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Truax

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[45] **Dec. 3, 1974**

[54] **ANTENNA INSULATION FAILURE DETECTOR**

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[52] **U.S. Cl.** ..... **340/253 R,** 324/133
[51] **Int. Cl.** **G08b 21/00**
[58] **Field of Search** ..... 340/253 R, 248 C, 248 R; 324/133

[56] **References Cited**

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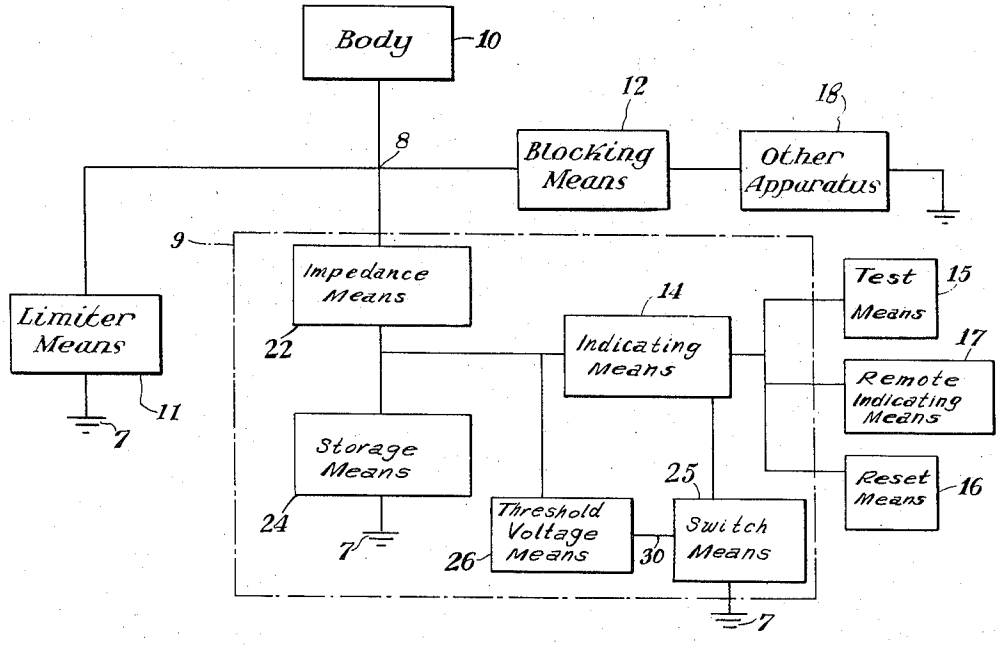
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Primary Examiner—Thomas B. Habecker

[57] **ABSTRACT**

A device for detecting direct current flow of either polarity, in a system, usually due to corona discharge or lightning attachment. The device is unresponsive to alternating currents; and therefore, passes radio frequency signals. The device employs a means for signaling direct current flow and a means whereby it may be reset to be used again.

