Aug. 19, 1969 D. E. HANSEN 3,462,755

CAPACITY ALARM

Filed April 26, 1966 3 Sheets-Sheet 1

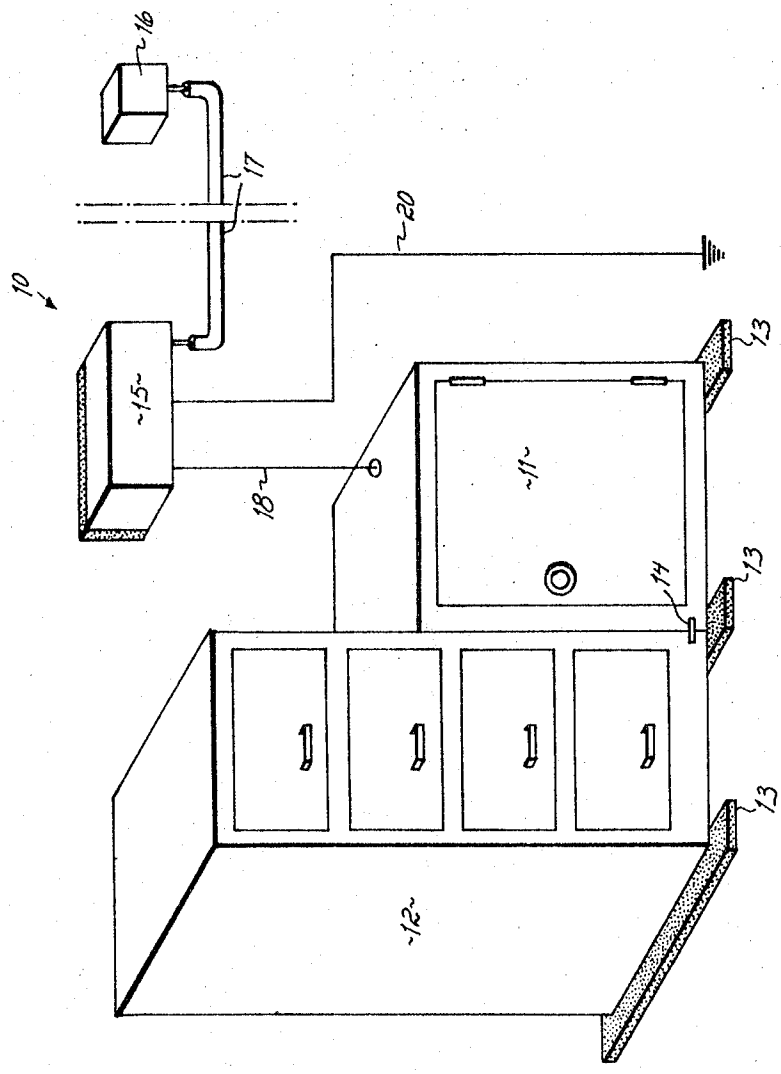


Fig. 1

INVENTOR
Donald E. Hansen
BY
Wood, Herron & Evans
ATTORNEYS.

