Dec. 22, 1964 L. B. MULVEY 3,162,848

ELECTRICAL SYSTEM USEFUL FOR INTRUSION ALARM WITH SELECTIVE SENSITIVITY

Filed Oct. 28, 1959 2 Sheets-Sheet 1

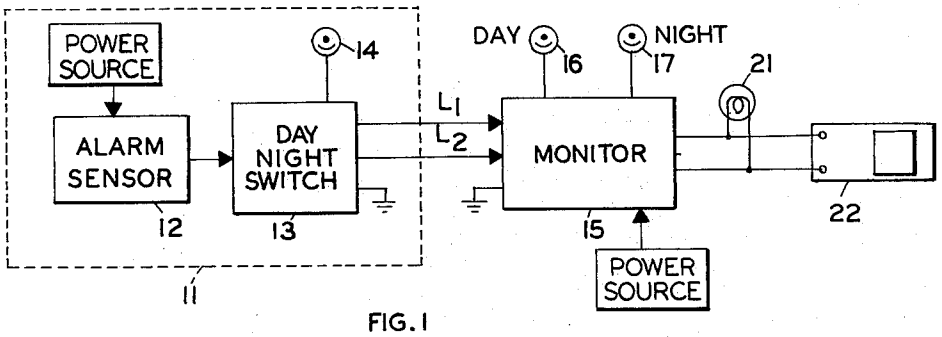


FIG. 1

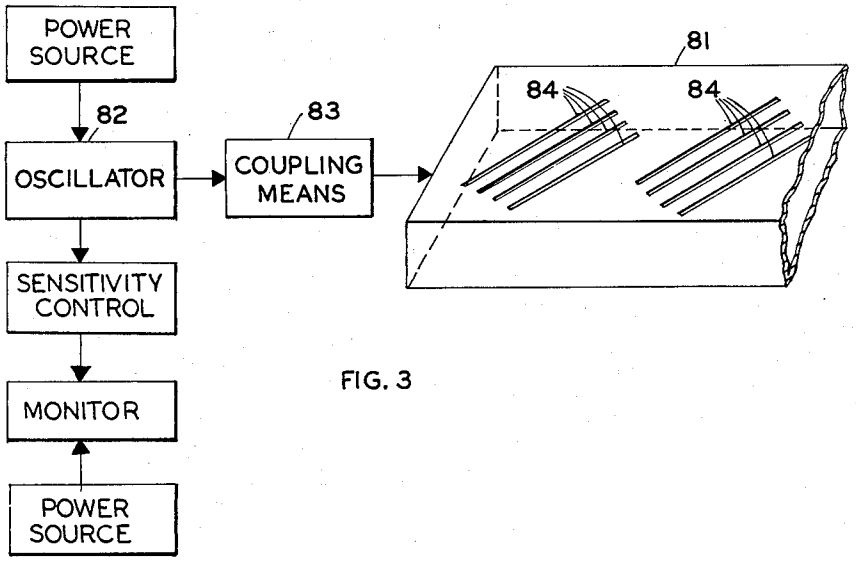


FIG. 3

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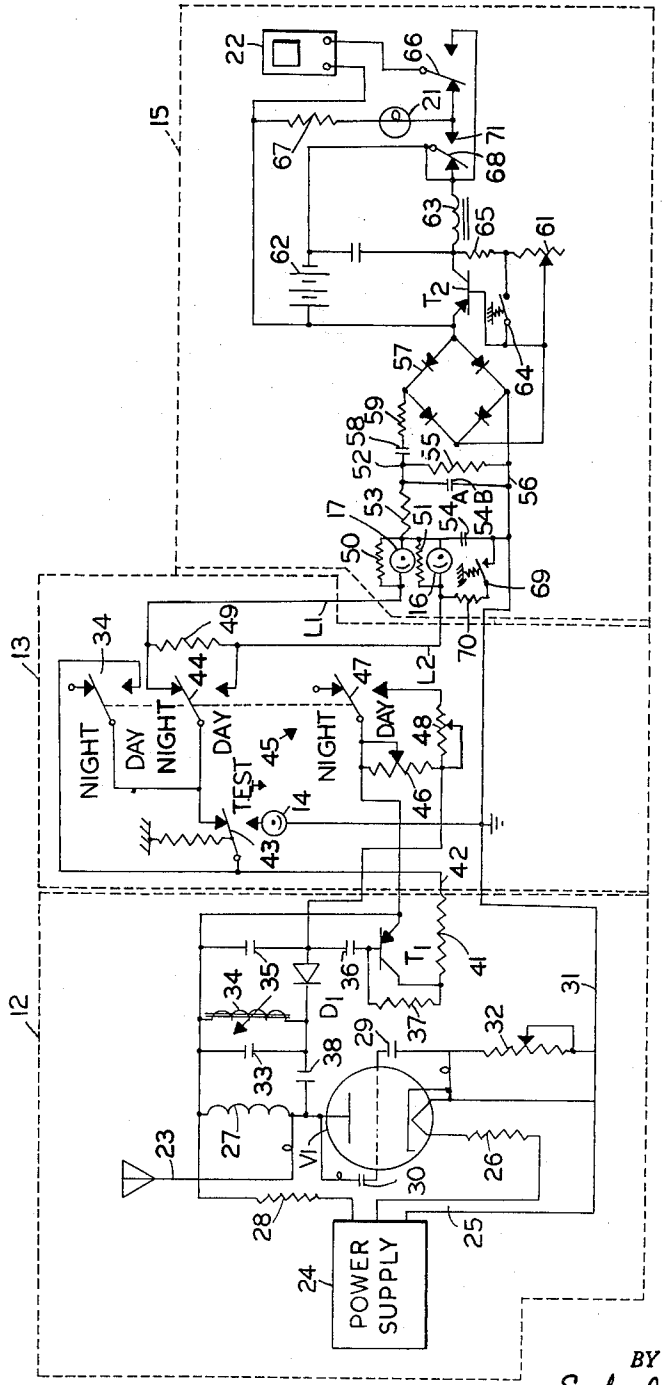


FIG. 2

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# ELECTRICAL SYSTEM USEFUL FOR INTRUSION ALARM WITH SELECTIVE SENSITIVITY

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The present invention relates in general to electrical protective systems and more particularly concerns an improved alarm system having a remote monitor for indicating the presence of an intruder and any deviation from normal operation of the equipment. Either the presence of an intruder or the failure of nearly any element in the system causes an alarm indication at the monitor. Thus, the novel system not only monitors a prescribed surveillance area, but also indicates its own malfunctioning.

In a preferred embodiment of the invention, the alarm sensor is preferably of the type disclosed in a copending application of Louis A. Mulvey, entitled Motion Detector, Serial No. 610,526, filed September 18, 1956 now Patent No. 3,126,539. Certain features of the present invention represent extensions of the novel concepts disclosed in that application.

In most alarm systems, clever intruders find it possible to enter a restricted area protected by an alarm system without causing an alarm indication. A number of possibilities exist for accomplishing this result. For example, it is possible to disable the sensor unit itself in some system without causing an alarm indication. In some remotely monitored systems, the alarm may be disabled by interfering with the transmission of signals over the lines coupling the sensor unit in the surveillance area to the remote monitor.

The present invention contemplates and has as an important object the provision of an alarm system which is free from the disadvantages noted above. More particularly, it is an object to provide an electrical protective system having a sensor coupled to a remote monitor which indicates an alarm when an intruder interferes with the normal operation of the sensor unit or the lines coupling the sensor to the monitor.

Still another object of the invention is the provision of means for selectively changing the sensitivity of the system in accordance with the prevailing conditions then in existence at the surveillance area while alerting an observer of the monitor that such change is being effected by authorized personnel.

It is still another object of the invention to provide a system in accordance with the preceding objects which provides an alarm indication to signify an abnormality in the system.