18 Claims, 2 Drawing Figures



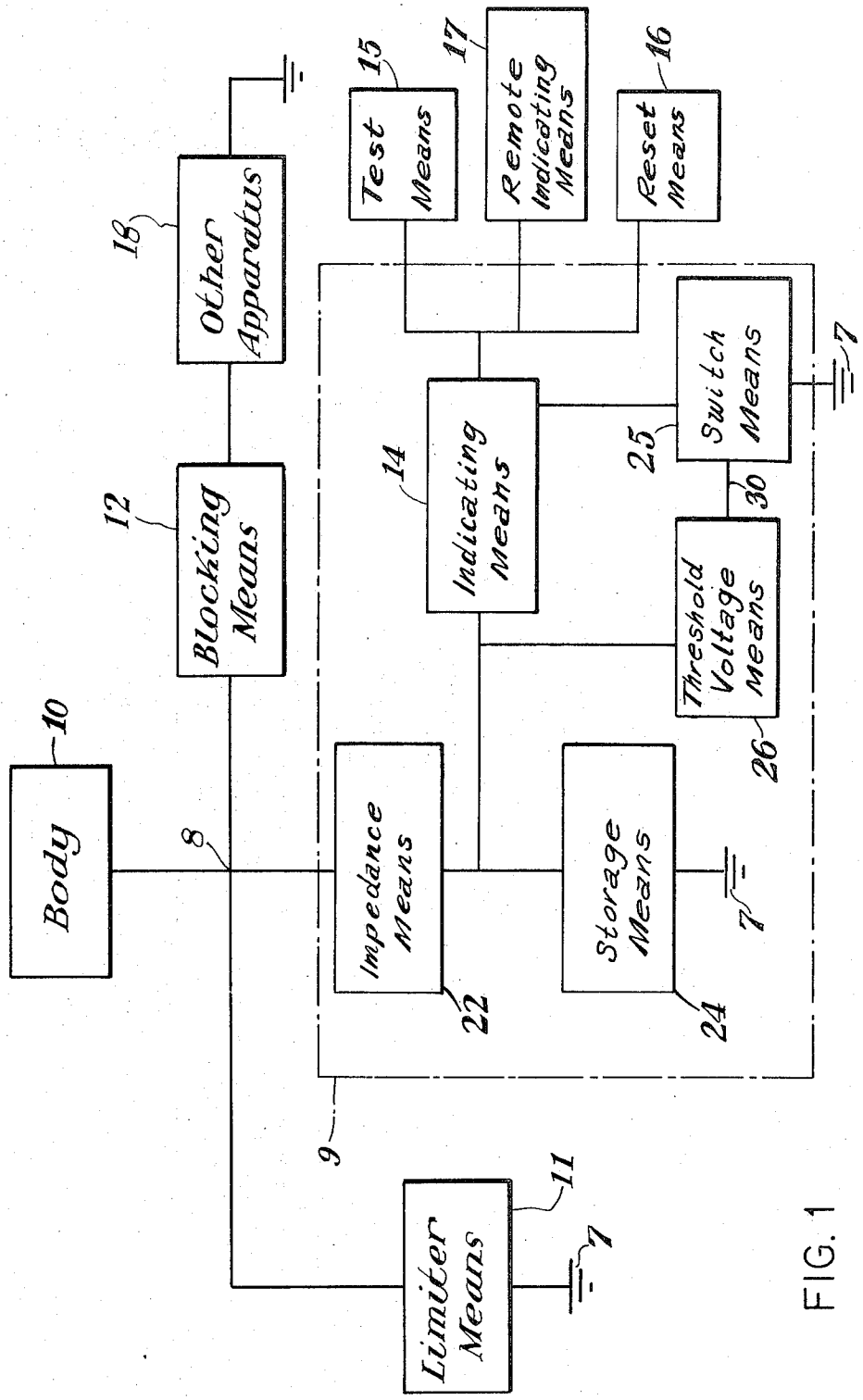

Body
10
8
Blocking Means
12
Other Apparatus
18
Test Means
15
Remote Indicating Means
17
Reset Means
16
Indicating Means
14
Switch Means
25
30
7
Threshold Voltage Means
26
Impedance Means
22
Storage Means
24
7
9
Limiter Means
11
7