Aug. 19, 1969 D. E. HANSEN 3,462,755

CAPACITY ALARM

Filed April 26, 1966 3 Sheets-Sheet 2

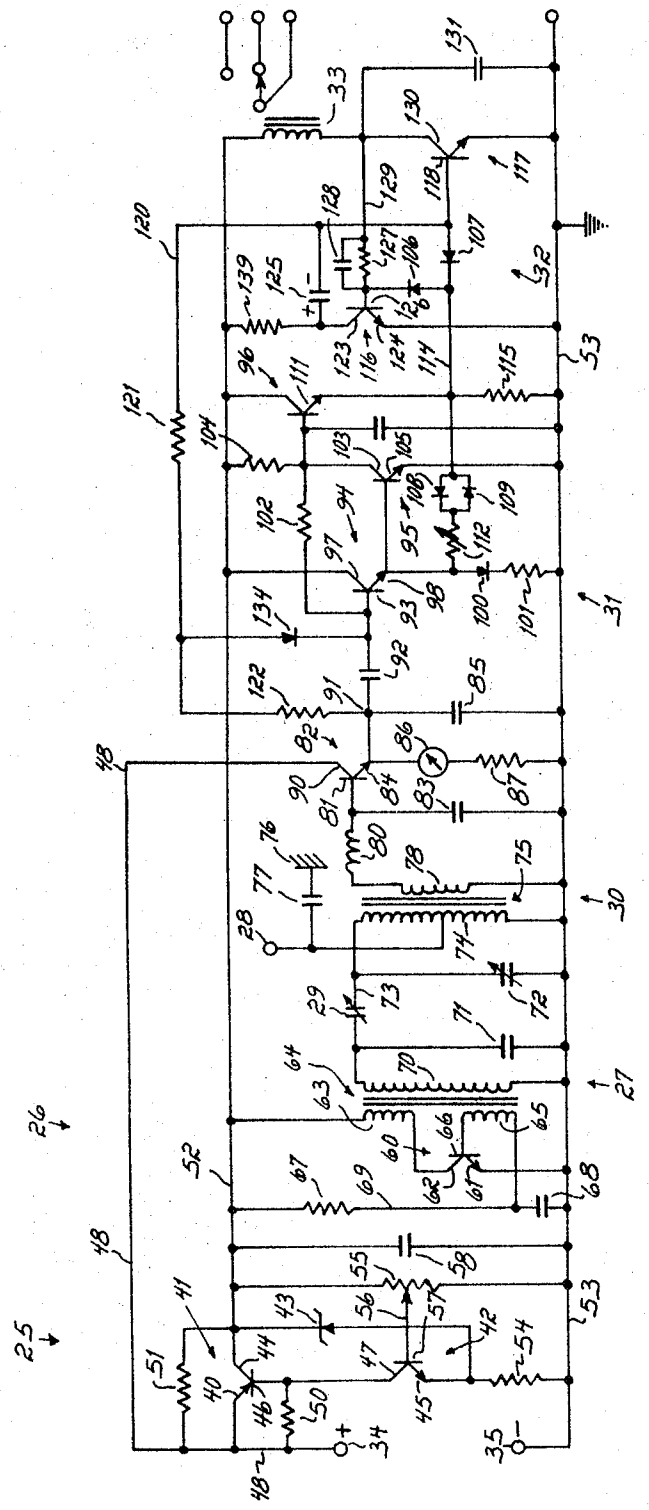


Fig. 2

INVENTOR
Donald E. Hansen
BY
Wood, Herron & Evans
ATTORNEYS.

Aug. 19, 1969 D. E. HANSEN 3,462,755

CAPACITY ALARM

Filed April 26, 1966 3 Sheets-Sheet 3

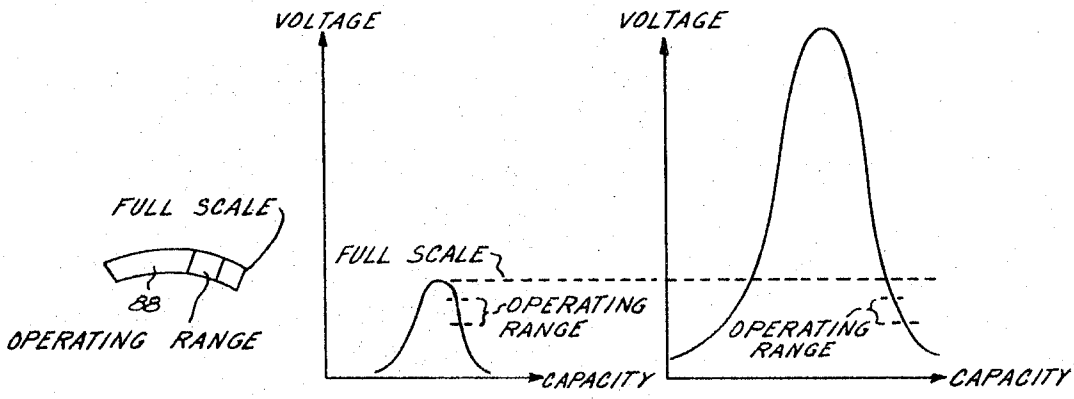


Fig. 3A Fig. 3B Fig. 3C

INVENTOR
Donald E. Hansen
BY
Wood, Herron & Evans
ATTORNEYS.