A further object of the invention is to achieve the foregoing object with equipment capable of being operated by self-contained power supplies and arranged to consume a minimum amount of power.

Still another object of the invention is to provide an electric protective system utilizing an oscillator circuit operative in the desired superregenerative mode immediately upon the application of operating power to the circuit.

Still another object of the invention is to provide an electrical protective system utilizing radiating high frequency energy wherein the protected area may be confined to a prescribed perimeter invisible to an intruder.

According to the invention, an alarm sensor and associated control means are located within the surveillance area and conductors couple these units to a remote monitor. The signal delivered over each conductor is arranged to pass through a bistable device whose state is reversed in response to a prescribed change in potential on the



associated line. This switching of the bistable device then causes an alarm indication. Thus, anyone cutting the wire or otherwise interfering with the transmission of a signal thereof causes the monitor to indicate an alarm condition.

According to another feature of the invention, the sensor comprises a superregenerative oscillator. This oscillator receives energizing potentials from a low impedance power supply through a resistor. The presence of this resistor is important because it insures that the oscillator will immediately go into superregeneration when the power switch is turned on.

Still another feature of the invention resides in utilizing a wave transmission conduit having apertures for radiating electromagnetic energy. This is advantageous because the conduits may be routed along the perimeter of the surveillance area or buried in the earth and hidden from the view of intruders. An alarm will be sounded whenever an object approaches this perimeter. By guiding the electromagnetic energy in this manner, sensitivity of the sensor is maximized at the perimeter of the surveillance area while minimizing spurious responses due to normal activity within the perimeter.

Other features, objects and advantages of the invention will become apparent from the following specification when read in connection with the accompanying drawing in which:

FIG. 1 is a block diagram generally illustrating the logical arrangement of the novel electrical protection system;

FIG. 2 is a combined block-schematic circuit diagram of a preferred embodiment of the invention; and

FIG. 3 is a pictorial representation of the preferred means for guiding the radiated energy so that sensitivity in the vicinity of the perimeter of the surveillance area is maximized while unwanted spurious response are minimized.

With reference now to the drawing and more particularly to FIG. 1 thereof, there is illustrated a block diagram generally illustrating the logical arrangement of a system arranged according to the invention.

The surveillance area 11 includes an alarm sensor 12 and a day-night switch 13. The alarm sensor 12 preferably includes a superregenerative oscillator. However, the invention contemplates other types of alarm-indicating devices, whether they do or do not rely upon electromagnetic radiation in sensing an alarm condition.

The day-night switch 13 includes means for selecting a desired degree of sensitivity. For example, in the daytime when the area is being watched manually, it is generally desired to reduce the sensitivity appreciably. On the other hand, at night it is generally desired to operate the system with high sensitivity.

The day-night switch 13 includes a test button for operation in causing the neon bulb 14 and the selected one of neon bulbs 16 and 17 to flash at the monitor in synchronism in accordance with a prearranged code. The test button is manually operated when the sensitivity is changed so that an operator at the monitor recognizes an authorized switching.

Two lines, L1 and L2, couple signals from the day-night switch 13 to the monitor 15. Both the day-night switch 13 and the monitor 15 have a grounded terminal. When the day-night switch 13 is set to the day position, a potential is delivered on line L2 causing the day bulb 16 to be ignited. Under night conditions, a potential is delivered on line L1 to ignite the night bulb 17. Any change in potential on the activated line will cause the warning light 21 to ignite and the buzzer 22 to sound.

The mode of operation of the system will be better understood after considering a preferred embodiment of the invention. Referring to FIG. 2, there is shown a

combined block-schematic circuit diagram of a preferred embodiment of the invention. The alarm sensor 12 includes a superregenerative oscillator coupled to external objects by suitable transducing means, such as the antenna 23. A single triode electron tube V1 is used as the signal amplifying device in the superregenerative oscillator. This tube receives energizing potentials from the power supply 24. Filament potentials are delivered over lines 25 in series with a resistor 26, which functions to limit surge currents and thereby prolong the tube life.

