

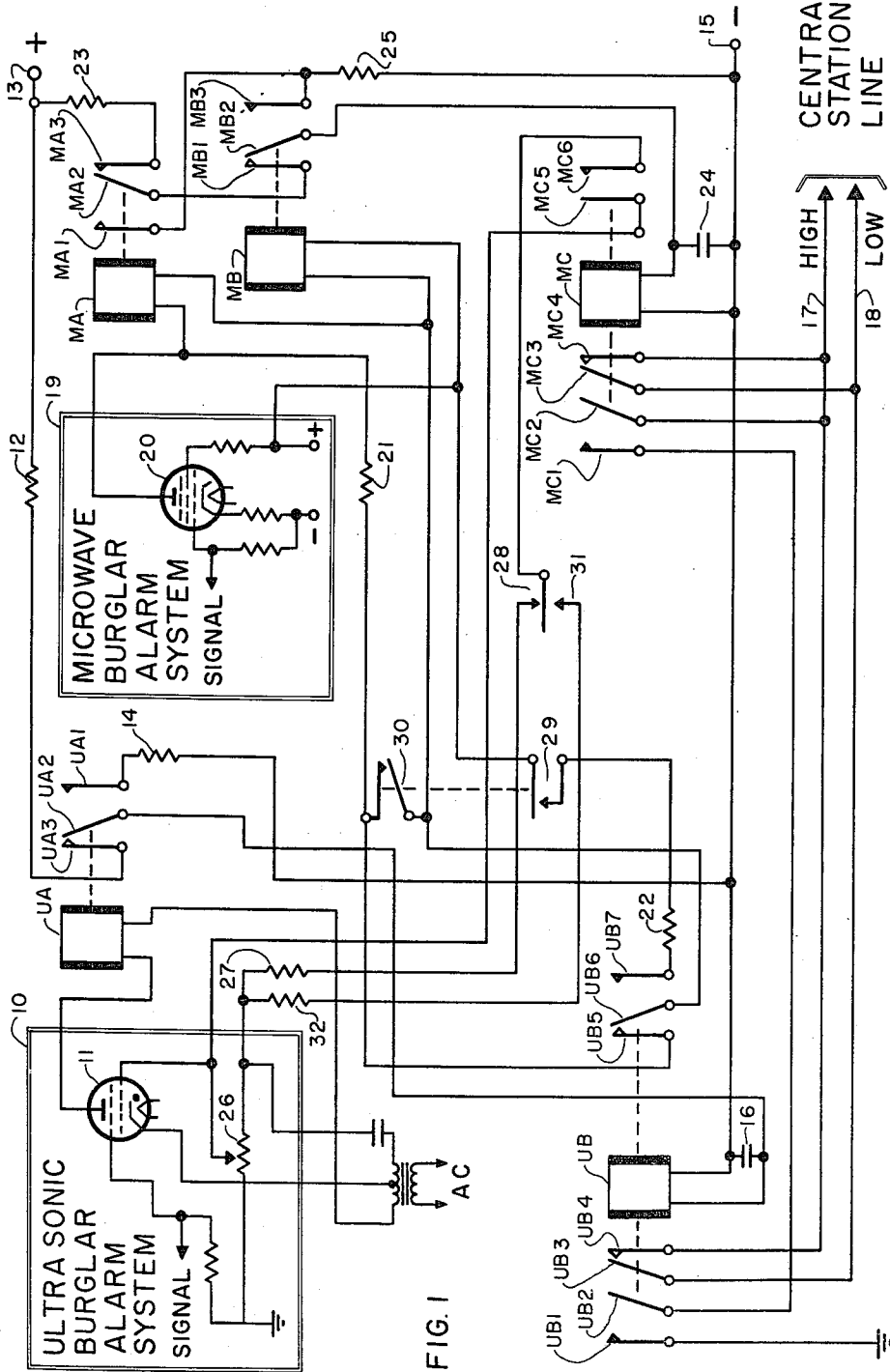
Jan. 15, 1963

V. T. McDONOUGH ETAL
ELECTRICAL SYSTEM AND METHOD FOR PROTECTING
PREMISES SUBJECT TO VARYING
AMBIENT CONDITIONS

3,074,053

Filed March 1, 1960

3 Sheets-Sheet 1



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3 Sheets-Sheet 2

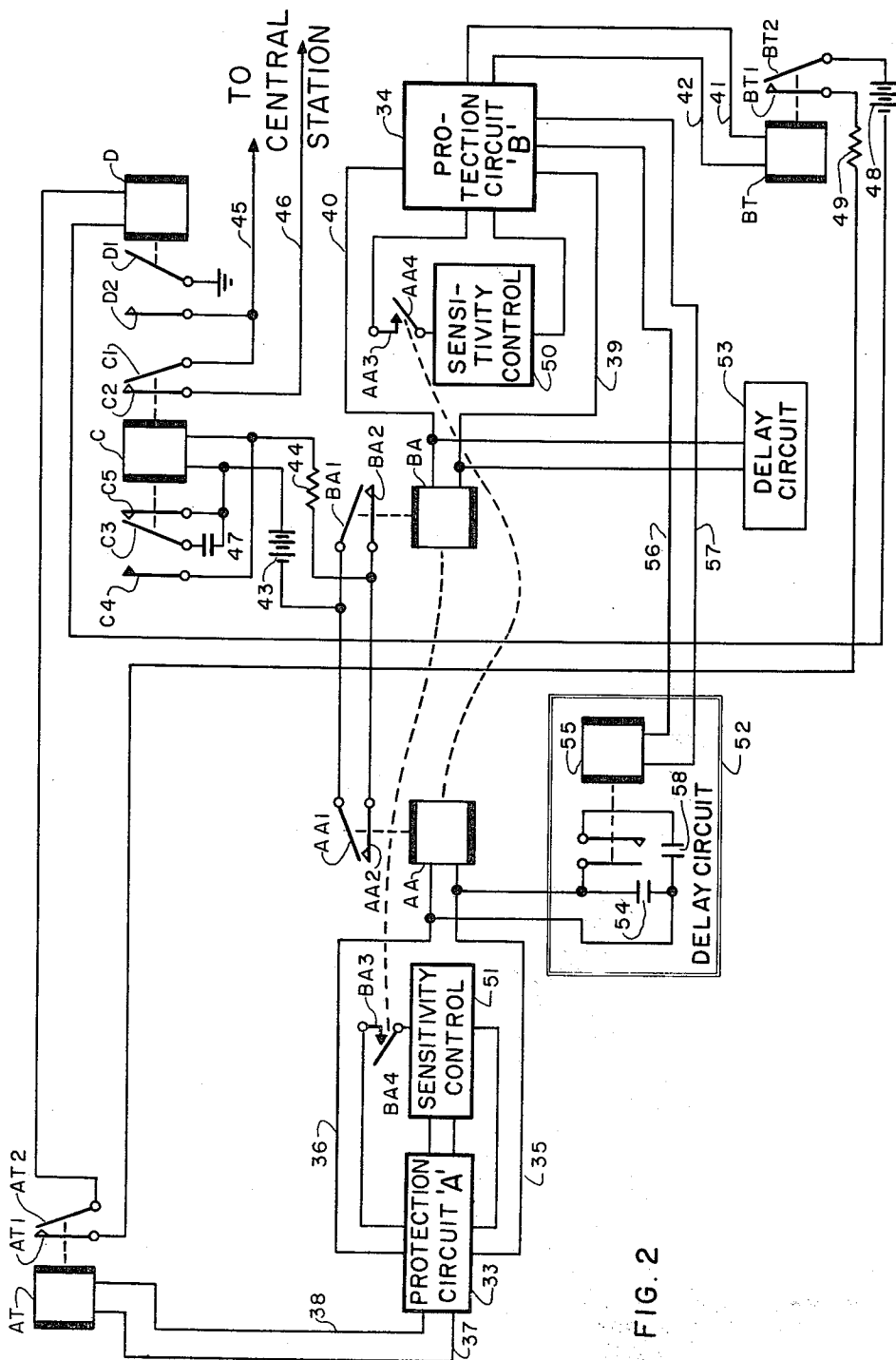


FIG. 2

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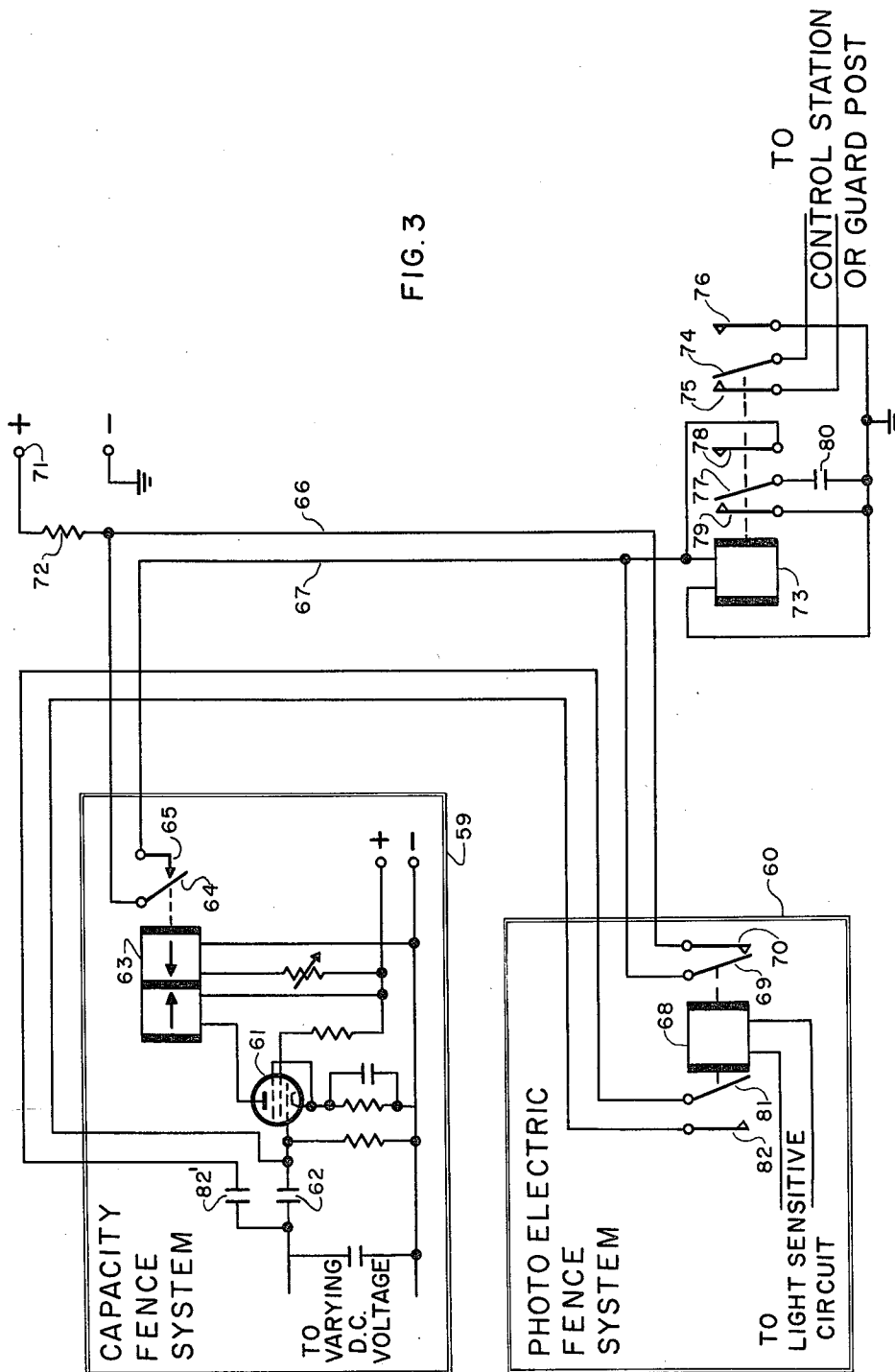
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FIG. 3



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3,074,053

ELECTRICAL SYSTEM AND METHOD FOR PROTECTING PREMISES SUBJECT TO VARYING AMBIENT CONDITIONS

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21 Claims. (Cl. 340—258)

The present invention relates to electrical protection systems and more particularly to such systems in which a comprise must be effected between detection sensitivity and stability with respect to changing ambient conditions.

In the protection of property from various hazards such as fire, burglary, holdup, etc., a variety of electrical protection devices and systems have been and are being used with great success, especially when such devices and systems are used in a central station electrical protection system. Many of the devices and systems used have been of the "go"—"no go" type, that is to say, they have been of the type in which occurrence of a particular protection situation causes an operation of