United States Patent Office 3,462,755 Patented Aug. 19, 1969

3,462,755

CAPACITY ALARM

Donald E. Hansen, Brookfield Center, Conn., assignor to Mosler Research Products, Inc., Danbury, Conn., a corporation of Delaware

Filed Apr. 26, 1966, Ser. No. 545,465
Int. Cl. G08b 13/26
U.S. Cl. 340—258 8 Claims

ABSTRACT OF THE DISCLOSURE

A capacity type intruder alarm system, including an oscillator and a tuned resonant circuit. The tuned resonant circuit includes an antenna formed by equipment being protected. The detector senses changes in oscillations due to intrusion. The detector normally has a predetermined output signal which rises or drops due to the presence of an intruder. This detector output is amplified and applied to a multivibrator. When the detector output changes in either direction, the multivibrator is flipped to actuate an alarm. High and low fail-safe circuits are provided. The unit also includes a regulated power supply and a variable capacitance coupling between the oscillator and detector.

This invention relates to intrusion alarm systems and is particularly directed to a novel alarm system of the capacity type.

Capacity alarm systems are utilized in many different types of installations to protect small areas or selected equipment against unauthorized intrusion. Thus, in a typical installation, a capacity alarm system can be utilized in a store or office to protect storage units, such as safes, file cabinets and the like.

Conventionally, a capacity alarm system includes an oscillator having a tuned resonant circuit comprising an inductance and a capacitance. This tuned resonant circuit also includes an antenna, a portion of which is preferably constituted by the files or other equipment being protected. The oscillator thus establishes a radio frequency energy field in the area surrounding the equipment being protected. A detector is provided for sensing changes in the oscillations resulting from an introduction of an object or intruder into the field. In the present alarm system, the output from the detector is applied to an amplifier which in turn controls operation of a one-shot multivibrator. When this multivibrator shifts from one state to another, it actuates an alarm relay resulting in an alarm signal being sent from the protected area to the remote alarm station. The alarm relay can also be used to actuate a local alarm, or both a local and remote alarm.

One of the principal objects of the present invention is to provide an alarm system which is several times more sensitive than previously proposed systems of this type, and which at the same time is very stable. Thus, one of the present alarm units can protect an area or a number of pieces of equipment which previously required several alarm units. This not only results in greater economy, but also eliminates problems inherent in the interaction of a number of oscillators.

A second object of the present invention is to provide a capacity alarm which can readily be set up in a wide variety of environments to have a preselected sensitivity despite differences in power factors due to differing environmental conditions.

Another object of the present invention is to provide a capacity alarm which does not utilize a meter relay and yet is actuated in response to either an increase or decrease in capacity. It will be appreciated that when an intruder approaches the protected equipment, the capacitance of the antenna circuit is increased. On the other hand, when the intruder withdraws, or moves away from the equipment, the capacitance of the system is decreased. The present alarm system is effective to provide an alarm in response to either an increase or decrease in capacity. As a result, the probability of an intruder's causing an alarm is greatly increased.

A further object of the present invention is to provide a capacity alarm which will be actuated in response to the presence of either a high or a low voltage at the detector output. As a result, the present system is effective to automatically provide an alarm in the event of power failure, the application of an antenna ground, an external signal, component failure or the like.

It is still another object of the present invention to provide a capacity alarm in which drain upon the self-contained battery, or other power sources, is minimized. Thus, for example, a typical alarm of the present type can be operated from conventional dry cells for a period in excess of one year.

