

16
20
22
23
14
11
24
10
30
12
54
BOOM LENGTH & ANTI-TWO-BLOCK CIRCUIT
52
CONSTANT CURRENT SOURCE

FIG.3

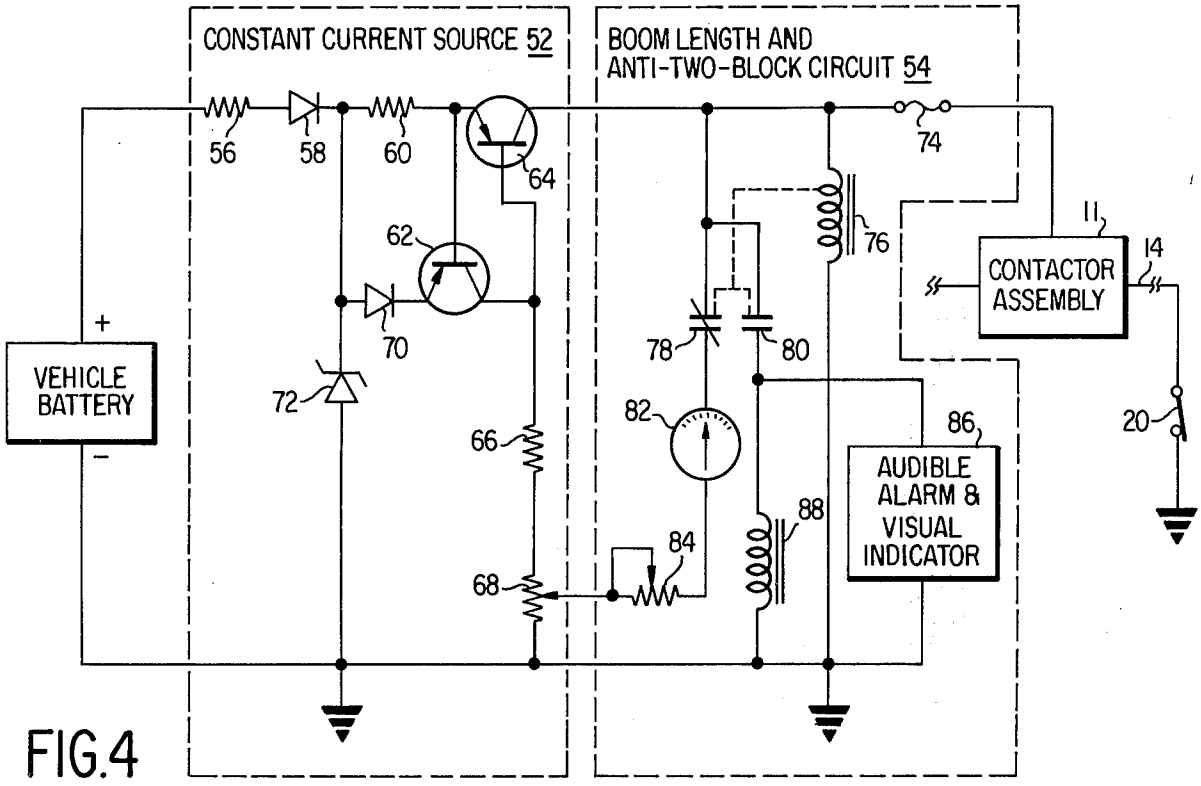

CONSTANT CURRENT SOURCE 52
BOOM LENGTH AND
ANTI-TWO-BLOCK CIRCUIT 54
56
58
60
64
62
70
72
66
68
74
76
78
80
82
84
86
88
11
14
CONTACTOR
ASSEMBLY
20
+
VEHICLE
BATTERY
−
AUDIBLE
ALARM &
VISUAL
INDICATOR