the device, and in the absence of such a situation the device does not operate (excluding equipment malfunction). Examples of such devices are waterflow actuated switches in sprinkler systems, protective contacts on doors and foil on windows, holdup alarm buttons, watchmen's supervisory devices and most industrial process supervision devices. With equipment of this type, sensitivity does not generally constitute a problem since the devices are set to operate if a particular condition or set of conditions occurs and without regard to unusual ambient conditions which might exist.

Other devices exist which are required to take into account ambient conditions to a controlled and limited extent; for example, pneumatic fire detection systems are generally vented at a controlled rate to accommodate changes in ambient temperature. In this type of device or system, a balance between sensitivity and freedom from spurious alarms without undue loss of sensitivity is not generally difficult to achieve, provided proper compensation is used. See for example Evans Patent 2,275,949.

But there are certain devices and systems which do present serious problems of balance between sensitivity and freedom from spurious alarms, and in the operation of such devices and systems a comprise must be struck between high sensitivity and stability with respect to changing ambient conditions. In order to afford adequate security, this comprise is generally weighted on the side of high sensitivity at the expense of a higher than desired rate of spurious alarms. One example of a situation in which this problem of compromise exists is in outdoor electronic fences which are often of the capacity-sensitive type, for instance, the fence described in Lindsay Patent 2,455,376 or the fence described in the copending United States patent application of Pearson, McDonough and Vassil, Serial No. 659,156, filed May 14, 1957, now Patent No. 2,971,184, issued February 7, 1961. Such fences must be made sensitive to the approach of a person (be the approach fast or slow) but they should not respond to the approach of small animals or birds or to changes in weather conditions, e.g., rain, snow, ice, etc. The problem is made especially acute where, as occurs in some areas, weather changes such as an advancing wall of rain sharply affect one end of the fence before the other. Another example of an electronic fence which raises the problem of balancing stability and sensitivity is described in the copending application of Rife and Finlay, Serial No. 668,204, filed June 26, 1957, now abandoned.

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Other examples of systems in which a substantial problem of comprise exists between sensitivity and freedom from spurious alarms are photoelectric intruder alarms (U.S. Patent No. 2,284,289) and smoke-sensitive fire detection systems (U.S. Patent No. 2,298,757).