More particularly, a preferred form of capacity alarm constructed in accordance with the principles of the present invention is powered from an unregulated dry cell or battery, the output of which is applied to a voltage regulator. This regulator maintains the battery output voltage at a predetermined fraction; for example, 60% of the maximum battery potential. The regulated voltage is applied to a voltage limited oscillator circuit. The oscillator applies an AC voltage to a resonant tank circuit. The provision of a regulated voltage driving the oscillator is not only effective to increase battery life, but also to maintain a constant voltage across the resonant circuit. This in turn stabilizes the sensitivity of the entire alarm system.

The present alarm system further includes a variable capacitor coupling the oscillator and detector. This variable coupling capacitor provides means for controlling the sensitivity of the alarm from unit to unit so that the same sensitivity can be maintained in all units despite changes in power factor due to differing environmental conditions.

More particularly, the variable coupling capacitor is set initially so that the meter of the alarm unit reads full scale under the worst power factor conditions likely to be encountered. The unit is then further adjusted by means of a trimmer capacity so that it operates at a point approximately 70% of the full scale meter voltage. As is explained in detail below, when the unit is operated in an installation presenting more favorable power factor conditions, the trimmer capacity is readjusted to return the meter to the same voltage reading. This results in an operation in which the change in voltage for a given change in capacitance is substantially the same as it was under the worst power factor conditions.

The present alarm system further includes a one-shot multivibrator adapted to be actuated by an amplified signal taken from the detector output. The one-shot multivibrator is effective to cause an alarm in the event that there is either an increase or decrease in capacity in the oscillator tuned resonant circuit. This multivibrator is also effective to provide both a high and a low fail-safe. Thus, an alarm is actuated if there is a potential either above or below predetermined limits in the detector output circuit. As a result, the present alarm system is effective to provide an alarm not only in the event of intrusion, but also in the event of battery, or other components, failure or attempted compromise, e.g. by the application of an external potential to the alarm circuit or by grounding of the antenna.

These and other objects and advantages of the present invention will be more readily apparent from a considera-

tion of the following detailed description of the drawings illustrating a preferred embodiment of the invention.

In the drawings:

FIGURE 1 is a semi-diagrammatic perspective view of a typical installation of the present alarm system.

FIGURE 2 is a schematic circuit diagram of the present alarm system.

FIGURES 3A, 3B and 3C are diagrammatic views showing the relationship between meter readings and voltage versus capacity curves for this system at the worst power factor and at a more optimum power factor.

As shown diagrammatically in FIGURE 1, in one typical installation an alarm system **10** is utilized to protect a bank of storage equipment, including a safe **11** and a file **12**. It will be appreciated, however, that the present alarm system can be utilized to protect many different types of equipment in stores, offices and the like. The units being protected are insulated from ground as indicated diagrammatically by strips of dielectric material **13** and are electrically tied together as by means of conductive strips **14**. The alarm system **10** comprises a local unit **15** mounted within the area being protected and a remote unit **16**. The remote alarm unit **16** may be located at a central guard station or the like.

The local unit **15** and remote unit **16** are interconnected by means of a suitable conductive cable arrangement **17**. The local unit **15** is interconnected to the safe and file being protected as by means of conductor **18**. As a result, the safe and file unit form part of the antenna system of the alarm unit. The local unit **15** is also provided with a ground line indicated at **20**.

The details of the alarm circuit are best shown in FIGURE 2. As there shown, the alarm includes a DC voltage regulator **25** which supplies regulated voltage to a transistorized oscillator circuit **26**. The transistorized oscillator circuit includes a parallel resonant tank circuit indicated at **27**. The oscillator is connected to an antenna system **28** including the apparatus, such as safe **11** and file **12**, being protected. Oscillator **26** is effective to radiate low radio frequency energy through this antenna system into the area surrounding the file and safe unit. As a result, an electrostatic field of stored low radio frequency energy is established surrounding this equipment. The alarm circuit further includes a detector **30** including a high Q-detector coil which is coupled to the oscillator through a variable capacitor **29**. This coil is also tied to the antenna system and is tuned to the frequency of the oscillator. Any increase in capacity to ground in the resonant circuit is effective to cause a voltage drop across the coil, while a decrease in capacitance will cause an increase in voltage across the coil.

