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[54] **ALARM SYSTEM**

[72] Inventors: **Siegfried Domin,** 22053 Independencia Street, Woodland Hills, Calif. 91364; **Roy Nembhard,** 1710 South Orange Drive, Los Angeles, Calif. 90019

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[58] **Field of Search**.....340/258 R, 258 C; 317/146; 331/66, 109, 183; 330/28, 59

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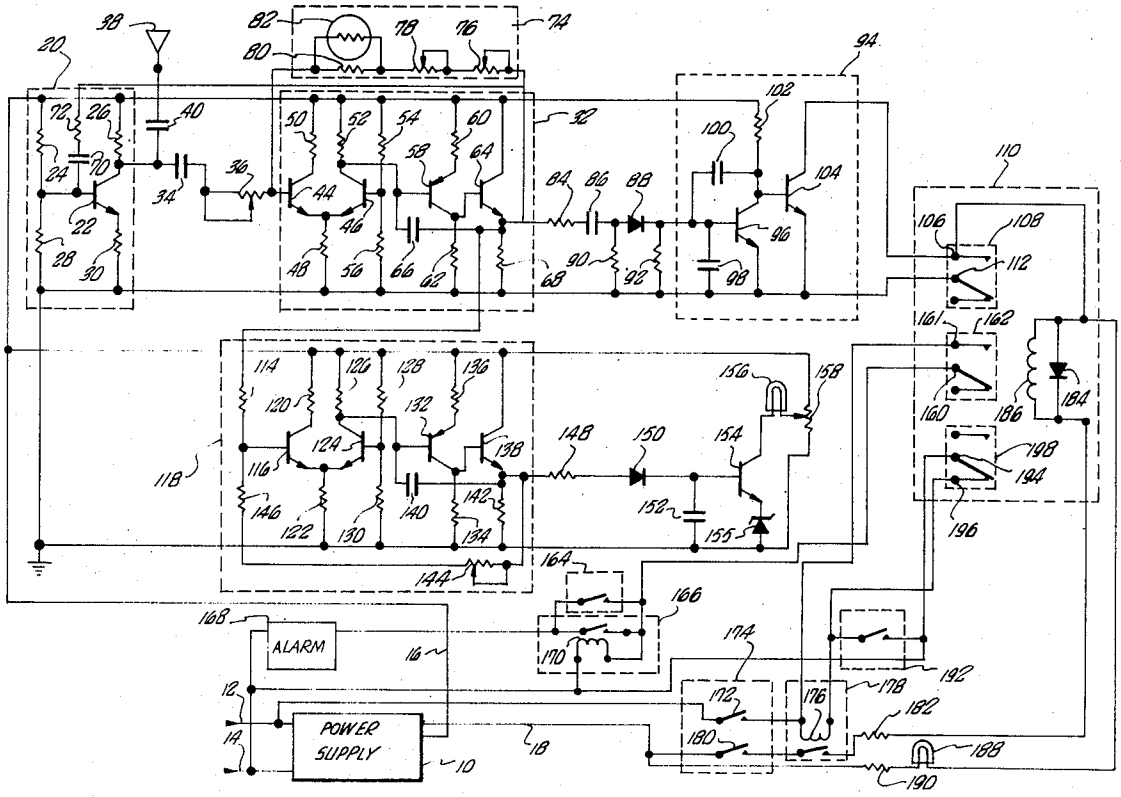
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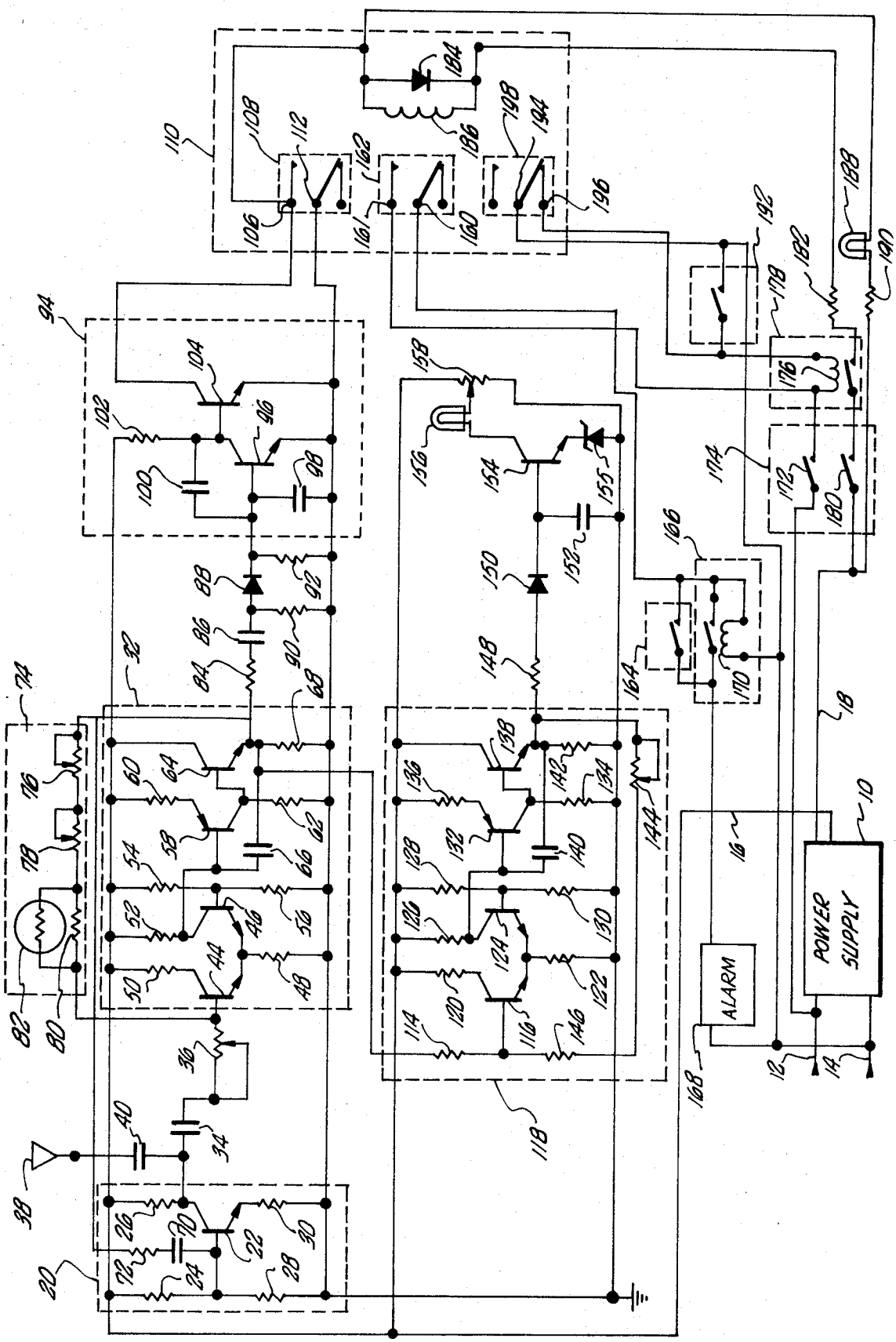
Primary Examiner—John W. Caldwell
Assistant Examiner—Robert J. Mooney
Attorney—Golove, Kleinberg & Morganstern and Richard Morganstern