The problem of achieving a satisfactory compromise between sensitivity and freedom from false alarms is particularly acute in connection with so-called space protection systems in which a space to be protected is filled with energy and in which the motion of an intruder within the protected space acts on the energy within the space to produce an alarm. Such space protection systems as heretofore used have been of two general types, viz., those using sound energy (usually at an ultrasonic frequency) and those using electromagnetic energy (usually at a very high or ultra high frequency). Examples of space protection systems using sound energy are those described in U.S. Patent No. 2,071,933 to Meissner, U.S. Patent No. 2,655,645 to Bagno, and U.S. Patent No. 2,769,972 to MacDonald. Examples of space protection systems using electromagnetic energy are those described in U.S. Patent No. 2,247,246 to Lindsay et al. and U.S. Patent No. 2,826,753 to Chapin.

Sound and electromagnetic-type space protection systems each have certain advantages and certain disadvantages. Thus, in a sonic-type system the energy is well confined within the walls of the protected space and is little, if at all, effected by activity outside of the protected space. On the other hand, sonic energy, being air-borne (sound being essentially a pressure effect), air currents within the protected space affect the distribution of sound energy within the protected space and under appropriate conditions can result in spurious alarms. Indeed, such air current-produced spurious alarms are a major problem in the operation of sonic protection systems and have led to compromises in the applications of such systems and to substantial complexities in design in an effort to overcome the effects of air currents. Air currents such as will affect a sonic protection system can result from many causes, e.g., heating and cooling systems, telephones and other noise producing sources, and wind acting through loose or partly opened doors and windows.

A major advantage of the electromagnetic-type of space protection system lies in the fact that the energy, being at a high frequency and not being dependent on air for transmission, is little, if at all, affected by air currents. On the other hand, with electromagnetic systems operating at conveniently usable frequencies, it is difficult, in fact virtually impossible, to confine the energy within an ordinary room. Metallic shielding or the equivalent is required to produce really effective confinement of the energy, but the use of such expedients is generally highly undesirable and in most cases totally impractical. But, if the energy escapes from the protected space, activity outside of this space can and often does result in a spurious alarm. For example, a truck or automobile passing at some distance from the protected space has been a frequent cause of false alarms.

As in the case of sonic systems, various limitations on system applicability and various circuit design complexities have been used in the electromagnetic systems to minimize the problems resulting from the relative ease with which spurious alarms can result. But, in general, in both types of systems satisfactory operation has been possible only in limited types of space protection conditions and with sensitivity levels lower than ideal.

The principal object of the present invention has been the provision of a novel method and apparatus whereby the disadvantages encountered in electrical protection systems in which sensitivity and stability must be balanced are greatly minimized. As used in this sense,

stability means freedom from spurious alarms caused by changes in ambient conditions resulting from causes other than those from which protection is desired. While the principles of the invention are generally applicable to a wide variety of protection devices and systems, the invention is of particular importance in connection with space protection systems in which the space to be protected is filled with energy, and certain aspects of the invention are applicable in substantial measure only to such systems. Hence the invention will be described primarily in connection with affording space protection.

The invention contemplates the provision of electrical protection of property through the concurrent use of two or more different types of devices or systems having different detection characteristics. An important object of the invention has been the provision of a method and apparatus for affording such protection and in which the protection sensitivity and stability are substantially higher than can be achieved with the individual devices or systems.

Another object of the invention has been the provision of a method and apparatus for providing electrical protection of property in which the incidence of spurious alarms is greatly reduced if not totally eliminated.

Still another object of the invention has been the provision of a method and apparatus for providing electrical protection in which failure of a portion of the protection system results in transmission of a trouble signal rather than alarm signal.

Other and further objects, features and advantages of the invention will appear more fully from the following description taken in connection with the drawings, in which:

FIG. 1 is a schematic diagram, partially in block form, illustrating one embodiment of the invention;

FIG. 2 is a simplified schematic diagram, partially in block form, illustrating another embodiment of the invention; and

FIG. 3 is a schematic diagram, partially in block form, illustrating a further embodiment of the invention.

Referring now to the drawings and more particularly to FIG. 1, there is illustrated one embodiment of the invention. In FIG. 1 the block 10 represents an ultrasonic burglar alarm system which might be of the type shown in United States Patent 2,769,972 to MacDonald. In this ultrasonic system a normal condition of the protected premises results in continued energization of a thyatron tube, here designated 11. When an alarm condition arises at the premises protected by system 10, a negative bias potential is supplied to the shield grid of the thyatron 11 to cut the latter off. But the alarm condition may be a true protection situation or a spurious situation, such as might be caused by thermal air currents in the protected space. In order to avoid an undue number of spurious alarms, it is customary to operate ultrasonic burglar alarm systems at less than ideal sensitivity, thus balancing protection and sensitivity. As will be explained hereinafter, the ultrasonic burglar alarm system 10 may normally be operated at a sensitivity level which, though less than ideal, is nevertheless substantially higher than would be feasible economically in conventional practice because of the high spurious alarm rate which would occur.