Tube V1 receives plate potential through an inductor 27 in series with a resistor 28 having an impedance which is high compared to that of the power supply. The inclusion of the resistor 28 has been discovered to be important because it insures that the oscillator will go into superregeneration as soon as the power supply 24 is turned on. If this resistor is omitted, superregeneration may not always occur. The other end of the inductor 27 is connected through an inductive loop coupled to the superregenerative oscillator tuned circuits 29 and 30 to antenna 23.

The grid of tube V1 is coupled to the ground bus 31 through a variable resistance 32, the adjustment of this resistance determining the quench rate of the superregenerative oscillator. A pair of tuned circuits 29 and 30 are coupled from the grid to the plate and cathode respectively. These circuits are tuned to the vicinity of the desired radiated carrier frequency and largely control this frequency.

Capacitor 33 and inductor 34 form a tuned circuit which is normally tuned above the quiescent quench rate so that it functions in cooperation with diode D1 as a slope detector. The signal on the plate of tube V1 is connected to the latter slope detector through capacitor 38.

Under quiescent conditions, the anode of diode D1 is at a prescribed D.-C. potential so that capacitors 35 and 36 are appropriately charged. Under quiescent conditions, PNP transistor T1 is normally conductive because the base is biased slightly negative with respect to the emitter by means of resistor 37. Therefore, any change in quench rate, indicative of a change in an object position sensed by the antenna 23, develops a pulse which is applied through capacitor 36 to the base of transistor T1. The amplified pulse is delivered through load resistor 41 to line 42. The utilization of this signal is discaused below in connection with the description of the monitor.

Considering now the day-night switch 13, it will be seen that line 42 is connected to line L1 through the arm of test switch 43 and the arm 44 of the triple-pole double throw day-night switch 45 when this switch is in the night position.

In the night position, a variable resistance 46 is connected between the anode of diode D1 and the emitter of transistor T1. The value of this resistance is related to the desired sensitivity for night operation. By decreasing the resistance 46, sensitivity is reduced. In the day position, sensitivity is reduced because the arm 47 of switch 45 connects the potentiometer 48 across the potentiometer 46 to reduce the total resistance between the emitter of transistor T1 and the anode of diode D1. Then switch 45 is in the day position, the arm 44 connects line 42 to line L2.

Neon bulb 14 is normally extinguished. However, when the arm of switch 43 is depressed, a potential is applied across bulb 14 to ignite it. Since this is a spring-loaded switch, an operator may key this switch in accordance with a prearranged code, causing bulb 14 and one of bulbs 16 and 17 to flash accordingly. Actuation of switch 43 also provides visual indication of sensor response to activity in the sensor area by means of shunting the sensor signal output current through neon bulb 14. Activity near a properly adjusted sensor will cause neon bulb 14 to flicker. Resistor 49 connected across the contact terminals of switch 49 acts to defeat attempts to tamper with telephone lines $L_1$ and $L_2$ by applying a "keep-alive" potential to the telephone line not in current use. Thus, shunting or opening circuits of either $L_1$ or $L_2$ causes a transient signal which actuates the monitor alarm circuit. Switch 39 inactivates switch 43 when the TPDT switch array is set in the day position.

The physical arrangement of the monitor is now described. The neon bulbs 16 and 17 are coupled to junction 52 by a resistor 53. A capacitor 54 shunted by a resistor 55 is connected between junction 52 and the ground bus 56. The potential between junction 52 and ground bus 56 is A.-C. coupled to opposed corners of the full-wave diode rectifying bridge 57 by capacitor 58. The remaining two corners of bridge 57 are connected between the emitter and base of PNP transistor T2.