FIG.4

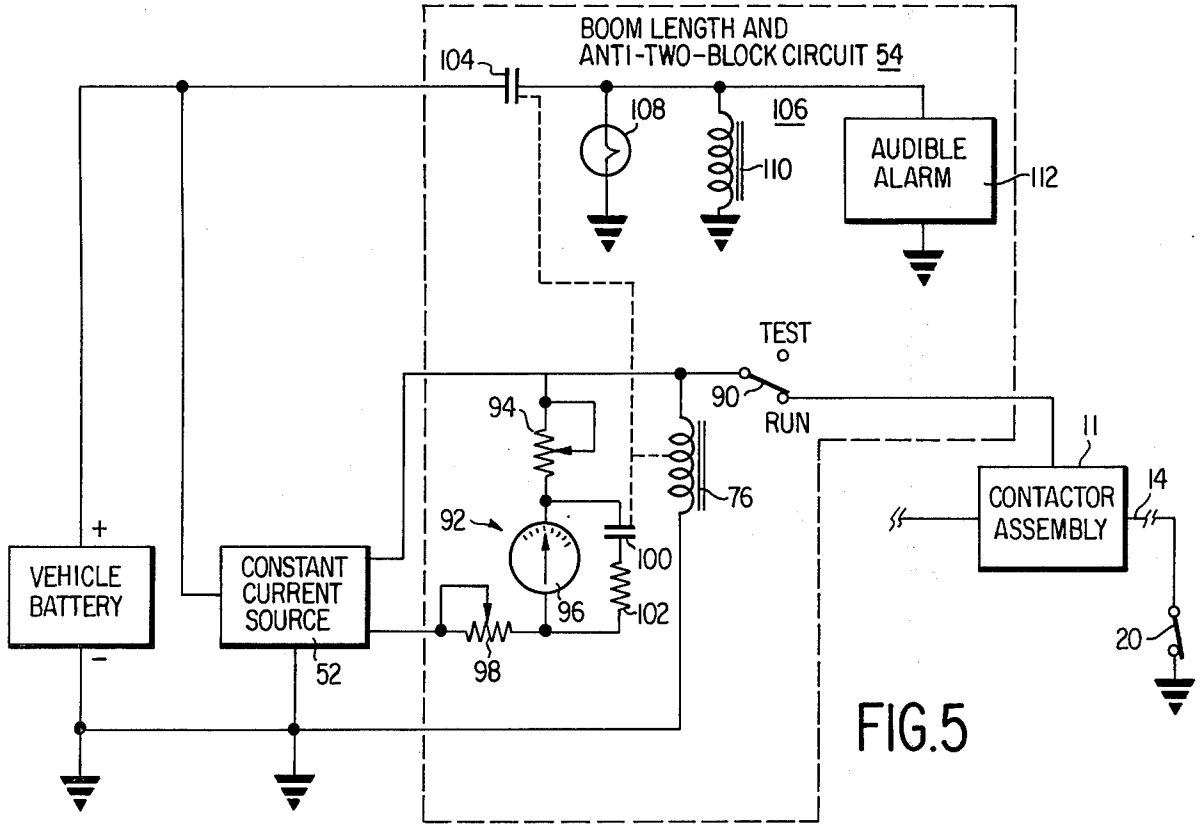

BOOM LENGTH AND
ANTI-TWO-BLOCK CIRCUIT 54
104
108
106
110
AUDIBLE
ALARM
112
TEST
90
RUN
94
92
96
98
100
102
76
11
14
CONTACTOR
ASSEMBLY
20
+
VEHICLE
BATTERY
−
CONSTANT
CURRENT
SOURCE
52