An alternating current relay UA is included in the anode circuit of thyatron 11 and is arranged to be energized when the thyatron 11 is conductive and to be deenergized when the thyatron 11 becomes deenergized. Thus the relay UA is energized when protection conditions, as indicated by the ultrasonic system, are normal, and is deenergized when these conditions are abnormal, e.g., during alarm or equipment failure conditions. The return connections for the coil of relay UA are not shown in detail, but may be made to the alternating current anode supply for thyatron 11 as shown in the aforementioned MacDonald patent. Relay UA is provided with a back contact UA1, an armature UA2 and a front

contact UA3. The armature of relay UA, like the other armatures in FIG. 1, is shown in the normal operational, i.e. non-alarm, position and not necessarily in the relay deenergized position.

Front contact UA3 is coupled through a resistor 12 to positive D.C. terminal 13. Armature UA2 is connected to one side of the coil of a relay UB. The other side of the coil of relay UB is also connected to negative D.C. terminal 15. Back contact UA1 is coupled to the other side of the coil of relay UB through a resistor 14. Relay UB is provided with a large sized capacitor 16 shunted across its coil to make this relay slow-to-energize.

With relay UA energized (protection condition normal), relay UB will be energized through a circuit extending from positive supply terminal 13 through resistor 12, front contact UA3, armature UA2, and the coil of relay UB to negative D.C. terminal 15.

When relay UA drops out, relay UB follows suit since its energizing circuit is opened at front contact UA3. Capacitor 16 is prevented from holding relay UB energized by the discharge path afforded for capacitor 16 through resistor 14 when armature UA2 moves to back contact UA1. On the other hand, when relay UA picks up again, relay UB is delayed in becoming reenergized by the time required to charge capacitor 16.

Relay UB is provided with three cooperating sets of armatures and contacts, as follows: (1) back contact UB1 and armature UB2, (2) armature UB3 and front contact UB4, and (3) front contact UB5, armature UB6 and back contact UB7. Back contact UB1 is connected to ground potential. Front contact UB4 is connected to a conductor 17, which may be taken as a system output conductor and, in a central station system, as the high side of the central station line. Armature UB3 is connected to a conductor 18, which may be taken as the other system output conductor and, in a central station system, as the low side of the central station line.

With ultrasonic alarm system 10 in normal condition, relays UA and UB will be energized and conductors 17 and 18 will be connected together through front contact UB4 and armature UB3. When a system trouble or alarm (true or spurious) causes thyatron 11 to become deenergized, relays UA and UB will drop out, opening the connection between conductors 17 and 18 at contact UB4.

In accordance with the invention, the premises protected by the ultrasonic system 10 are also protected by a microwave burglar alarm system 19, which may be of the type shown in United States Patent 2,247,246 to Lindsay and Woloschak. In the microwave system described in the patent a normal condition of the protected premises results in the output of a pentode tube being within a range to maintain a galvanometer type relay in balanced condition. A decrease or an increase of sufficient magnitude in the output current of the pentode tube unbalances the galvanometer relay, signaling an alarm, true or spurious. Since the energy in such a system is normally not confined to the protected premises but radiates outwardly therefrom, external conditions, such as a passing truck, may result in a spurious alarm. Such a microwave system is not nearly so sensitive to ambient conditions within the protected premises as is the ultrasonic system, but is far more sensitive to external ambient conditions than is the ultrasonic system. In order to reduce spurious alarms to a tolerable level, it is customary to reduce the sensitivity level at which such systems are operated substantially below the ideal level. In accordance with the invention, the microwave system may be maintained normally at a sensitivity level well above that at which it could be operated alone.

The galvanometer relay of the aforementioned Lindsay patent is here replaced with two series connected sensitive relays MA and MB. The free end of the coil of relay MA is shown as connected to the anode of the output pentode tube 20 of the microwave system 19, while the free end of the coil of relay MB is connected to the anode.

supply source of the microwave system 19, whereby the series connected coils serve as the plate load for the tube 20.

One end of the coil of relay MA is coupled to front contact UB5 through a resistor 21, while the other end of this coil is connected to armature UB6. The junction of the coils of relays MA and MB is likewise connected to armature UB6. The other end of the coil of relay MB is coupled to back contact UB7 through a resistor 22.

Relay MA, as shown, is normally deenergized and operates on an increase in anode current of tube 20 above the normal level. Relay MB, as shown, is normally energized and drops out upon a decrease in anode current of tube 20 below the normal level. Thus an alarm results in either energization of relay MA or deenergization of relay MB depending upon the effect of the alarm-producing condition on the microwave system 19.

Relay MA is provided with front contact MA1, armature MA2 and back contact MA3. Relay MB is provided with front contact MB1, armature MB2 and back contact MB3.