Transistor T2 is normally conductive. The bias on the base is selected for quiescent conditions by adjusting the variable resistance 61. A battery 62 is connected in series with a relay coil 63 to deliver collector current to transistor T2. A normally open reset switch 64 is connected between the junction of resistors 61 and 65 and the base of transistor T2. The arm 68 of the monitor relay is normally held over to the left, as indicated, by collector current flow. A permanent connection is made between the arm and the left hand contact to avoid interrupting the flow of collector current due to mechanical vibration of the relay.

The armature of switch 66 is normally positioned as shown. An alarm light 21 is in series with a resistor 67 between the right hand contact 71 opposite the relay switch arm 68 and the battery 62. A buzzer 22 is connected in series between the switch arm 66 and the same battery electrode. Thus, when current flow in the relay coil 63 is interrupted, relay armature 68 moves to the right to illuminate bulb 21 and sound buzzer 22.

Operation of the monitor circuit is as follows. A transient signal developed on line 42 is coupled over the selected one of lines L1 and L2 and applied to the rectifying bridge 57. The bridge alters the bias between the emitter and base of transistor T2 to render this transistor nonconductive, thereby interrupting the flow of current through relay coil 63. The relay switch arm 68 moves to the right to cause an alarm indication.

The function of neon bulbs 16 and 17 is to insure that the system will respond to all intruders. If these bulbs were not present, it would be possible to place a potentiometer across the lines L1 and L2 and gradually decrease the resistance between these lines and ground until they reach ground potential. This could occur without introducing a transient voltage for rectification by the bridge 57 to cut off transistor T2. By utilizing the neon bulbs 16 and 17, as soon as the extinguishing potential across the illuminated bulb is reached, there is a sudden change in potential which produces a transient voltage rectified by the bridge 57 and applied to transistor T2 to cut it off and produce an alarm.

The bulbs 16 and 17 have another function, that of indicating whether the day-night switch 13 is set in the day or night sensitivity position.

The bulbs also indicate that power is being supplied to the sensor unit and that the telephone and other connecting cables are intact.

Flickering intensity of the bulbs also indicates sensor response to activity in the sensor area when sensitivity controls 46 and/or 48 are properly adjusted.

The bulbs have another function. An operator at the monitor can observe one of neon bulbs 16 and 17 flashing in accordance with the keying of switch 43 to insure that an authorized person is changing the sensitivity.

Resistors 50 and 51 shunt neon bulbs 17 and 16 to insure that the glow is extinguished when circuits $L_1$ or $L_2$ are in a state of slight conduction. The monitor may be reset by pushing the switch 64 which couples a potential to the base of transistor T2 effective in rendering this transistor again conductive.

The function of normally-open spring loaded switch 69 and resistor 70 connected between line $L_2$ and circuit ground is to provide means for testing the integrity of the telephone lines and the monitor detection and alarm circuits by arbitrarily shunting a small portion of the sensor quiescent signal output current flowing through lines $L_1$ and $L_2$ to ground, thereby simulating a transient signal and presenting it through $L_1$ to the monitor alarm circuit. Thus proper operation of the telephone line and monitor may be tested at will by personnel at central guard station.

It will be observed that the system is essentially fail-safe. If the superregenerative oscillator becomes inoperative for any reason, a transient signal is developed which causes the alarm to sound. Similarly, this will occur if either transistor T1 or T2 becomes nonconductive. The only place where the fail-safe feature is not provided is in the monitor where an alarm might not be detected if both the buzzer and warning lamp became inoperative simultaneously. This might be corrected in a number of ways, but is so unlikely that it is probably unnecessary. For example, a second bulb might be connected in parallel across the first bulb. An aging battery is detectable since the lower voltage would cause the transistor T2 current to drop sufficiently to activate the alarm. This is readily accomplished because the transistor may be selected so that it becomes nonconductive at a voltage which is higher than that required to illuminate the bulb and operate the buzzer. Resistor 59 connected between capacitor 58 and the top junction of diode bridge 57 serves to limit current surges flowing in the A.-C. leg of the bridge to permissible diode operating level.