[57] **ABSTRACT**

A capacitive alarm system for detecting the presence of an intruder, including an oscillator, a level sensitive switch driven by the oscillator, an alarm controlled by the switch, and an antenna coupled to the oscillator. Changes in capacitance in the proximity of the antenna vary the level of the oscillator output and, in the presence of an intruder, trigger the switch and alarm. A negative feed-back network, including a light-sensitive variable resistor, is connected to the oscillator. The output of the oscillator also drives a lamp that illuminates the light-sensitive variable resistor. Slowly varying changes in capacitance, due to variations in temperature and humidity, vary the level of the oscillator output and the intensity of the light from the lamp. The variation in intensity of illumination from the lamp directly varies the resistance of the light-sensitive variable resistor so as to maintain the level of the oscillator output constant. The long-time constant of the lamp and the light-sensitive variable resistor circuit prevents compensation for the rapid variations in capacitance associated with the appearance of an intruder.

13 Claims, 1 Drawing Figure




POWER SUPPLY
ALARM

ALARM SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to proximity detectors and, more particularly, to a capacitive alarm system.

2. Description of the Prior Art

Capacitive type alarm systems find use in many types of installations to detect and signal the occurrence of an unauthorized intrusion into the proximity of the area protected by the installation. One exemplary use is in the protection of a private residence. In this application, a capacitance alarm system can be utilized to detect the presence of a prowler or burglar within close proximity of the residence.

Another application is in the hospital field. In this application, capacitive alarm systems can be used in conjunction with a nurse call system wherein patients request a nurse. In many cases, the patient is too weak or incapable of pushing the standard call button or calling for aid. With a capacitive alarm system, a patient need only place his hand or arm in proximity to the capacitive alarm sensor in order to initiate a call request. Capacitive alarm systems are useful in many applications due to their inherent ability to detect "-proximity" events as opposed to other systems which require for activation some direct or indirect contact with a portion of the system.

Most prior art capacitance alarm systems include an oscillator having a tuned resonance circuit comprising an inductance and a capacitance. The tuned resonance circuit also includes an antenna placed in the area to be protected. The antenna may be a piece of wire, a window screen, or even the object to be protected. The oscillator, in conjunction with the antenna, establishes a radio frequency energy field in the area surrounding the installation being protected. The introduction of a foreign object or an intruder into the field results in a change in capacitance between the antenna and ground, and thus in the resonant circuit. This change in capacitance causes a variation in the frequency of the oscillation of the oscillator circuit. A detector is normally provided to sense changes in the oscillations and to actuate an alarm relay. The alarm relay can be used to actuate a local alarm such as a bell, buzzer, or siren, or can produce an alarm signal to be sent to a remote position.

In most applications, it is necessary to provide an alarm system that is insensitive to variations in capacitance due to humidity changes or temperature changes. Changes in humidity and in temperature produce changes in the capacitance between the antenna and ground. Prior art systems of the kind described are unable to distinguish variations in capacitance due to the presence of an intruder from those due to changes in humidity or temperature. Consequently, these systems produce erroneous alarms due to changes in atmospheric conditions.

It is also desirable to provide a capacitive alarm system in which adjustments can be readily and easily made for various antennas. Since most installations have different physical layouts, varying antenna lengths and types must be employed. Since the antenna length and type affects the level and frequency of the oscillator output, prior art systems cannot readily accommodate such antenna variations.

SUMMARY OF THE INVENTION

In accordance with the present invention, a capacitive alarm system is provided which overcomes the above-noted difficulties. Briefly described, an oscillator, driving a level sensitive switch, is provided. Changes in the capacitance in the field of an antenna attached to the oscillator vary the level of the oscillator output so as to trigger the switch and initiate an alarm.

The oscillator includes a negative feedback network, containing a light-sensitive variable resistor. A lamp, driven by the oscillator output, illuminates the light-sensible variable resistance. Variations in the level of the oscillator output due to changes in capacitance caused by variations in humidity and temperature vary the intensity of the light from the lamp. The resulting variation in intensity of illumination upon the light-sensitive variable resistor results in a correction in the level of the oscillator output, making the alarm insensitive to variations in humidity and temperature.

The alarm system of the present invention thus automatically compensates for variations in humidity and temperature. The system is insensitive to variations in capacitance due to changes in atmospheric conditions, yet is responsive to changes in capacitance due to the introduction of an intruder.

The invention further provides means by which the sensitivity of the system can be readily adjusted in order to accommodate various antenna lengths and types.