A relay MC is normally energized through a circuit extending from positive D.C. terminal 13 through a resistor 23, back contact MA3, armature MA2, front contact MB1, armature MB2, and the coil of relay MC to negative D.C. terminal 15. Upon detection of an alarm condition (true or spurious) by microwave system 19, this energizing circuit will be opened at contact MA3 or at contact MB1, dropping out relay MC. When the energizing circuit is restored, relay MC will pick up, but with a time delay imposed by a large condenser 24 shunting the coil of relay MC. The condenser 24 does not delay appreciably the drop out of relay MC because when either relay MA picks up or relay MB drops out, a resistor 25 is connected in shunt with capacitor 24, affording a convenient discharge path. This connection of resistor 25 may be effected either through armature MB2 and back contact MB3 or through front contact MA1 and armature MA2.

Relay MC is provided with three sets of armatures and contacts, as follows: (1) back contact MC1 and armature MC2, (2) armature MC3 and front contact MC4, and (3) armature MC5 and back contact MC6. Back contact MC1 is connected to armature UB2, armature MC2 is connected to conductor 17, armature MC3 is connected to conductor 18, and front contact MC4 is connected to conductor 17.

Armature MC5 is connected to the slider of a potentiometer 26 while back contact MC6 is coupled to the high end of potentiometer 26 through a resistor 27. The arrangement is such that, with relay MC deenergized, contact MC6 and armature MC5 will make and connect resistor 27 in shunt with the high end of potentiometer 26, decreasing the A.C. control grid-cathode voltage of thyatron 11 available for firing the thyatron and hence decreasing the shield grid negative voltage necessary to cut off the thyatron. In other words closing of armature MC5 and contact MC6 increases the sensitivity of thyatron 11 by reducing the alarm signal voltage necessary for cutoff.

A similar increase in sensitivity of the microwave system 19 occurs when relay UB drops out since armature UB6 in moving from front contact UB5 to back contact UB7 removes resistor 21 from its shunt connection with the coil of relay MA and places resistor 22 in shunt with the coil of relay MB. Since relay MA operates to alarm position on increasing current, removal of the shunt path renders this relay sensitive to lower value increases in current. Relay MB drops out to alarm position on decreasing current, so provision of the shunt path around its coil renders it more sensitive to decreases in current.

To transmit an alarm to the central station or other alarm receiving point, the current flow in conductors 17 and 18 needs to be altered. Preferably the circuit through these conductors will be opened and then grounded, giving

the so-called double drop signal which operates both drops of a typical central station galvanometer type mechanism. As illustrated the connection from conductor 17 to conductor 18 can only be broken if both relays UB and MC are deenergized since conductors 17 and 18 are bridged by both armature MC3-front contact MC4 and armature UB3-front contact UB4. Similarly, a ground potential will be applied to the high side of the line only when both relays UB and MC are deenergized since the connection to ground is through a series circuit formed by armature MC2, back contact MC1, armature UB2 and back contact UB1. A ground of course will follow a break since whichever one of relays UB and MC drops out last, one contact will open just before the ground connection is made.

It will be evident that for both relay UB and MC to be deenergized it is necessary for both ultrasonic system 10 and microwave system 12 to register alarms. This arrangement permits both systems to be operated at a higher sensitivity than would be permissible alone, but without increasing the incidence of spurious alarms since those ambient conditions likely to produce a spurious alarm for one system will not be likely to produce a spurious alarm for the other system and both systems must register an alarm before an alarm signal indication is transmitted by the combined system.

Because of the different characteristics of the systems, it is likely that under some conditions different acts of a burglar or other intruder made at somewhat different times will put the respective systems into alarm. Moreover, the response times of the two systems tend to be different. To prevent one system going into alarm and then out of alarm before the other system goes into alarm, both relays UB and MC are made slow-to-operate, as described, by the respective capacitors 16 and 24. The UB and MC relays thus act to hold or sustain their alarm conditions for predetermined time intervals after the corresponding alarm systems have ceased to register alarms. In this way potential loss of an alarm through non-overlapping of the alarm registrations is greatly reduced and for practical purposes substantially eliminated if both systems are properly installed and adjusted. The amount of time which may elapse after one system goes out of alarm before the other system must also go into alarm if the alarm signal is not to be suppressed may be adjusted to any desired value by proper selection of the capacitors 16 and 24.

In accordance with a further feature of the invention, when either of the systems 10 and 19 goes into alarm, the sensitivity of the other system may be immediately increased to make detection of a burglar or other intruder more certain. While this will somewhat increase the likelihood of the system not in alarm registering a spurious alarm, it is statistically unlikely that a false alarm producing situation will occur during the brief interval of increased sensitivity. In this connection, it should be recalled that the two systems are in general not subject to spurious alarms from the same causes so that if one system registers a false alarm, this does not mean that increasing the sensitivity of the other system will produce a false alarm condition therein from the same cause. If the first system to register an alarm does so because of system trouble rather than an alarm condition, the alarm will be suppressed because coincident or substantially coincident alarm registrations for both systems are required to transmit an alarm signal to the central station. But so long as the first alarm remains registered, which be indefinitely if caused by equipment failure, the sensitivity of the other system will remain at its abnormally high level. Over a substantial period of time this second system will likely register a false alarm because of its high sensitivity. This will generally be an advantage since it will generally be desirable for the central station to dispatch personnel to the protected premises in order to correct the equipment failure. If instead of relying on

the high sensitivity system registering a false alarm to indicate the trouble, it is preferred to prevent a false alarm and maintain protection with only the operative system, timing mechanisms or circuits may be used to return sensitivity to normal after some predetermined interval of time. But with one system in trouble, the quality of protection at the protected premises can be maintained at a relatively high level by maintaining the high sensitivity level of the second system, although in most instances the protection will not be as good as that afforded by both systems in operative condition.