FIG. 1

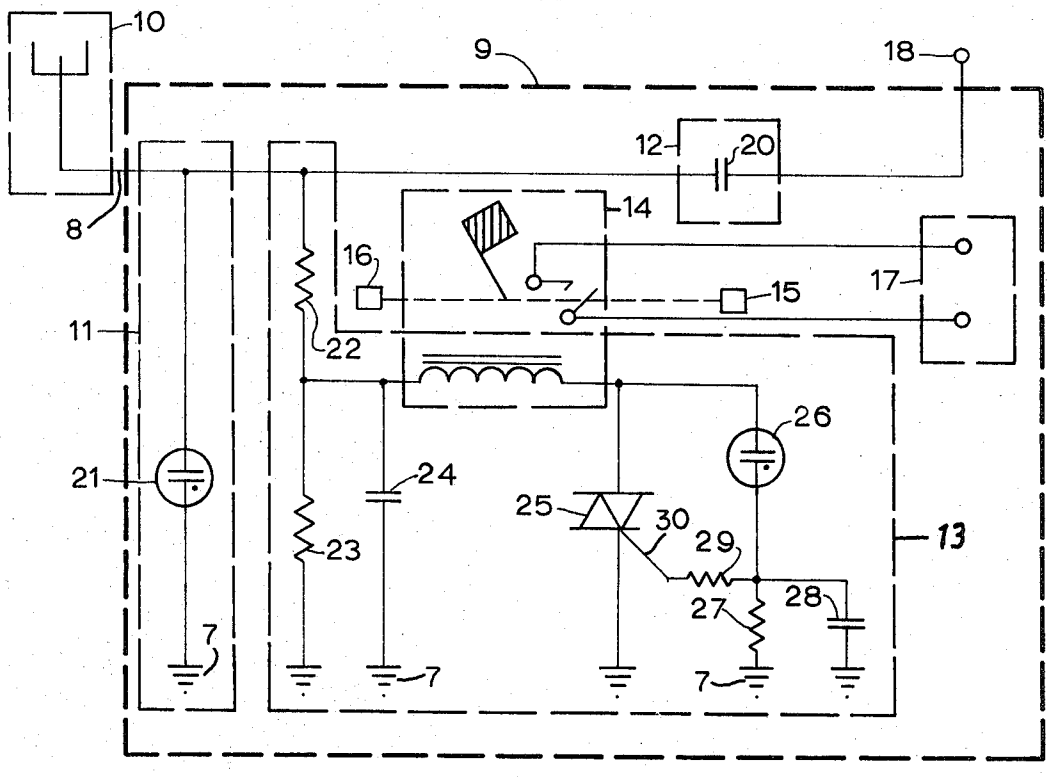


FIG. 2

ANTENNA INSULATION FAILURE DETECTOR

BACKGROUND OF THE INVENTION

Antennas are frequently insulated from the atmosphere to prevent corona discharge and the consequent direct coupling of "precipitation static" (corona discharge) noise to radio receivers. Corona discharge from an uninsulated antenna may result from high electric field gradients, as are present in the vicinity of a thunderstorm, or from the charging of a structure supporting the antenna by tribo-electric or engine ionization means.

Antenna insulation may fail for any number of reasons. The insulation may be inadequate to prevent insulation breakdown during encountered electrical stresses. Vibration may fatigue insulating plastics. Ultraviolet radiation and other mechanisms may age insulation and seals. Lightning may strike and damage the antenna. Physical damage to the insulation may occur due to mishandling, impingement of ice particles or other reasons.

Once the antenna insulation fails the antenna will go into corona whenever an electric field of sufficient magnitude is encountered. This corona discharge will interfere with or disrupt radio reception at frequencies to at least the UHF range. Such interference may be hazardous, especially to aeronautical radio navigation.

Only very sophisticated radio operators can identify most occasions of corona discharge noise interference. Many radio signals are of the data type, where operators do not constantly, or may not be able to, monitor reception signal quality.

Visual inspection of antenna insulation is frequently impractical. Insulation failures are often difficult, if not impossible, to detect visually. The extremely high voltages necessary to create corona discharge from uninsulated antennas may be hazardous, and are therefore seldom, if ever, used to test antennas in the field.

The present invention will detect antenna insulation failures when corona discharge occurs from an antenna and when antenna insulation is punctured by a lightning stroke.

BRIEF SUMMARY OF THE INVENTION

Corona discharge results in a series of direct current pulses, of either positive or negative polarity. In the case of an antenna, these direct current pulses will flow through the antenna circuit to the system ground. Corona currents may vary from a microampere, or less, to several milliamperes. The corona discharge current may occur for periods of a fraction of a second to several hours.

Lightning stroke currents puncturing antenna insulation also result in a direct current flow in the antenna circuitry, which may be of either polarity. The current will flow for periods ranging from a fraction of a second to several seconds, and multiple strokes may attach during an event. Currents may range from a milliampere, or less, to 200,000 amperes or more.

The present invention may be inserted in an antenna system between the antenna and the transmitter/-receiver. Alternating currents, as in radio frequency signals pass through the invention relatively unimpeded by its electronics. Direct currents as are generated by corona discharge or lightning attachment activate this invention.

The invention requires no source of power for its operation, except the direct current energy present when corona discharge occurs from the antenna, or when lightning attaches to the antenna.

The sensitivity of the invention is variable. Component values can be selected so as to cause operation of the monitor at a minimum direct current flow of a few microamperes, or less, to values of several amperes, if desired. The time constant of operation at a given direct current value above the minimum operating current threshold can also be pre-determined.