Still other features and attendant advantages of the invention will become apparent to those skilled in the art from the reading of the following description of a preferred embodiment.

BRIEF DESCRIPTION OF THE DRAWINGS

An embodiment of the invention is disclosed more fully in the following detailed description taken together with the accompanying drawing in which:

The FIG. is a schematic diagram of an exemplary capacitive alarm system constructed in accordance with the principles of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to the FIG., there is shown an embodiment of the capacitive alarm system, constructed in accordance with the principles of the invention. D.C. power supply **10** is adapted to receive standard 15 volts A.C. power available from commercial utilities on input terminals **12** and **14**. D.C. power supply **10** converts the alternating current input signal to a D.C. bias signal appearing on D.C. bias line **16** and a D.C. relay driver signal appearing on driver line **18**. Any well known D.C. power supply design such as a diode bridge, full-wave, rectified D.C. and regulated power supply may be employed.

A linear amplifier **20** is provided. Linear amplifier **20** is comprised of transistor **22** and associated biasing resistors. Bias resistor **24** is connected between D.C. bias line **16** and the base of transistor **22**, while bias resistor **26** is connected between D.C. bias line **16** and the collector of transistor **22**. Resistor **28** is connected between the base of transistor **22** and ground potential, while resistor **30** is connected between the emitter of transistor **22** and ground potential. The collector of

transistor 22 serves as the output of linear amplifier 20 and is coupled to the input of operational amplifier 32 by the series combination of capacitor 34 and variable resistor 36. Antenna 38 is coupled to the collector of transistor 22 by D.C. decoupling capacitor 40.

Variable resistor 36 is connected to the base of transistor 44 which is the input for operational amplifier 32. The emitter of transistor 44 is connected to the emitter of transistor 46. Resistor 48 is connected between the emitters of transistors 44 and 46 and ground potential. Resistor 50 is connected between the collector of transistor 44 and D.C. bias line 16, while resistor 52 is connected between the collector of transistor 46 and D.C. bias line 16. Resistor 54 is connected between D.C. bias line 16 and the base of transistor 46 while resistor 56 is connected between the base of transistor 46 and ground potential. The collector of transistor 46 is connected to the base of transistor 58. The emitter of transistor 58 is coupled to D.C. bias line 16 by resistor 60. The collector of transistor 58 is coupled to ground potential by resistor 62 and is connected directly to the base of transistor 64. The collector of transistor 64 is connected directly to D.C. bias line 16. Capacitor 66 is coupled between the base of transistor 58 and the emitter of transistor 64. Resister 68 is connected between the emitter of transistor 64 and ground potential. Capacitor 70 and resistor 72 are connected in series to form a positive feedback network and are connected between the base of transistor 22 and the emitter of transistor 64. Negative feedback network 74 is connected between the base of transistor 44 and the emitter of transistor 64. One side of coarse variable resistor 76 is connected to the emitter of transistor 64. The other side of variable resistor 76 is connected to one side of fine variable resistor 78. The other side of fine variable resistor 78 is connected to one side of the parallel combination of resistor 80 and light-sensitive variable resistor 82. The other side of this combination is connected to the base transistor 44. Light-sensitive variable resistor 82 functions as a variable impedance element in negative feedback network 74.

The output of operational amplifier 32, which appears at the emitter of transistor 64, is coupled by resistor 84 and D.C. decoupling capacitor 86 to the anode of rectifier diode 88. Resistor 90 is connected between the anode of diode 88 and ground potential. The cathode of diode 88 is connected to the input of level sensitive switch 94 at the base of transistor 96. Capacitor 98 is connected between the base of transistor 96 and ground potential. Resistor 102 is connected between D.C. bias line 16 and the collector of transistor 96. The emitter of transistor 96 is connected to ground potential and the collector of transistor 96 is connected to the base of transistor 104. The emitter of transistor 104 is connected to ground potential. The collector of transistor 104 is connected to contact 106 of contact bank 108 of relay 110. Armature 112 of contact bank 108 is connected to ground potential. Transistors 96 and 104 with their associated biasing circuitry form a level sensitive switch having a normal state in which transistor 96 is saturated and transistor 104 is off and an alarm state in which transistor 96 is out of saturation and transistor 104 is on.