Referring now to FIG. 3, there is shown a combined block-pictorial diagram of a preferred means for radiating the electromagnetic energy. A wave transmission conduit, such as the rectangular waveguide 81, is routed along the perimeter of the surveillance area. Energy is exchanged between the wave transmission conduit 81 and the high frequency oscillator 82 through suitable coupling means 83. The specific coupling means may be any of the well-known techniques of coupling high frequency energy into a waveguide. For example, it might be introduced through a small coupling loop. The oscillator 82 may be, for example, essentially the oscillator shown in FIG. 2.

The wave transmission conduit is preferably arranged with the radiating slots such as slots 84 oriented in a plane perpendicular to the orientation of the E vector in the wave transmission conduit.

In the illustrated rectangular waveguide, the slots appear in the broad walls of the guide. Best results have been found to occur when the slots are diagonally oriented as shown. It has also been found to be desirable to have a number of groups of slots. The groups of slots are preferably spaced about six feet apart along the perimeter when using a high frequency of about 2000 megacycles. An alternate radiating means might be a coaxial cable formed with opening in the outer conductor and having conductors extending from the inner conductor through the openings.

This means for radiating has a number of advantages. First, the perimeter can be concealed from an intruder. Secondly, the sensitive area of the detector is confined to a narrow region around the perimeter of the surveillance area. Therefore, those within and without the area far from the perimeter do not cause the occurrence of spurious alarms.

There has been described a very sensitive and virtually foolproof alarm system capable of monitoring a relatively large area. The novel system employs relatively inexpensive but reliable standard components in a compact arrangement which consumes relatively small amounts of power. It is evident that those skilled in the art may now make numerous modifications of and departures from the specific embodiments described herein without departing from the inventive concepts. Consequently, the invention is to be construed as limited only by the spirit and scope of the appended claims.

What is claimed is:

1. An alarm monitoring system comprising, means for sensing an alarm condition in a first location, control means at said first location for selectively determining the sensitivity of said sensing means, monitoring means remote from said first location for providing an indication of an alarm condition, a bistable device at the location of said monitoring means, a conductor in series with said bistable device normally direct coupling a direct potential from said control means to said monitoring means to maintain said bistable device in a normal state, said bistable device assuming an abnormal state upon interruption of said normal direct potential, and means responsive to a change in the state of said bistable device from said normal to said abnormal state for actuating said monitoring means to provide an indication of an alarm condition, said bistable device being a two terminal gas discharge tube having conductive and non-conductive states, a second conductor in series with a second two terminal gas discharge tube direct coupling said control means to said monitoring means, said means responsive to the change in state of said bistable device also responding to a change in the conductive state of said second gas discharge tube, said tubes being conductive during mutually exclusive time intervals.

2. An alarm monitoring system comprising, means for sensing an alarm condition in a first location, control means at said first location for selectively determining the sensitivity of said sensing means, monitoring means remote from said first location for providing an indication of an alarm condition, a bistable device at the location of said monitoring means, a conductor in series with said bistable device normally direct coupling a direct potential from said control means to said monitoring means to maintain said bistable device in a normal state, said bistable device assuming an abnormal state upon interruption of said direct potential, and means responsive to a change in the state of said bistable device from said normal to said abnormal state for actuating said monitoring means to provide an indication of said alarm condition being sensed and a change in the selection of said sensitivity, said sensing means comprising in combination, an electrical circuit including a signal amplifying device having an electrode for developing amplified signals in series with an inductor and further including circuit elements arranged to support and radiate superregenerative oscillations, a low impedance source of direct potential, means including a resistor greater than said low impedance for coupling said source to said electrode through said inductor, a tuned circuit resonant at a frequency near the quench rate of said superregenerative oscillations for developing a signal of said quench rate whose amplitude is a function of the contemporary quench rate, means including a diode for rectifying the latter signal and developing a control signal representative of said quench rate, and a control transistor responsive to said control signal for developing a degree of conductivity related to said control signal, said transistor being in series with said conductor for controlling the state of said bistable device in accordance with said degree of conductivity.