Upon detection of a direct current the invention may be reset without replacement of any parts.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram of the invention.

FIG. **2** is a schematic drawing of a typical embodiment of the teachings of this invention, using state of the art components.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the drawings and FIG. **1,** in particular, the monitor shown generally by number **9** is coupled by a terminal **8** between a body **10,** typically an antenna, and some other apparatus **18** which it is supposed to monitor, typically a radio receiver/transmitter. The monitor **9** can have within it a potential limiter **11** designed to shunt current to a reference point **7** such as ground when the potential reaches levels that could damage the monitor **9.** The monitor **9** can also have within it a blocking means **12** designed to allow A/C currents to flow to the monitor **9** but to stop D/C current from reaching the apparatus **18.** When direct current is flowing in the system, sensor **13** evaluates its amplitude and duration and, if it determines that the current is substantial, sensor **13** causes means for signaling to show a current flow. Coupled to means for signaling is remote indicating means **17,** which is used to display the current information to a remote observer. In order to make the monitor **9** practicable, a reset means **16** can be coupled to the indicating means **14** so that the monitor **9** may be used again after indicating a D/C current. A test means **15** can be included in the monitor **9,** which when activated, indicates whether or not the monitor **9** is functioning properly.

FIG. **2** is a typical device built according to Applicant's teachings using state-of-the-art components. Antenna **10** is coupled to monitor **9** which is coupled to radio receiver/transmitter **18.** The blocking means **12** is a capacitor **20** in the radio frequency line. Capacitor **20** is chosen so as to achieve minimum impedence, and to minimize other undesirable effects, at the operating radio frequencies. The potential limiting means **11** is a lightning gap arrester **21,** or other device for limiting potential across the monitor circuitry and capacitor **20** chosen to protect the monitor from excessive voltages on the antenna. The breakdown potential of this lightning arrester **21** is selected so as to be lower than the direct current working voltage of capacitor **20.** And, at the same time, higher than the voltage drop across the resistance bleeder network and the operating components of the monitor. In some embodiments the potential limiting means **11** may be omitted.

Impedance means **22** is a radio frequency isolation resister chosen to prevent undesirable radio frequency energy leakage to ground, or into the operating components of the monitor. At the same time resistor **22** must not excessively impede the flow of direct current corona discharge or lightning pulse energy from the antenna **10** to capacitor **24** and other monitor components. Resistor **22** also functions as one of the elements in the monitor that determine the monitor operating time constant. In most embodiments, resistor **22** will vary from a few thousand ohms to many megohms.

Resistor **23** is a static drain means or bleeder resistance. This resistor provides a "static current drain" to ground. It may also function to establish the minimum direct current operating point of the monitor. It can also be chosen to effect the monitor operating point. It can also be chosen to effect the monitor operating time constant. In various embodiments resistor **23** may range in value from less than 100,000 ohms to more than 100 megohms. In other embodiments it may be omitted, in which case the leakage resistance of capacitor **24** and the electrical paths through the TRIAC **25,** threshold voltage means **26** and resistor **27** provide the "static current drain" path.

Capacitor **24** functions as a direct current storage means for corona discharge and lightning currents from the antenna **10.** The capacitance may be varied to meet specific requirements. The monitor operating time constant is partially a function of capacitor **24.** The direct current working voltage of capacitor **24** must be high enough to provide a safe margin over the voltage required to operate the monitor and the capacitance must be sufficient to store enough energy to positively actuate the indicating means **14** when that voltage is reached. Further, the insulation resistance of capacitor **24** must be such that, at the chosen operating voltage of threshold voltage means **26** and the desired current sensitivity of the overall device, the leakage current through capacitor **24** is not excessive. In practice capacitor **24** may have a capacitance ranging from a few tens of picofarads to several microfarads.