Resistor 114 is connected between the emitter of transistor 64 and the base of transistor 116 of operational amplifier 118. Resistor 120 is connected between the connector of transistor 116 and D.C. bias line 16, while resistor 122 is connected between the emitter of transistor 116 and ground potential. The emitter of transistor 116 is also connected to the emitter of transistor 124. Resistor 126 is connected between the collector of transistor 124 and D.C. bias line 16, while resistor 128 is connected between D.C. bias line 16 and the base of transistor 124. Resistor 130 is connected between the base of transistor 124 and ground potential. The collector of transistor 124 is connected to the base of transistor 132. Resistor 136 is connected between the emitter of transistor 132 and D.C. bias line 16, while resistor 134 is connected between the collector of transistor 132 and ground potential. The collector of transistor 132 is also connected to the base of transistor 138. The collector of transistor 138 is connected to D.C. bias line 16. Capacitor 140 is connected between the base of transistor 132 and the emitter of transistor 138. Resistor 142 is connected between the emitter of transistor 138 and ground potential. One side of variable resistor 144 is connected to the emitter of transistor 138. Resistor 146 is connected between the other side of variable resistor 144 and the base of transistor 116. Resistor 148 is connected between the emitter of transistor 138 and the anode of diode 150. Capacitor 152 is connected between the cathode of diode 150 and ground potential. The emitter of transistor 154 is connected to the cathode of zener diode 155. The anode of zener diode 156 is connected to ground potential. The collector of transistor 154 is connected to one side of lamp 156. Transistor 154 and the associated biasing circuitry constitute a lamp driver for lamp 156. The other side of lamp 156 is connected to the center tap of potentiometer 158.One of the ends of potentiometer 158 is connected to D.C. bias line 16, while the other end is connected to ground potential. Armature 160 of contact bank 162, one side of switch 164 and one side of thermally activated switch 166, are interconnected as shown. The other sides of switches 164 and 166 are connected together and to alarm 168. Switch 166 is a thermally activated switch with one side of heating coil 170 connected to A.C. input terminal 14 and the other side connected to armature 160. Alarm 168 is also connected to A.C. input terminal 14. One side of pole 172 of double pole single throw on-reset switch 174 is connected to A.C. input terminal 12, while the other side is connected to one side of heating coil 176 of thermally actuated switch 178. One side of pole 180 of switch 174 is connected to driver line 18. The other side of pole 180 is connected to one side of thermally actuated switch 178. The other side of thermally actuated switch 178 is connected to one side of resistor 182. The other side of resistor 182 is connected to the cathode of diode 184. The anode of diode 184 is connected to contact 106 of contact bank 108. Armature coil 186 is connected across diode 184. The anode of diode 184 is also connected to one side of approach indicator lamp 188. Resistor 190 is connected between the other side of approach indicator 188 and driver line 18. Manual automatic reset switch 192 is connected between one side of heater coil 176 and contact 196 of

contact bank **198**. In addition, manual automatic reset switch **192** is connected between armature **194** and A.C. input terminal **14**.

In operation, the closing of on-reset switch **174** applies A.C. power to heating coil **176** and D.C. power to one side of thermal actuated switch **178**. After about **10** seconds, heating coil **176** reaches sufficient temperature to close switch **178**. The purpose of this delay is to permit an authorized person to set the alarm and walk away from the installation through the antenna path without activating the alarm. The delayed activation of thermal switch **178** applies D.C. power to relay **110**.