FIG.5

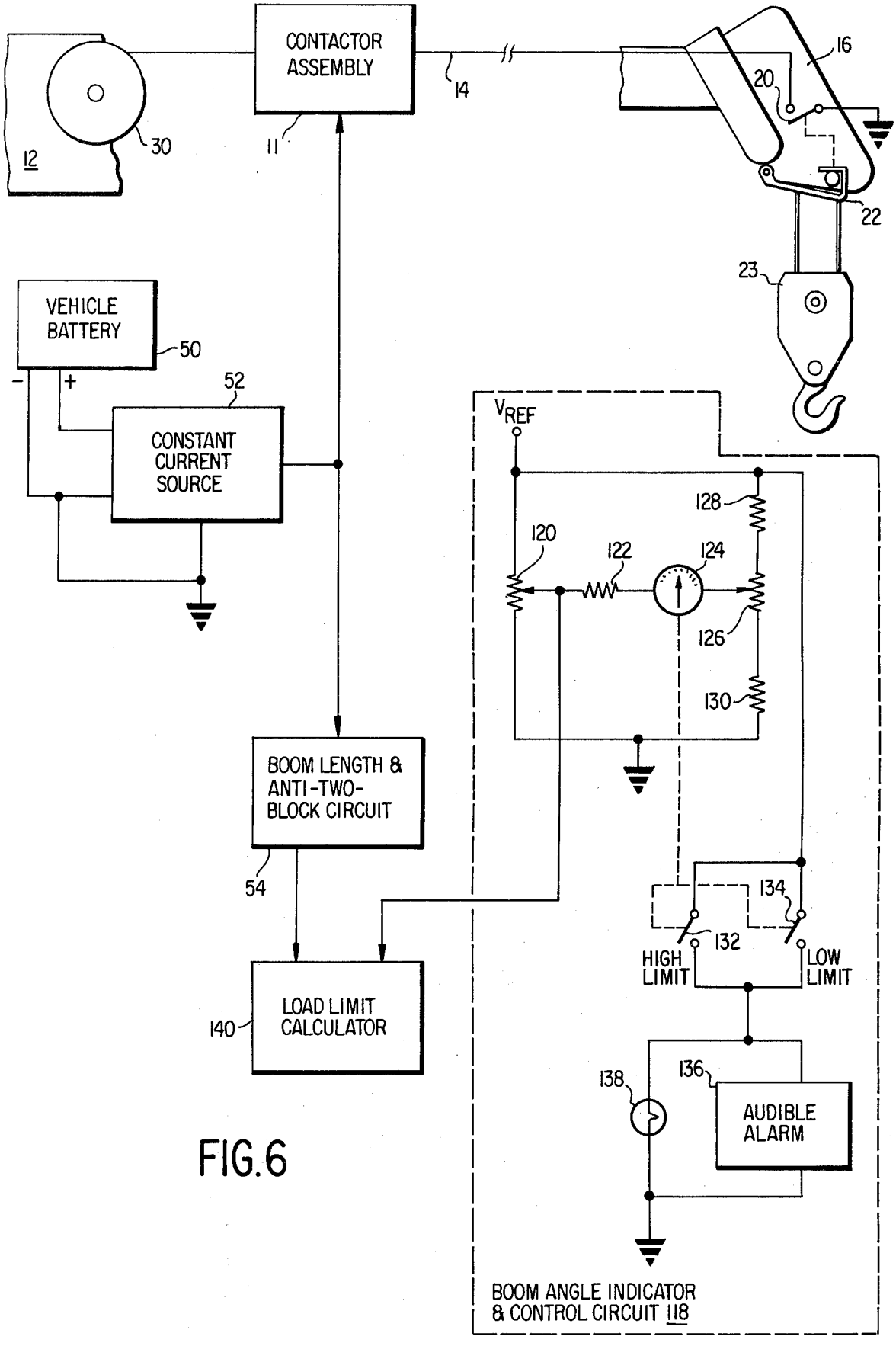

CONTACTOR ASSEMBLY
14
16
20
22
23
12
30
11
VEHICLE BATTERY
50
52
CONSTANT CURRENT SOURCE
V_{REF}
128
120
122
124
126
130
BOOM LENGTH & ANTI-TWO-BLOCK CIRCUIT
54
134
132
HIGH LIMIT
LOW LIMIT
LOAD LIMIT CALCULATOR
140
138
136
AUDIBLE ALARM
BOOM ANGLE INDICATOR & CONTROL CIRCUIT 118

FIG.6

BOOM LENGTH SENSING SYSTEM WITH TWO-BLOCK CONDITION SENSING

BACKGROUND OF THE INVENTION

The present invention relates to cranes having extendible booms and, more particularly, to a system for electrically sensing the length of an extendible boom of a crane and for sensing the impending occurrence of a two-block condition.

In operating a crane with an extendible boom, many factors are important in determining the stability of the crane and the maximum safe load conditions under various conditions of boom position. For example, safe load conditions for the boom depend upon certain dynamic operating conditions including boom length and boom angle. The stability of the crane is also dependent upon these conditions as well as other factors such as the orientation of the boom relative to the body of the crane.

While the operator may be able to estimate factors such as boom length and angle, more accurate indications may be required when operating the crane near the maximum load and/or stability limits. Accordingly, various systems have been devised to provide more accurate indications of boom length, boom angle and boom orientation. Such systems are typically complex and accordingly quite expensive and may still provide less than optimum accuracy. Moreover, known sensing systems typically provide single function outputs, further complicating the overall indicating and/or control system.

OBJECTS AND SUMMARY OF THE INVENTION

It is accordingly an object of the present invention to provide a novel boom length sensing system which is relatively inexpensive, yet extremely accurate and reliable.

It is another object of the present invention to provide a novel boom length indicating system which incorporates a two-block condition sensing system therein.

It is yet another object of the present invention to provide a novel boom length indicating system which provides a boom length related output signal having characteristics readily usable for both boom length indications and other more complex functions.