The detector signal is in turn fed to a DC amplifier **31**. Amplifier **31** is connected to a one-shot multivibrator indicated at **32**. This multivibrator in turn controls energization of an alarm relay **33**. When this latter relay is dropped out, an alarm is energized at the central, or remote, unit **16**. Alternatively, an alarm can be actuated at the local unit **15**, or an alarm can be energized at both the local and remote units.

Considering the circuit in more detail, the voltage regulator portion of the circuit **25** includes terminals **34** and **35** adapted to be connected to an unregulated three-volt battery or dry cell. Positive terminal **34** is connected to the emitter **40** of transistor **41**. Transistor **41** and transistor **42** form a series voltage regulator with Zener diode **43** providing the voltage reference element. This Zener diode is connected between the collector **44** of transistor **41** and the emitter **45** of transistor **42**. The base **46** of transistor **41** is interconnected to the collector **47** of transistor **42**. Base **46** is also connected through resistor **50** and lead **48** to battery terminal **34**. This resistor is provided to reduce the effect of leakage current of transistor **41**. A second resistor **51** interconnects lead **48** and a lead **52**, lead **52** in turn being joined to collector **44** and diode **43**. Resistor **51** is provided to insure starting of the regulator.

Negative battery terminal **35** is connected to a common line **53** which is grounded. A resistor **54** interconnects this line and emitter **45** of transistor **42**. A potentiometer winding **55** is shunted between lines **52** and **53**. The tap **56** of this potentiometer is tied to base **57** of transistor **42**. Potentiometer **55** is adjusted to provide a voltage substantially less than the maximum voltage of the dry cells or battery connected between terminals **34** and **35**. For example, in one preferred embodiment, the dry cells connected between these terminals have three-volt maximum potential, while potentiometer **55** is adjusted to maintain a 1.8 volt potential at collector **44**. A capacitor **58** is also shunted between lines **52** and **53**.

The regulated output voltage from regulator **25** is applied to the oscillator circuit **26**. This circuit includes a transistor **60**, the emitter **61** of which is tied to line **53**. The collector **62** of transistor **60** is joined to primary winding **63** of transformer **64**. Winding **63** is also connected to lead **52**. A second primary winding **65** of transformer **64** is interconnected to the base **66** of transistor **60** and to a lead **69**. Lead **69** is interconnected to line **52** through resistor **67** to provide bias for transistor **60**. Lead **69** is also interconnected to line **53** through R.F. capacitor **68**. The secondary winding **70** of transformer **64** is shunted by capacitor **71**. These two components constitute the parallel resonant tank circuit of the oscillator. Secondary winding **70** and capacitor **71** determine the R.F. output of the oscillator circuit. Preferably, the output frequency is in the low radio frequency range; for example, 15 kc.

Oscillator **26** operates as a voltage limited oscillator, i.e. with the oscillator collector **62** swinging through the full applied voltage at the loads which are applied. Consequently, the AC voltage across the parallel resonant circuit **27** remains constant at the value determined by the voltage regulator **25**.

The oscillator output is coupled to the detector circuit **30** through variable coupling capacitor **29**. A trimmer capacitor **72** interconnects ground line **53** and lead **73** which is joined to the coupling capacitor.

This trimmer capacitor is connected in parallel with primary winding **74** of detector transformer **75**. One lead of winding **74** is tied to common line **53**, while the other lead of the transformer is connected through lead **73** to coupling capacitor **29**. The antenna system **28**, including files **12** and safe **11**, is connected through lead **18** to an intermediate tap on primary winding **74**. The casing **76** of the alarm unit **15** is preferably also connected to lead **18** through capacitor **77**. As a result, all of the circuitry of the local alarm unit mounted within local unit **15** is protected since casing **76** in effect forms part of the antenna system.