Transistor **22**, with its associated biasing resistors forms linear amplifier **20** having a voltage gain of approximately **10**. Transistors **44**, **46**, **58** and **64** form operational amplifier **32**, which appears at the emitter of transistor **64**, is fed back to the input of the linear amplifier by means of the positive feedback network comprised of resistor **72** and capacitor **70**. This combination of linear amplifier **20** and differential amplifier **32** forms a positive feedback amplifier which functions as an oscillator. The frequency of the oscillation is dependent upon the values of the capacitor **70**, resistor **72**, and the antenna length. In one application, the frequency of the oscillation is dependent upon the valves of the capacitor **70** and resistor **72**. In one application, the frequency of oscillation was 100 KHz. The output of operational amplifier **32** is also fed back to its input through negative feedback network **74** comprised of variable resistors **76**, **78**, and the parallel combination of resistor **80** and light sensitive variable resistor **82**. This feedback network controls the gain of operational amplifier **32**. This combination of amplifier **32** and negative feedback network **74** comprises a differential operational amplifier. POtentiometer **76** serves as a course adjustment for the gain of operational amplifier **32**, while variable resistor **78** serves as the fine adjustment. Antenna **38** is connected to the output of linear amplifier **20** by means of capacitor **40** which serves to D.C. isolate antenna **38**. Antenna **38** may be composed of solid or stranded wire, braid, or any type of metallic element connected by a wire. In one application, an antenna of one-fourth inch braided wire, 100 feet in length, was used successfully. In residential applications, metallic screens found on the windows could serve as suitable antennas. Alternatively, metallic tape positioned around door and window frames is another suitable arrangement. While the frequency of oscillation is determined primarily by the valves of capacitor **70** and resister **72**, the frequency is also varied slightly by the antenna. The length of the antenna, and the surroundings in which the antenna is mounted, will determine the final frequency. Variable resistor **36** provides very coarse adjustment for accommodating antennas of varying lengths and types. The sensitivity adjustments available from variable resistors **76** and **78** cannot accommodate the large variations which could occur from widely varying antennas. Variable resistor **36** provides for this compensation.

The oscillating output signal of operational amplifier **32** appearing at the emitter of transistor **64** is rectified by diode **88** in conjunction with the resistor **92** and capacitor **98** to produce a D.C. signal. Capacitor **98** serves to filter the rectified output. Resistor **84** prevents transistor **64** from being overloaded by the base of transistor **96**. Capacitor **86** serves to decouple the base of transistor **96** from any D.C. voltage from operational amplifier **32**. The rectified signal biases transistor **96** on, which in turn biases transistor **104** off. With transistor **104**, off relay **110** is not activated. It is activation of relay **110** that initiates the alarm.

The system is initially adjusted by means of variable resistors **78** and **76** These resistors adjust the sensitivity of operational amplifier **32** by varying the negative feedback. The adjustment is performed with on-reset switch **174** open. Resistor **76** is varied until approach indicator **188** goes out. At this point, transistor **104** is off and transistor **96** is in saturation.

The presence of an object or an intruder within the field of the antenna causes a variation in the capacitance to ground as seen by the antenna. This increased capacitance increases the load on the output of linear amplifier **20**, thus reducing the level of the oscillating signal appearing at the output of operational amplifier **32** and at the base of transistor **96**. A reduction in the current available at the base of transistor **96** brings transistor **96** out of saturation, causing the collector of transistor **96** to go positive. This positive excursion at the base of transistor **104** turns transistor **104** on, bringing one side of armature coil **186** toward ground potential, activating relay **110** and switching the armature of relay **110**. When armature **160** of contact bank **162** contacts contact **161**, the A.C. power signal is impressed across heater coil **170** of thermally actuated switch **166**. In addition, the A.C. signal appearing at input terminal **12** is impressed on one side of switch **164** and on one side of switch **166**. If switch **164** is in a closed position, this A.C. potential is applied to alarm **168** to initiate the alarm. If switch **164** is open, a delay is experienced before thermally actuated contact switch **166** closes to apply the A.C. voltage to alarm **168**. The purpose of this delay is to permit authorized personnel to enter the field of the alarm and to turn off the alarm within a fixed period of time, usually about 10 seconds.