These and other objects and advantages of the present invention are accomplished through the provision of a system which senses the length of an extendible boom of a crane by sensing the changes in resistance of a cable variable in length in response to variations in boom length. One end of the cable is wound on a take-up reel mounted on a non-extending portion of the crane boom and the other end of the cable is secured to and electrically connected to the upper-most movable section of the crane boom. An electrical contactor mounted on the non-extending portion of the crane boom electrically contacts the cable and provides a moving electrical contact therewith. Current is applied to the contactor to supply through a length of cable between the contactor and the end of the cable connected to the upper-most movable section of the crane boom. A circuit connected to the contactor senses a resistance value for the length of the cable between the contactor and the end of the cable connected to the upper-most movable section of the crane boom in response to the current applied to the contactor. A manifestation of crane boom length is provided as a function of the sensed resistance.

In addition, the cable provides a means for sensing the impending occurrence of a two-block condition through the provision of a normally closed switch between the end of the cable and its electrical connection to the upper-most movable section of the boom. An arm positioned to be engaged by the load connecting block at a point of impending occurrence of a two-block condition cooperates with the switch and opens the switch in response to the impending two-block condition. The open condition of the switch is sensed in response to the current flowing through the cable and the two-block condition can thus be avoided.

In accordance with the preferred embodiment of the invention, the cable and the contactor are fabricated from different electrically conductive metals thereby producing a predetermined thermal EMF characteristic at the contact point therebetween. The thermal EMF characteristic is selected such that the thermal EMF tends to cancel thermal effects on the resistance of the cable due to temperature variations. Such a characteristic is obtained, for example, by employing a brass contactor and a type **304** stainless steel cable.

The manner in which the present invention accomplishes these and other objects and provides further advantages will become apparent to one skilled in the art to which the invention pertains from the following detailed description when read in conjunction with the appended drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a view in elevation of a crane equipped with a boom length and two-block sensing system in accordance with the present invention;

FIG. **2A** is a view in elevation of a portion of the boom illustrating the reel and contactor assemblies of the system of FIG. **1** in greater detail;

FIG. **2B** is a view in cross-section taken along the lines IIB—IIB of FIG. **2A**;

FIG. **3** is a functional diagram schematically illustrating the system of FIG. **1** in greater detail;

FIG. **4** is a circuit diagram illustrating the constant current source and boom length and anti-two-block circuit of FIG. **3** in greater detail;

FIG. **5** is a circuit diagram illustrating another embodiment of the boom length and anti-two-block circuit of FIG. **3**; and,

FIG. **6** is a circuit diagram illustrating a load limit calculating system in accordance with the present invention.

DETAILED DESCRIPTION

FIG. **1** illustrates a crane with an extendible boom employing the system of the present invention to sense boom length and to sense an impending two-block condition. Referring now to FIG. **1**, a take-up reel assembly **10** and a contactor assembly **11** are mounted on the nonextending base **12** of the crane boom in a suitable conventional manner. A sensing cable or wire **14** wound on the reel assembly **10** extends outwardly from the reel and contactor assemblies along the boom to the uppermost movable section or peak **16** of the boom and is there fixedly secured to the peak **16** by suitable electrical insulator **18.** The end of the wire **14** secured to the boom peak **16** is electrically grounded to the boom peak through the normally closed contacts of a suitable switch generally indicated at **20.**

An arm 22 or other suitable member is pivotally connected to the boom peak 16 and is biased out of contact with the actuator of the switch 20 as will hereinafter be described in greater detail. The arm 22 extends beneath the underside of the boom peak and is positioned to be engaged by a loading connecting means such as the illustrated block 23 when the block is raised and approaches a position of contact with the underside of the boom peak. The arm 22 is thereby moved into contact with the actuator of the switch 20, opening the switch 20 and actuating anti-two-block circuitry hereinafter described.

A cable 24 or other suitable means may be utilized to connect the contactor assembly 11 to control and indicating circuitry located in the cab 26 of the crane. Suitable insulators 28 may be connected to various sections of the crane boom to support the wire 14 and guide the wire as it is wound and unwound from the reel assembly 10 through the contactor assembly 11. Additionally, grounding straps or wires may be provided between the boom sections to insure good electrical contact therebetween. Typically, however, such precautions are not necessary since there is usually an adequate return path over the entire length of the boom.