Indicating means **14** may be any of several switching, signaling or indicating devices that are dependent upon a flow of direct current, of either polarity, to operate. It may be a latching device that holds after actuation, or it may indicate each instance of current flow through the monitor circuitry. It may also indicate the value of current flow. Indicating means **14** in conjunction with storage means **24,** may also be used to prevent excessive transmitter radio frequency energy from reaching and possibly damaging threshold voltage or trigger means **26** or the switch means **25.** In the embodiment shown in FIG. **2,** the means for signaling **14** is a latching relay or solenoid. Means for signaling **14** is chosen to operate at a voltage somewhat lower than that required to breakdown the trigger means **26** and at a current compatible with the storage means **24** and the switch means **25** chosen. The choice of a latching relay or solenoid was shown in FIG. **2,** to illustrate several methods of signaling an antenna insulation failure and one method of "self-testing" the indication system. When operating as a latching system, provision of a reset means **16** is required if the detector is to be used again. In the embodiment shown, a mechanical indication of antenna insulation failure is incorporated. Further, a circuit to ground is closed to simultaneously provide for a remote warning indication **17,** such as a light or other indicator. The grounding circuit, mechanical indication and latching operation may be verified by use of the test means **15.** After such test the monitor may be reset. The actuating voltages and currents of indicating means **14** may vary widely, dependent upon the desired operating parameters of the monitor and component choices for the monitor. Voltages from a few millivolts to hundreds of volts are practical, as are currents from the microampere to hundreds of milliamperes, or even several amperes, range.

The threshold voltage means or trigger means **26** is a device for providing a signal to the control terminal **30** of the normally-open switch means **25** and in this particular embodiment a trigger input to the gate **30** of TRIAC **25.** It may be any device that permits current to flow when a threshold voltage is reached. This includes, but is not limited to, avalanche diodes, ionizing gas tubes, thyratrons and spark gaps. It must also prevent current flow when some minimum voltage is reached, thereby opening the switch means **25** by gating the TRIAC **25** off, so that capacitor or storage means **24** may again charge to a potential sufficient to again operate trigger means **26.** It must have characteristics such that potentials of either polarity will result in a current flow. Current capacity of threshold voltage means or trigger means **26** must be such that it can pass, without damage, any current that can flow from capacitor **24** through the indicating means or means for signaling **14** and resistor **22.** The threshold potential at which current flows through trigger means **26** is selected to provide a margin exceeding the minimum operating voltage of means for signaling **14.**

Resistor **27** is in series with trigger means **26.** Current flow through trigger means **26** creates a voltage drop across resistor **27.** The resistance of resistor **27** may be any value that will result in a potential sufficient to trigger the gate-controlled silicon switch generally referred to as a TRIAC **25** by placing a signal on the control terminal or gate **30.**

Capacitor **28** is used in embodiments where the current through trigger means **26** is insufficient to trigger the TRIAC **25** gate. Its value is such as is required to supply the necessary signal or gate trigger current and, in conjunction with the impedence of trigger means **26** at a time constant consistant with other time constants of the monitor.

Resistor **29** is used in embodiments where it is necessary, or desirable, to limit the TRIAC **25** gate trigger current.

The TRIAC **25** functioning as a normally-open switch presents a very high impedence to potentials of either polarity, until the control terminal or gate **30** is triggered. When the gate is triggered the impedence of the TRIAC **25** approaches a short circuit. Since both the TRIAC **25** and trigger means **26** can be in series with means for signaling **14,** all, or nearly all, of the energy stored in capacitor **24** is shorted to ground through means for signaling **14.** By a proper choice of component values throughout the monitor, this energy then operates the means for signaling **14.** The TRIAC **25** is chosen to have a V_{DRM} exceeding the voltage drop across trigger means **26** and resistor **27.** It is chosen to have gate trigger characteristics compatible with the characteristics of trigger means **26,** resistor **27,** capacitor **28,** and resistor **29.** The TRIAC **25** is also chosen to have current and power dissipation characteristics

exceeding the energy stored in capacitor **24** and that necessary to operate means for signaling **14**.

The instant invention has been shown and described herein in what is considered to be the most practical and preferred embodiment. It is recognized, however, that departures may be made therefrom within the scope of the invention and that obvious modifications will occur to a person skilled in the art.