If manual automatic switch **192** is in the open position, actuation of relay **110** will break the connection between armature **194** and contact **190** of contact bank **198**, thereby removing the A.C. power from heating coil **176** on thermally actuated switch **178**. After heating coil **176** cools, switch **178** will open. With relay **178** open, D.C. power is removed from relay **110**, causing the relay to go back to the normal state so that the system is reset. It switch **192** is closed, power would not be removed from heating coil **178**, therefore, D.C. power would not be removed from relay **110** so that resetting of the alarm would have to be done manually through the use of on-reset switch **174**.

The activation of relay **110** also causes armature **112** to contact contact **106** of contact bank **108**, thereby holding one end of relay **110** at ground potential. This serves to insure that the contact of relay **110** will stay on, even though the intruder or object that has entered the antenna field has left the area.

The output of operational amplifier **32** serves as the input to operational amplifier **118**. The level of the signal at the operational amplifier **118** which appears at the emitter of transistor **138** is directly proportional to the level of the output of operational amplifier **32**. The

signal appearing at the output of operational amplifier **118** is rectified by diode **150** in conjunction with capacitor **152**. This rectified signal serves to bias transistor **154** either on or off. The gain of amplifier **118** is adjusted by variable resistor **144**. As the level of the oscillator output signal appearing at the emitter of transistor **64** decreases, the level of the output of operational amplifier **118** will decrease. This decrease results in a lower level bias signal appearing at the base of transistor **154**, resulting in a lower potential appearing across lamp **156**. This reduced potential reduces the illumination from lamp **156** and consequently the intensity of the illumination received by light sensitive variable resistor **82**. This increased resistance reduces the negative feedback from the output of operational amplifier **32** to the input, causing the level of the signal at the output of operational amplifier **32** to increase. Thus, slow variations in the capacitance related effects in the field of the antenna which cause an increase or a decrease in the level of the signal at the output of operational amplifier **32** are compensated by the operation of operational amplifier **118** in connection with lamp **156** and photo light-sensitive variable resistor **82**. The combination of lamp **156** and light-sensitive photo resistor **82** operates with a long-time constant. This long-time constant prevents the compensation network from compensating for a rapid variation in capacitance, such as that occasioned by the introduction of an intruder. Variations in temperature and humidity, however, normally occur over a long period of time and very slowly. The above described feedback combination is capable of accommodating these types of changes while not interfering with the normal operation of the alarm system.

Variable resistor **158** serves to prevent false alarms in the event of momentary power failure. If power fails momentarily, lamp **156** would go out and light-sensitive variable resistor would receive no illumination and would increase in resistance. The resulting decrease in negative feedback on operational amplifier **32** would cause the oscillator output to be of a high level upon the resumption of power. This high level output signal would be coupled through operational amplifier **118** to turn transistor **154** on hard. If variable resistor **158** were not present, a large voltage drop would appear across lamp **156** producing an intense illumination of light sensitive variable resistor **158** which would severely reduce the output of operational amplifier **118** so as to initiate an alarm. Variable resistor **158** limits the voltage drop across lamp **156** to a level that would not initiate a false alarm.

Operational amplifier **118** and lamp **156** and its driving circuitry, operate in conjunction with negative feedback network means for compensating for the slow variations in the level of the output of operational amplifier **32** caused by variations in capacitance between antenna **38** and ground due to variations in humidity or temperature.

We claim:

1. A capacitive alarm system for detecting an intrusion into the proximity of the system, comprising:

oscillator means having a range of self-resonant operating frequencies for producing an output signal, the level of said output signal being substantially constant within said operating range;

antenna means coupled to the oscillator means for varying the level of the output signal in response to variations in capacitance between the antenna means and ground;

a level sensitive switch having a normal and an alarm state, said switch being coupled to the oscillator means output and being responsive to variations of predetermined magnitudes in the level of the oscillator means output signal to change from said normal to said alarm state;

an alarm coupled to the level sensitive switch and responsive to change in state of the level sensitive switch to produce an alarm signal; and

feedback means coupled to the oscillator means and having a long time constant relative to variations in capacitance due to intrusion in the proximity of the antenna means for maintaining the level of the oscillator means output signal relatively constant over a wide range of slow variations in capacitance between the antenna means and ground, whereby variations in atmospheric conditions will not trigger said alarm.