A portion of the boom of the crane illustrated in FIG. 1 is illustrated in greater detail in FIGS. 2A and 2B in order to facilitate an understanding of the invention. Referring now to FIGS. 2A and 2B, the reel and contactor assemblies 10 and 11 include a reel 30 mounted on a bracket 32 secured to the side of the boom base 12. The wire 14 is wound on the reel and extends through an insulated support member 34 and apertures 36 through the assembly housing 38 to the connection 18 on the boom peak 16. The reel 30 is conventionally journaled for rotation on the bracket 32 and is biased by a spring 40 or other suitable means so that the reel 30 applies tension to the wire 14 and tends to wind the wire 14 onto the reel 30 as slack is available.

The reel 30 is preferably electrically insulated from the boom base 12 in a suitable conventional manner. For example, the bracket 32 on which the reel 30 is mounted may be insulated from the boom base 12 by a sheet of non-conductive or insulative material as is generally indicated at 33. Insulative washers 35 and suitable inserts may be provided to prevent contact between the bracket 32 and the fasteners used to mount the bracket 32 to the boom base 12.

The contactor assembly 11 includes a pair of rollers 42 each journaled for rotation on an arm 44 connected to the housing 38 of the assembly. The rollers 42 are mounted so that the wire 14 passes therebetween in electrical contact therewith. To insure good contact, the arms 44 may be spring members mounted so as to force the rollers 42 toward one another and into firm contact with the wire 14 running therebetween. In addition, each of the rollers 42 may be slightly fluted to receive and guide the wire therebetween.

The arms 44 are insulated from the housing 38 in a suitable manner, e.g. through the provision of an insulative arrangement 45 such as that previously described in connection with the mounting of the reel 30 to the boom base 12. Such an arrangement prevents electrical contact between the rollers 42 and the housing 38 so that the rollers are not grounded to the crane.

An electrical connection to the rollers 42 may be made through the connection of an electrical lead or wire 46 to one or both of the arms 44 supporting the rollers 42. To prevent electrical contact between the wire 14 and the housing 38 where the wire 14 passes through the apertures 36, suitable insulative grommets 48 or other insulators may be mounted in the apertures 36 as illustrated. The wire 46 may provide an electrical connection between the portion of the wire 14 in contact with the rollers 42 of the contactor assembly 11 and the circuitry in the cab of the crane thus functioning as the transmission line 24 as was previously described.

In the illustrated embodiment of the contactor assembly 11, the rollers 42 are brass and are journaled for rotation in brass bushings 47. The brass bushings are carried by the arms 44 which are made of a sheet of brass, bent to provide a central portion 49 to which the electrical lead 46 is connected.

The wire 14 is preferably of a metal cable such as a commercially available type 304 stainless steel seven strand aircraft control cable which, at the point of contact with the rollers 42, generates a thermal EMF which varies with temperature in a predetermined manner and tends to cancel the affect of temperature variations on the resistance of the wire 14. In other words, the point of contact between the roller 42 (of one metal) and the wire 14 (of another metal) provides thermo-couple action with the resultant generation of a temperature responsive thermal EMF. By selecting the two metals of the roller 42 and wire 14 such that the thermal EMF varies with temperature in the same manner as the resistance of the wire 14, errors in the length measurement due to changes in the resistance of the wire 14 with temperature may be minimized. With the brass roller and stainless steel cable described above, less than a 3% total error has been obtained between temperatures in the freezing and boiling ranges.

To facilitate an understanding of the operation of the present invention, reference may be had to the boom length and two-block sensing system according to the present invention illustrated schematically in FIG. 3. Referring now to FIG. 3, the circuitry in the cab of the crane includes a constant current source 52 and a boom length and anti-two-block circuit 54 described hereinafter in greater detail. The constant current source 52 may be any suitable circuit for regulating current from an unregulated source such as the vehicle battery indicated at 50.

A desired value of constant current, e.g. a constant 25 milliamp current, is supplied from the constant current source 52 through the boom length and anti-two-block circuit 54 and the contactor assembly 11. The boom length and anti-two-block circuit 54 and the portion of the wire 14 between the contactor assembly 11 and the boom peak 16 are connected in parallel between the constant current source output and ground, thereby presenting two parallel paths for the flow of current supplied by the constant current source 52. Accordingly, the current supplied from the constant current source 52 is divided between the two paths as a function of the impedance presented by the two paths.