As illustrated in FIG. 1, registration of an alarm by the ultrasonic system 10 results in operation of armature UB6 to back contact UB7, increasing the sensitivity of the microwave system 19 as previously described by removing a shunt around the coil of relay MA and placing a shunt around the coil of relay MB. Similarly, registration of an alarm by microwave system 19 results in operation of armature MC5 to back contact MC6, decreasing the grid-cathode A.C. bias of the thyatron 11 and accordingly increasing the ultrasonic system sensitivity by reducing the regative voltage required at the thyatron shield grid to cut off the thyatron. It should be understood that alteration of sensitivity of the ultrasonic and microwave systems may be effected at any convenient point in these systems, as may be desired.

As mentioned above, the increased sensitivity of the non-alarm system may be eliminated after a predetermined time. For this purpose, thermally operated contacts 28 are shown in the connection to back contact MC6. The contacts 28 open a predetermined time interval after deenergization of relay MC, removing the resistor 27 from its shunt connection around the high end of potentiometer 26. The contacts 28 open because of the A.C. current flow therethrough. These contacts might conveniently include a sensitive bimetallic thermostat element as the current carrying temperature sensitive device. A similar set of thermal contacts 29 may be provided in series with the resistor 22 to remove this resistor from its shunt connection across the coil of relay MB a predetermined time interval after relay UB has become deenergized. Opening of contacts 29 results in closing of another set of contacts 30 arranged to bridge front contact UB5-armature UB6 when contacts 29 open. For this purpose, the contacts 29 and 30 may be mechanically ganged.

The contacts 28, 29 and 30 may, if desired, be of the type which must be reset manually to restore them to their normal positions. Alternatively, these contacts may be of the type which will return to their normal positions some predetermined time after actuation, thus for a short time and at set intervals increasing the sensitivity of the non-alarm condition system, if the alarm condition system be still in alarm. For most central station type service, the contacts 28, 29 and 30 will not be provided since it will usually be considered preferable maintain high sensitivity until a false alarm initiates an investigation.

If it be desired to effect a comprises between a return to normal sensitivity and full increased sensitivity of the non-alarm condition system, operation of the timing contacts may be made to restore the non-alarm system to an intermediate sensitivity level. Such an arrangement is illustrated in FIG. 1 by the provision of a front contact element 31 in association with the contacts 28. The element 31 is arranged so that opening of contacts 28 will result in circuit replacement of resistor 27 by a resistor 32 which is chosen so as to afford the desired intermediate sensitivity level.

It should be understood that the thermal contacts suggested may be replaced by any convenient timing mechanisms, such as by time delayed relays operated by additional contacts on the UB and MC relays and made to effect the desired circuit alterations at a predetermined time interval after release of either of relays UB and MC.

An important advantage achieved by increasing the sensitivity of the non-alarm condition system is to decrease the possibility of successful attack by a burglar or other intruder moving with extreme slowness. Thus, space protection systems normally operate, at least in part, on detection of motion rather than mere difference in radiation resistance. If a momentary careless move causes one system to go into alarm—as is almost inevitable under the psychological strain of an attack—the resulting increased sensitivity of the other system, especially if maintained for an appreciable time, greatly increases the likelihood of detection. The alarm sustaining feature afforded by the capacitors 16 and 24 assists in this regard.

The basic principles of the invention, as illustrated in some detail in FIG. 1, and also certain additional features, are also demonstrated in reference to FIG. 2. In FIG. 2 the block 33 represents one form of electrical protection equipment arranged to protect certain premises, while the block 34 represents another form of electrical protection equipment arranged to protect the same premises. The protection circuit A of block 33 and the protection circuit B of block 34 may be of any desired type but should protect against the same conditions with different characteristics, especially as regards ambient condition changes which are likely to result in spurious alarms.

Protection circuit A, when in normal, i.e., non-alarm and non-trouble, condition, provides current flows in conductors 35—36 and 37—38 sufficient to retain relays AA and AT energized. Upon the occurrence of an alarm condition (true or spurious) detected by circuit A, relay AA will drop out. Upon the occurrence of a trouble condition which registers in the protection circuit A other than as an alarm, relay AT will drop out.