Detector transformer **75** is provided with a secondary winding **78** having one lead connected to common line **53**. The other lead of this winding is connected through choke **80** to the base **81** of detector transistor **82**. Base **81** of transistor **82** is also connected to common line **53** through a capacitor **83**. The choke **80** and capacitor **83** function to suppress high frequency signals which might be picked up in the antenna circuit. The output current flowing through emitter **84** is filtered by a capacitor **85** and is fed to a meter **86**. One terminal of meter **86** is connected to emitter **84** while the second terminal is connected through resistance **87** to the common line **53**. Meter **86** is a DC current meter, the scale **88** of which is illustrated in FIGURE 3A. It will be noted that the collector **90** of transistor **82** is connected to positive terminal **34** through lead **48**.

The detector output signal appears at junction **91**. This output is coupled through capacitor **92** to the base **93** of transistor **94**. Transistor **94** together with transistors **95** and **96** form a direct coupled stabilized amplifier. Transistor **94** is a high impedance input stage allowing a reduction in size of the coupling capacitor **92**, while

retaining an adequate time constant. The collector **97** of this transistor is connected to line **52**, while the emitter **98** is connected through a diode **100** and resistor **101** to common lead **53**. Transistor **95** is a common emitter stage stabilized from a feedback through resistor **102**, this resistor being interconnected between the collector **103** of transistor **95** and the base **93** of transistor **94**. The collector **103** of transistor **95** is also connected through resistor **104** to line **52**. Emitter **105** of this transmitter is connected to common line **53**.

Transistor **96** provides a low impedance output for the amplifier and a stabilized voltage to the input of diodes **106** and **107**. Two other diodes **108** and **109** are joined to the emitter **111** of transistor **96**. These diodes are connected in parallel and are joined to emitter **98** of transistor **94** through potentiometer **112**. Potentiometer **112** controls the gain of the amplifier and consequently the sensitivity of the alarm system. Diodes **108** and **109** in the gain circuit compensate for the change in voltage drop with temperature of diodes **106** and **107**.

The output of the amplifier is taken from emitter **111** of transistor **96**. This emitter is tied to coupling lead **114**. A resistor **115** is connected between this lead and common line **53**. Lead **114** is connected to the one-shot multivibrator formed by transistors **116** and **117**. The base **118** of transistor **117** normally receives bias voltage through a low voltage fail-safe circuit. Specifically, this circuit includes lead **120** and resistors **121** and **122** which are effective to interconnect base **118** to junction **91** (the detector output). As a result, transistor **117** is normally biased on.

The other transistor **116** of the multivibrator includes a collector **123** which is joined to lead **52** through a resistor **139** and an emitter **124** connected to common line **53**. A capacitor **125** is interconnected between collector **123** and lead **120**. This capacitor is normally charged with the polarity shown in FIGURE 2. The base **126** of transistor **116** is connected through the parallel combination of resistor **127** and capacitor **128** and through lead **129** to the collector **130** of transistor **117**. Rectifiers **106** and **107** interconnect the base **118** of transistor **117** with the base **126** of transistor **116**.

It is to be understood that transistor **116** is normally biased off and transistor **117** is normally biased on. The collector circuit of transistor **117** includes the coil of relay **33** and a bypass capacitor **131**. It is to be understood that the relay is provided with suitable contacts arranged so that as long as the relay is held energized, no alarm is is given. However, when the relay drops out in response to the turn-off of transistor **117**, an alarm signal is given. This may cause a local alarm to be sounded, a remote alarm to be sounded, or both. The circuits actuated by the contacts of relay **33** are conventional and no detailed explanation is considered necessary.

In addition to these components, the alarm circuit includes a high voltage fail-safe circuit including a diode **134**, one side of which is connected between resistors **121** and **122**, and the other side of which is connected to base **93** of transistor **94**. In operation, if the alarm unit is operating normally, diode **134** is non-conductive. However, if the voltage rises, diode **134** becomes conductive. This causes the amplifier output voltage (**114**) to drop and if this condition persists, the alarm unit will cycle in and out of alarm.