As the boom is extended and retracted, the length of the wire 14 between the contactor 11 and the boom peak 16 increases and decreases. The increase and decrease in the length of the wire 14 results in an increase and decrease, respectively, in the resistance of the wire 14 between the contactor assembly 11 and the boom peak 16. Current from the constant current source 52 is thus fed to two paths, one of which presents a constant impedance (the circuit 54) and the other of which presents an impedance varying directly with variations

in boom length.

In addition, the normally closed switch **20** is opened by the arm **22** when the block **23** is raised to a position of engagement with the arm **22**, i.e., a position adjacent the underside of the boom peak **16**, signaling an impending two-block condition. When the switch **20** is opened in this fashion, all of the current normally flowing through the wire **14** is diverted through the boom length and anti-two-block circuit **54** and is sensed as an impending two-block condition. The boom length and anti-two-block circuit **54** may disengage the power to the winch driving the block **23** (not shown) or may otherwise indicate or prevent the impending two-block condition.

One embodiment of the constant current source **52** and the boom length and anti-two-block circuit **54** is illustrated in greater detail in a schematic diagram of FIG. **4**. Referring now to FIG. **4**, the constant current source **52** may be any suitable conventional circuit for supplying a constant output current from the vehicle battery. The positive output terminal of the vehicle battery **50** may be connected through a resistor **56**, a diode **58** and a resistor **60**, the base electrode of a PNP transistor **62** and to the emitter electrode PNP transistor **64**. The collector electrode of the transistor **62** may be connected to the base electrode of the transistor **64** and the collector-base junction may be grounded through series connected resistor **66** and potentiometer **68**. The junction of the cathode electrode of the diode **58** and the resistor **60** may be connected through a diode **70** to the emitter electrode of the transistor **62** and through a reverse poled Zener diode **72** to ground.

The collector electrode of the transistor **64** supplies a constant current to the boom length and anti-two-block circuit **54** and the potentiometer **68** provides a selectively variable dropping resistance as will hereinafter be described in greater detail. The collector electrode of the transistor **64** may be connected directly to the contactor assembly **11** to supply the constant current to the wire **14**. A fuse **74** or other over-current protection device may be provided to protect the constant current source **52** from damage.

The coil of a two-block sensing relay **76** may be connected between the collector electrode of the transistor **64** and ground to provide for anti-two-block sensing. The collector electrode of the transistor **64** may also be connected to one side of a normally closed set of relay contacts **78** and to one side of a set normally open contacts **80**, the contacts **78** and **80** being associated with the relay coil **76**. The other side of the relay contacts **78** may be connected through a suitable meter **82** and a rheostat **84** to the arm of the potentiometer **68** and the constant current source **52**. The other side of the set of relay contacts **80** may be connected through a suitable audible alarm and visual indicator **86** to ground and through a relay coil **88** to ground.

In operation, the constant current source **52** supplies a constant current output both to the contactor assembly **11** and to the boom length and anti-two-block circuit **54**. The total current supplied from the constant current source **52** is divided between the two circuit paths including the path through the contactor assembly **11** and the wire **14** and the path through the boom length and anti-two-block circuit **54** as a function of the impedance of the circuit. The impedance of the boom length and anti-two-block circuit **54** is a constant once the potentiometer **68** and the rheostat **84** have been adjusted to indicate current changes directly on the meter **82** as length changes Therefore, current flows through the respective circuits remains unchanged unless the length of the wire **14** changes.

As the length of the wire **14** varies with variation in boom length, more or less current flows through the movement of the meter **82** thereby providing an indication related to changes in the length of the wire **14** and thus in the length of the boom of the crane. As was previously mentioned, the meter **82** may be callibrated directly in terms of boom length through adjustment of the rheostat **84** and potentiometer **68**.

A slight amount of current flows through the relay coil **76** but the amount is insufficient to energize the relay. However, if the switch **20** is opened through the sensing of an impending two-block condition, a much larger proportion of the current from the constant current source **52** is diverted through the relay coil **76** thereby opening the contacts **78** and closing the contacts **80**. With the contacts **80** closed, an audible and/or visual alarm may be provided by the indicator **86** and the relay coil **88** is energized. The relay coil **88** may operate contacts in the crane winch control circuitry so as to deenergize the winch when the impending two-block condition is sensed. Damage to the hoist cable and/or winch as a result of a two-block condition may thereby be prevented.

It should be additionally noted that the length related signal supplied to the meter **82** may be utilized to provide additional output signals such as boom extension velocity and acceleration. For example, by differentiating the boom length signal with respect to time, the boom extension velocity may be determined. Boom extension acceleration may be determined by a similar conventional technique. The length, velocity and acceleration signals may be readily utilized in installations requiring dynamic analysis and control functions such as that described hereinafter in connection with FIG. **6**.