3. An alarm system comprising, a high frequency oscillatory circuit including a signal amplifying device having an electrode for developing amplified signals in series with an inductor and further including circuit elements arranged to support and radiate superregenerative oscillations, a low impedance source of direct potential, means including a resistance greater than said low impedance for coupling said source to said electrode through said inductor, a wave transmission conduit formed with radiating apertures therein and positioned along the boundary of an area to be monitored, means for exchanging high

frequency energy between said circuit and said conduit, a tuned circuit resonant at a frequency nearer the quench rate of said superregenerative oscillations for developing a signal of said quench rate whose amplitude is a function of the contemporary quench rate, means including a diode for rectifying the latter signal and developing a control signal representative of said quench rate, a control transistor responsive to said control signal for developing a degree of conductivity related to said control signal and providing a deviation signal corresponding to said degree of conductivity, control means near the location of said oscillatory circuit responsive to said deviation signal exceeding a preselected value to provide an alarm signal, switching means for selecting one of two magnitudes for said preselected value and directing said alarm signal to that one of first and second conductors associated with the selected magnitude, keying means near said location for interrupting the signals carried by said conductors, said conductors coupling said control means to a remote monitor which comprises, first and second gas discharge bulbs in series with said first and second conductors respectively and coupling said conductors to a capacitor in series with a rectifying circuit, the conductive state of that one of said bulbs associated with the conductor selected by said switching means being responsive to said alarm signal, a signal amplifying device normally delivering energy to alarm indicating means to prevent the latter from indicating an alarm, said signal amplifying device having a control electrode coupled to the output of said rectifying circuit, said rectifying circuit responding to changes in the conductive state of said gas discharge bulbs by delivering signals of the proper polarity to said control electrode to interrupt the delivery of energy to said alarm indicating means and cause the latter to indicate an alarm, said first and second conductors each normally carrying a direct potential from said control means to said first and second gas discharge bulbs to maintain said bulbs normally in the ignited state.

4. An alarm monitoring system comprising,
means for sensing an alarm condition in a first location,
control means at said first location for selectively determining the sensitivity of said sensing means,
monitoring means remote from said first location for providing an indication of an alarm condition,
a bistable device at the location of said monitoring means,
a conductor in series with said bistable device normally direct coupling a direct potential from said control means to said monitoring means to maintain said bistable device in a normal state,
said bistable device assuming an abnormal state upon interruption of said direct potential,
means responsive to a change in the state of said bistable device from said normal state to said abnormal state for actuating said monitoring means to provide an indication of said alarm condition being sensed and a change in the selection of said sensitivity,
said means for selectively determining sensitivity comprising switching means for selecting one of a plurality of degrees of sensitivity,
and a conductor and bistable device for each of said degrees of sensitivity coupling said control means to said monitoring means,
each of the latter coupling arrangements delivering signals to a common device responsive to a change in the state of any of said bistable devices to indicate an alarm condition.



5. An alarm monitoring system comprising,
means for sensing an alarm condition in a first location,
control means at said first location for selectively determining the sensitivity of said sensing means,
monitoring means remote from said first location for providing an indication of an alarm condition,
a bistable device at the location of said monitoring means,
a conductor in series with said bistable device normally direct coupling a direct potential from said control means to said monitoring means to maintain said bistable device in a normal state,
said bistable device assuming an abnormal state upon interruption of said direct potential,
means responsive to a change in the state of said bistable device from said normal state to said abnormal state for actuating said monitoring means to provide an indication of said alarm conditioning being sensed and a change in the selection of said sensitivity,
said responsive means at said first remote location comprising a signal amplifying device normaly delivering energy to alarm indicating means to prevent the latter from indicating an alarm,
said signal amplifying device having a control electrode,
and a rectifying circuit coupling said bistable device to said signal amplifying device,
said rectifying circuit responding to changes in the state of said bistable device by delivering signals of the proper polarity to said control electrode to interrupt delivery of energy to said alarm indicating means and cause the latter to indicate an alarm.


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