The initial set-up and manner of operation of the present alarm unit can best be appreciated from a consideration of FIGURE 3A, 3B and 3C in conjunction with FIGURE 2. More particularly, prior to shipment of the present alarm system, coupling capacitor **29** is normally adjusted so that the needle of meter **86** reaches full scale with a full antenna load and a shunt resistor representing the worst power factor which should be encountered using reasonable care in installing the system. With this loading the trimmer capacitor **72** is then increased to cause the meter needle to be brought within the operating range.

FIGURE 3B represents a Q-curve at the worst possible power factor. The operating range is chosen so that it preferably lies at about 70% of the full scale voltage on the voltage capacity curve of FIGURE 3B.

It will, of course, be appreciated that most installations are not made under load conditions which give the worst power factor. Rather, the installations are made under more favorable power factors. The Q-curve of a system operating at a better power factor is illustrated in FIGURE 3C. When the alarm system is actually installed under conditions resulting in the better power factor represented by FIGURE 3C, the trimmer capacitor **72** is adjusted to bring the meter needle into the operating range which is still approximately 70% of the maximum voltage at the worst power factor. It will be seen that the alarm is thus operating in a substantially lower portion of the Q-curve than would be the case if the unit were set to operate at 70% of the maximum voltage of the curve in FIGURE 3C.

At this lower operating point which is actually obtained through the initial adjustment of variable capacitor **29**, a much lower rate of change of voltage with capacity, i.e. vV/dC, is obtained. This rate of change of voltage with capacity more nearly approximates that obtained under the original condition as shown in FIGURE 3B. Thus, it is relatively easy to install a number of alarm systems of the present type in various environments having quite different power factors so that the alarms will have generally the same sensitivity. In other words, a given increase in capacity caused by an intrusion will result in approximately the same change in detector voltage in each of the alarm systems.

After an alarm system has been installed and adjusted, the multivibrator is normally in a condition in which transistor **117** is turned on and transistor **116** is turned off. Capacitor **125** is charged to the polarity shown. If a person intrudes upon a protected area and approaches the protected units, such as the filing cabinets or safe, he causes an increase in capacity of the system relative to ground of the tuning circuit. This causes a drop in the voltage across winding **78** and a drop in the rectified voltage at junction **91**. The voltage in lead **114** at the output of the amplifier rises. When the voltage at lead **114** rises to a certain point, diode **106** begins to conduct, turning on transistor **116**. When transistor **116** turns on, the capacitor **125** begins to discharge, turning off transistor **117**. This causes relay **33** to drop out, establishing an alarm signal. If the voltage in lead **114** has returned to normal when the capacitor **125** is fully reverse charged to approximately one-half volt, transistor **117** turns on, turning off transistor **116**. Relay **33** is again energized and the system is ready for another alarm. (It will, of course, be appreciated that if desired, the circuit energized by the contacts of relay **33** can be provided with a hold-in arrangement effective to maintain the alarm signal despite recycling of the multivibrator and reenergization of relay **33**.)

The present alarm system is also effective to detect and cause an alarm in response to a decrease in capacitance such as that which would accompany a movement by an intruder away from the protected area. In the case of such a withdrawal, there is a decrease in capacitance and an increase in voltage at junction **91**. This in turn causes a decrease in voltage in the amplifier output lead **114**. In such a case, diode **107** becomes conductive. This again results in the turning off of transistor **117** and the turning on of transistor **116**. When transistor **117** is turned off, it drops out relay **33** causing an alarm signal as explained above.

Capacitance **125** again goes through a discharge and reverse charging cycle. If as before when capacitor **125** is completely reverse charged to one-half of a volt, the voltage at lead **114** is returned to normal, transistor **117** turns on and transistor **116** turns off so that the system is ready for a subsequent alarm.