Another form of the boom length and anti-two-block circuit **54** is schematically illustrated in FIG. **5**. Referring now to FIG. **5**, the constant current output signal from the constant current source **52** may be supplied directly to the contactor assembly **11** through a test/run switch **90**. The output from the constant current source **52** may also be connected through the two-block sensing relay coil **76** to ground and through a boom length indicating circuit **92** to the arm of the potentiometer **68** (FIG. **4**) and the constant current source **52**.

The boom length indicating circuit **92** may include a rheostat **94**, a meter **96** and a rheostat **98** connected in series between the output of the constant current source **52** and the arm of the potentiometer **68**. A set of relay contacts **100** and a current limiting resistor **102** may be connected in series across the meter **96** so as to bypass the meter **96** when the relay contacts **100** are closed.

The positive output terminal of a vehicle battery **50** may be connected to the constant current source **52** as was previously described and through a normally open set of relay contacts **104** to a two-block indicating circuit generally indicated at **106**. The two-block indicating circuit may include a visual indicator **108**, a relay coil **110** and an audible alarm **112**, all of which are arranged to be connected across the vehicle battery when the relay contacts **104** are closed.

In operation, the meter **96** indicates boom length in response to changes in the length of the wire **14** as was previously described in connection with FIG. **4**. When the two-block switch **20** is opened, the relay **76** is ener-

gized and the contacts **100** and **104** are closed thereby bypassing the meter **96** and energizing the two-block circuit **106.** The visual indicator **108,** the relay coil **110** and the audible alarm **112** are thus energized providing visual and audible indications of an impending two-block condition and deenergizing the hoist cable winch circuitry as was previously described.

Since an electrical signal related to boom length is readily available from the boom length and anti-two-block circuit **54,** this signal may be utilized, in conjunction with a boom angle related signal produced by a boom angle indicator and control circuit **118,** to provide load limit calculations as is illustrated in FIG. **6.** Referring now to FIG. **6,** the boom of the crane may be mechanically coupled to the arm of a potentiometer **120** in the boom angle indicator and control circuit **118.** The potentiometer **120** may be connected between a reference voltage V_{REF} and ground. The arm of the potentiometer **120** may be connected through a current limiting resistor **122** and a meter **124** to the arm of a potentiometer **126.**

The potentiometer **126** may be connected as part of a voltage dividing network comprising resistors **128** and **130** connected in series with the potentiometer **126** between the reference voltage V_{REF} and ground. The meter **124** may include two normally open switches **132** and **134** which sense and are closed in response to the respective high and low limits of boom angle. In this regard, the meter **124** may be any suitable conventional meter having movement actuated high and low limit switches (e.g. a Simpson model 29XA, 0–50 microamp meter).

One side of each of the switches **132** and **134** may be connected to the reference voltage V_{REF} and the other side of each of the switches may be connected together and through both an audible alarm **136** and a visual indicator **138** to ground. An output signal from the arm of the potentiometer **120** may be coupled to a conventional load limit calculator **140,** and the boom length related signal from the boom length and anti-two-block circuit **54** may also be supplied to the load limit calculator **140.**

In operation, the boom length and anti-two-block circuit **54** senses a resistance value for the length of the cable **14** between the contactor assembly **11** and the boom peak **16** as was previously described. This resistance value is supplied as a length related electrical signal to the load limit calculator **140** together with a boom angle related signal from the potentiometer **120.** The load limit calculator employs the boom length signal and the boom angle signal in a conventional manner to calculate a maximum safe load limit for a particular sensed boom length and boom angle.

In addition, the meter **124** provides a visual indication of boom angle. If boom angle reaches either a predetermined high or low limit, the associated one of the switches **132** and **134** is closed, applying the reference voltage V_{REF} to the audible alarm **136** and the visual angle limit indicator **138** to provide the operator with an indication that a boom angle limit has been reached.