What I claim is:

1. An apparatus for monitoring a direct current between a body normally electrically insulated from a reference point and said reference point, said apparatus comprising:

A. a terminal, insulated from a reference point, adapted to be connected to a body,

B. storage means, connected between said terminal and said reference point, for storing energy,

C. indicating means, connected to said storage means, for indicating the occurrence of direct current therethrough,

D. normally open switch means, connected to said indicating means and to said reference point, for connecting said indicating means to said reference point when the switch means is closed, the switch means having a control terminal for closing the switch means in response to a signal on said control terminal, and

E. threshold voltage means, connected to said control terminal and responsive to a potential on said storage means, for closing said normally open switch means by placing a signal on said control terminal when the potential on said storage means reaches a predetermined voltage.

2. The apparatus of claim **1** further comprising impedance means, connected between said terminal and said storage means, for preventing the flow of radio frequency energy through said threshold voltage means to said reference point.

3. The apparatus of claim **1** further comprising potential limiting means, connected between said terminal and said reference point, for shunting excessively high potentials to said reference point.

4. The apparatus of claim **1** further comprising static drain means, connected between said terminal and said reference point, for draining static charge from said storage means.

5. The apparatus of claim **1** wherein said indicating means is a latching relay responsive to a current flowing through said switch means.

6. The apparatus of claim **1** wherein the normally open switch means is a gate-controlled silicon switch.

7. An apparatus for monitoring a direct current between an antenna normally electrically insulated from a ground and said ground comprising:

A. a terminal insulated from ground and adapted to be connected to an antenna,

B. a capacitor connected between said terminal and ground for storing energy,

C. a relay, connected to said capacitor, for indicating the occurrence of direct current therethrough,

D. a gate controlled silicon switch, connected between said relay and ground, for connecting said relay to ground when the silicon switch is conducting, the silicon switch having a control terminal for causing the silicon switch to conduct in response to a signal on said control terminal, and

E. threshold voltage means, connected to said control terminal and responsive to a potential on said capacitor, for causing said gate controlled silicon switch to conduct by placing a signal on said control terminal when the potential across said capacitor reaches a predetermined voltage.

8. The apparatus of claim **7** wherein the threshold voltage means is an avalanche diode.

9. The apparatus of claim **7** further comprising a resistor, connected between said terminal and said capacitor, for preventing the flow of radio frequency energy through said threshold voltage means to ground.

10. The apparatus of claim **7** further comprising a resistor connected in parallel with said capacitor between said terminal and ground for draining static charge from said capacitor.

11. The apparatus of claim **7** further comprising an avalanche diode, connected between said terminal and ground, for shunting excessively high potentials to ground.

12. The apparatus of claim **7** wherein said relay is a latching relay.

13. The apparatus of claim **12** further comprising means for resetting said latching relay to an unlatched position.

14. The apparatus of claim **7** further comprising a resistor connected between said threshold voltage means and said silicone switch control terminal for limiting the current to said control terminal.

15. The apparatus of claim **7** further comprising means for testing for correct operation of said relay.

16. The apparatus of claim **7** further comprising indicating means, remotely positioned from and connected to said relay, for remotely indicating the occurrence of a direct current therethrough.

17. An apparatus for monitoring a direct current between a body normally electrically insulated from a reference point and said reference point, said apparatus comprising:

A. a terminal, insulated from a reference point, adapted to be connected to a body,

B. storage means, connected between said terminal and said reference point, for storing energy,

C. indicating means, connected to said storage means and adapted for repeated operation, for repeatedly indicating the occurrence of direct current therethrough,

D. normally open switch means, connected between said indicating means and said reference point, for connecting said indicating means to said reference point when the switch means is closed, the switch means having a control terminal for closing the switch means in response to a signal on said control terminal, and

E. threshold voltage means, connected to said control terminal and responsive to a potential on said storage means, for closing said normally open switch means by placing a signal on said control terminal when the potential on said storage means reaches a predetermined voltage.

18. The apparatus of claim **17** wherein said body is an antenna having insulation thereon and said storage means is adapted to store energy from a current resulting from a failure of said insulation.

* * * * *

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3852734 Dated December 3, 1974

Inventor(s) Robert L. Truax

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Inventor's address should be Fort Myers.

Column 4, line 19, the word "when should read ---until---.

Column 6, line 29, the word "silicone" should read

---silicon---.

Signed and sealed this 13th day of May 1975.

(SEAL)
Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents
and Trademarks

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