2. The apparatus defined in claim **1** wherein the feedback means includes a negative feedback network in which the amount of feedback varies as a function of the level of the oscillator means output signal for slow variations in capacitance between the antenna means and ground due to variations in atmospheric conditions.

3. The apparatus defined in claim **2** wherein the negative feedback network includes a variable impedance element and wherein the feedback means includes conditioning means for varying the impedance of the variable impedance element in response to the level of the oscillator means output signal.

4. The apparatus of claim **3** wherein:

the variable impedance element comprises a light sensitive variable resistor; and

the conditioning means including a lamp positioned to illuminate the light-sensitive variable resistor.

5. The apparatus of claim **1** wherein:

the oscillator means includes a linear amplifier having an input and an output, an operational amplifier having an input and an output and having its input coupled to the linear amplifier output and its output coupled to the oscillator means output, and a positive feedback network coupled between the linear amplifier input and the operational amplifier output; and

the antenna is coupled to the linear amplifier output.

6. The apparatus of claim **5** wherein the feedback means includes a negative feedback network coupled between the input and output of the operational amplifier for varying the amount of feedback responsive to the level of the oscillator means output signal for slow variations in capacitance between the antenna means and ground due to atmospheric variations.

7. In a capacitive alarm system the combination comprising:

a first amplifier having an input and an output;

a second amplifier having an input and output and having the input coupled to the first amplifier output;

a positive feedback network coupled between the second amplifier output and the first amplifier

input forming a frequency independent oscillator circuit with the output appearing at the second amplifier output;

antenna means coupled to the first amplifier output for coupling changes in capacitance in the area proximate the antenna means to the first amplifier output;

a wide range negative feedback network coupled between the input and output of the second amplifier and including a light-sensitive variable resistor coupled in series in the network;

a lamp driver having an input and an output and having the input coupled to the output of the second amplifier; and

a lamp coupled to the output of the lamp driver positioned to illuminate the light-sensitive variable resistor, and having the intensity proportional to the amplitude of the signal appearing at the output of the second amplifier.

8. The apparatus defined in claim **7** wherein the second amplifier and the negative feedback network form a differential operational amplifier.

9. The apparatus defined in claim **8** wherein the negative feedback network includes a second variable resistor connected in series with the light-sensitive variable resistor to permit adjustment of the gain of the second amplifier whereby various antenna means may be accommodated by varying the feedback of the differential operational amplifier.

10. The apparatus defined in claim **9** wherein the first amplifier is a linear amplifier.

11. The apparatus defined in claim **9** wherein the differential operational amplifier includes a third variable resistor connected in series with the input to permit adjustment of the gain of the operational amplifier to accommodate various antenna means.

12. A capacitive alarm system comprising:

a first amplifier having an input and an output;

a second amplifier having an input and an output and having its input coupled to the first amplifier output;

a positive feedback network coupled between the second amplifier output and the first amplifier input forming a frequency independent oscillator circuit with the output appearing at the second amplifier output;

antenna means coupled to the first amplifier output for coupling changes in capacitance in the area surrounding the antenna means to the first amplifier output;

a wide range negative feedback network coupled between the input and output of the second amplifier and including a variable resistor for fine adjustment of the gain of the second amplifier;

a level sensitive switch having an input and an output, its input connected to the output of the second amplifier, said switch being responsive to the level of the signal appearing at the output of the second amplifier to switch from a normal to an alarm state; and

an alarm connected to the output of the level sensitive switch.

13. The apparatus defined in claim **12** including a variable resistor connected in series with the input of the second amplifier to permit course adjustment of the gain of the second amplifier and thus the level of the signal appearing at the oscillator output, whereby various antenna means may be accommodated.

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