The present invention may be embodied in other specific forms without departing from the spirit or essential characteristics thereof. The presently disclosed embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

I claim:

1. Apparatus for sensing the length of an extendible boom of a crane comprising:

a reel mounted for rotation on a nonextending portion of the crane boom, said reel being electrically insulated from said boom;

an electrically conductive cable having a substantially uniform resistance per unit length thereof, one end of said cable being secured to and electrically connected to the uppermost movable section of the crane boom and the other end of said cable being wound on said reel;

biasing means for biasing said reel in a direction of rotation tending to wind said cable onto said reel;

means mounted on said nonextending portion of the crane boom adjacent said cable for electrically contacting said cable and providing a moving electrical contact with said cable;

means for applying current to said contacting means to thereby apply said current through a length of said cable between said contacting means and said one end of said cable; and,

circuit means for sensing a resistance value for said length of said cable between said contacting means and said one end of said cable in response to said current flowing therethrough, and for providing a manifestation of the length of the crane boom as a function of the sensed resistance of said length of said cable between said contacting means and said one end of said cable.

2. The apparatus of claim **1** wherein said cable and said contacting means are fabricated from different electrically conductive metals producing a predetermined thermal EMF characteristic at the contact point therebetween, the thermal EMF characteristic being selected such that the thermal EMF tends to cancel thermal effects on the resistance of the cable due to temperature variations.

3. The apparatus of claim **2** wherein said cable is type **304** stainless steel and said contacting means is brass.

4. The apparatus of claim **2** wherein said electrical current is a constant direct current supplied from a constant current source.

5. The apparatus of claim **4** wherein said circuit means includes a meter electrically connected between said contacting means and ground to sense the voltage therebetween.

6. The apparatus of claim **1** wherein said electrical current is a constant direct current supplied from a constant current source.

7. The apparatus of claim **6** wherein said circuit means includes a meter electrically connected between said contacting means and ground to sense the voltage therebetween.

8. The apparatus of claim **1** including a normally closed switch mounted on said uppermost movable section of the crane boom and wherein said cable is electrically connected to said section through said switch.

9. The apparatus of claim **8** including means mounted on said uppermost movable section of the crane boom in cooperable relation to said switch for opening said switch in response to an impending two-block condition and wherein said circuit means includes means electrically connected to said contacting means for sensing an open condition of said switch.

10. The apparatus of claim 9 wherein said electrical current is a constant direct current supplied from a constant current source.

11. The apparatus of claim 10 where said circuit means includes a meter electrically connected between said contacting means and ground to sense the voltage therebetween.

12. The apparatus of claim 11 wherein said cable and said contacting means are fabricated from different electrically conductive metals producing a predetermined thermal EMF characteristic at the contact point therebetween, the thermal EMF characteristic being selected such that the thermal EMF tends to cancel thermal effects on the resistance of the cable due to temperature variations.

13. Apparatus for sensing the length of an extendible boom of a crane and the impending occurrence of a two-block condition comprising:

a reel mounted for rotation on a nonextending portion of the crane boom;

an electrically conductive cable having a substantially uniform resistance per unit length thereof, one end of said cable being electrically connected through a normally closed switch to the uppermost movable section of the crane boom and the other end of said cable being wound on said reel;

means cooperable with said switch and mounted on said uppermost movable section of the crane boom for opening said switch in response to an impending two-block condition;

biasing means for biasing said reel in a direction of rotation tending to wind said cable onto said reel;

means mounted on said nonextending portion of the crane boom adjacent said cable for electrically contacting said cable and providing a moving electrical contact with said cable;

means for applying an electrical current to said contacting means to thereby apply said current through a length of said cable between said contacting means and said one end of said cable;

circuit means for sensing a resistance value for said length of said cable between said contacting means and said one end of said cable in response to said current, and for providing a manifestation of the length of the crane boom as a function of the resistance of said length of said cable between said contacting means and said one end of said cable; and,

circuit means for sensing an open condition of said normally closed switch in response to said current flowing through said cable.

14. The apparatus of claim 13 wherin said electrical current is a constant direct current supplied from a constant current source.

15. The apparatus of claim 14 wherein said circuit means includes a meter electrically connected between said contacting means and ground to sense the voltage therebetween.

16. The apparatus of claim 13 wherein said cable and said contacting means are fabricated from different electrically conductive metals producing a predetermined thermal EMF characteristic at the contact point therebetween, the thermal EMF characteristic being selected such that the thermal EMF tends to cancel thermal effects on the resistance of the cable due to temperature variations.

17. The apparatus of claim 15 wherein said cable and said contacting means are fabricated from different electrically conductive metals producing a predetermined thermal EMF characteristic at the contact point therebetween, the thermal EMF characteristic being selected such that the thermal EMF tends to cancel thermal effects on the resistance of the cable due to temperature variations.

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