In addition to providing for an alarm in the event of an increase or decrease in capacitance, the present system also provides an alarm in the event of an increase or decrease in detector output signal. Specifically, the system is protected against a low detector output signal by a low fail-safe circuit directly interconnecting the base of transistor **117** with the detector output at junction **91**. This circuit includes resistors **121** and **122** and lead **120**. Should the detector voltage drop below a predetermined limit (for example to one-third the full scale voltage of meter **86**), the base current of transistor **117** will be reduced to a point at which the relay **33** is dropped out causing an alarm signal. This low fail-safe circuit is thus effective to supervise the oscillator and antenna circuits against power failure, component failure, antenna grounds and the like.

The system is also protected against a high detector output voltage by a high fail-safe circuit including voltage divider resistors **122** and **121** and diode **134**. When the alarm unit is operating in the normal range, diode **134** is non-conductive. However, if the detector output voltage at junction **91** rises, diode **134** becomes conductive. This will cause the voltage in lead **114** to drop, deenergizing transistor **117** and dropping out relay **33**. If the high voltage persists, the alarm unit will cycle in and out of alarm as explained above.

Having described my invention, I claim:

1. A capacity alarm system comprising an oscillator, a tuned resonant circuit connected to said oscillator, said resonant circuit including antenna means, a detector for sensing changes in capacitance in said tuned resonant circuit, said detector normally having a predetermined DC output potential, and developing changes in said DC potential in response to changes in said capacitance, amplifier means for amplifying said changes of DC potential, a multivibrator having an input lead connected to said amplifier means and having an output circuit effective to energize an alarm relay, said multivibrator normally being in a first state when said detector output signal corresponds to said predetermined DC potential, said multivibrator being shifted from said first to a second state to cause actuation of said relay in response to either a rise or fall in the voltage output of said amplifier means, said changes of DC potential corresponding to an increase or decrease in capacitance in said tuned resonant circuit.

2. The capacity alarm system of claim **1** including a low voltage fail-safe circuit interconnecting said detector and said multivibrator, said low voltage fail-safe circuit being effective to cause said multivibrator to shift to said second state when said DC potential of said detector drops below a predetermined level.

3. The capacity alarm system of claim **2** in which said low voltage fail-safe circuit comprises a resistive connection between said detector and said multivibrator, said fail-safe circuit normally providing operating bias for holding said multivibrator in said first state.

4. The capacity alarm system of claim **1** in which the connection between said oscillator and detector comprises a variable capacitance and in which said detector circuit includes a DC meter adapted to be set at full scale reading by adjustment of said variable capacitance.

5. The capacity alarm system of claim **1** in which said oscillator is a voltage limited oscillator and in which voltage regulator means are provided for applying power to said oscillator, said detector, said amplifier and said multivibrator.

6. The capacity alarm system of claim **1** including a high voltage fail-safe circuit interconnecting said detector and said amplifier, said high voltage fail-safe circuit being effective to cause said multivibrator to shift to said second state when said DC potential of said detector rises above a predetermined level.

7. The capacity alarm system of claim **6** in which said high voltage fail-safe circuit comprises a voltage divider network interconnecting said detector and said multivibrator, a normally non-conductive diode connected to the voltage divider network, said diode becoming conductive upon a rise of detector output above a preselected level and being effective to cause said multivibrator to shift to said second state.

8. The capacity alarm system of claim **2** further including a high voltage fail-safe circuit interconnecting said detector and said amplifier, said high voltage fail-safe circuit being effective to cause said multivibrator to shift to said second state when said DC potential rises above a predetermined level.

References Cited

UNITED STATES PATENTS

3,041,592	6/1962	Schmidt	340—258
3,235,857	2/1966	Bagno	340—258 X
3,255,380	6/1966	Atkins et al.	340—258 X
3,309,689	3/1967	Keeney	340—258

JOHN W. CALDWELL, Primary Examiner

D. L. TRAFTON, Assistant Examiner

U.S. Cl. X.R.

331—75, 112; 340—276