Protection circuit B, when in normal condition, provides current flows in conductors 39—40 and 41—42 sufficient to retain relays BA and BT energized. Upon the occurrence of an alarm condition (true or spurious) detected by circuit B, relay BA will drop out. Upon the occurrence of a trouble condition which registers in the protection circuit B other than as an alarm, relay BT will drop out.

Armature AA1 and front contact AA2 of relay AA and armature BA1 and front contact BA2 of relay BA are connected in parallel and are arranged in an energizing circuit for a relay C, which circuit includes a battery 43 and a current limiting resistor 44. With either of relays AA and BA energized, relay C will remain energized. Thus, alarms must be registered by both circuits A and B to drop out both relays AA and BA in order for relay C to drop out. When relay C drops out, armature C1 thereof leaves front contact C2, opening the central station line indicated as conductors 45 and 46. Release of relay C can, of course, be used to initiate an alarm signal locally or at some place other than a central station, but the best protection practice requires an alarm to be registered at some place where trained personnel are prepared to respond appropriately.

When relay C drops out, a capacitor 47 is shunted across the coil of relay C. When either relay AA or relay BA, or both, pick up, capacitor 47 delays reenergization of relay C until capacitor 47 becomes charged, thus sustaining the alarm signal given by the release of relay C for at least a minimum time interval. When relay C finally becomes energized, capacitor 47 will discharge through front contact C5.

In the event of a trouble condition in circuit A, relay AT drops out, opening front contact AT1 and armature AT2. Similarly, a trouble condition in circuit B causes relay BT to drop out, opening front contact BT1 and armature BT2. Contact AT1, armature AT2, contact BT1 and armature BT2 are included in a series energizing circuit for a relay D, which circuit also includes a

battery 48 and a current limiting resistor 49. Thus, if either relay AT or relay BT (or both) drops out, relay D will drop out, closing armature D1 and back contact D2. Armature D1 and contact D2, when closed, apply ground potential to conductor 45, which acts as a distinctive trouble signal.

When relay AA drops out, back contact AA3 and armature AA4 close, completing a circuit connecting a sensitivity control device 50 to protection circuit B. The sensitivity control device 50 may be arranged in any desired way to raise the alarm condition sensitivity of protection circuit B. Similarly, when relay BA drops out, back contact BA3 and armature BA4 close, completing a circuit connecting a sensitivity control device 51 to protection circuit A. The sensitivity control device 51 may be arranged in any desired way to raise the alarm condition sensitivity of protection circuit A.

To provide time overlap for the alarm operations of the protection circuits A and B, suitable delay circuits 52 and 53 are connected to the coils of relays AA and BA, respectively, to hold these relays deenergized for any desired time interval after their respective protection circuits have ceased to be in alarm condition. The time delay provided may, if desired, be made variable and might be made responsive to conditions in the other protection circuit. For example, the delay circuit 52 might include a capacitor 54 and a relay 55 arranged to be energized through a current supplied by protection circuit B through conductors 56 and 57. This current may be arranged to energize relay 55 when protection circuit B has sensed a protection situation whose magnitude is insufficient to actually register an alarm. For example, the shield grid potential of the thyatron 11 of FIG. 1 increases negatively with detected motion until the motion becomes sufficient so that this potential will be great enough to cut off thyatron 11. Relay 55, when operated, will connect a capacitor 58 in parallel with capacitor 54, increasing the time delay for energization of relay AA. Capacitor 58 should not be so large that it will cause deenergization of relay AA if relay 55 is operated with relay AA energized.

In providing outdoor perimeter protection by means of electronic fences, spurious alarms resulting from weather changes and attempts to defeat the protection by extremely slow movement of an intruder present mutually inconsistent requirements. Thus to compensate against weather changes, especially weather changes affecting one part of the fence more than another, it is desirable that only rapid changes in the detection variable result in registration of an alarm. On the other hand, in order to detect a slow moving intruder it is desirable that relatively slow changes in the detection variable result in registration of an alarm. As a result, such systems are normally operated at a sensitivity level selected as a practical compromise between these requirements.

A capacity fence, for example, of the type described in Lindsay Patent 2,455,376, is especially sensitive to rain, freezing rain or sleet, snow drifts and electrical disturbances such as lightning, since these weather conditions tend to upset the capacity balance, especially when they affect one part of the fence more than another. But fog or falling snow, unless extremely wet, has a relatively minor effect on such a fence, and changes in ambient light have no effect. A photoelectric perimeter protection system, on the other hand, is affected to only a minor extent by rain or ice, and virtually not at all by snowdrifts (unless very high) or electrical disturbances. However, photoelectric systems are highly sensitive to fog and falling snow and, to some extent, to ambient light changes. Such a photoelectric system is described in Lindsay Patent 2,284,289.

The principles of the invention are well adapted to affording sensitive outdoor perimeter protection through the use of different protection systems having different responses to changes in ambient conditions. A combined

system in accordance with the invention and using a photoelectric perimeter fence and a capacity perimeter fence is shown in FIG. 3.

The capacity fence system, which might be of the type shown in Lindsay Patent 2,455,376, is shown by the block 59, while the photoelectric fence system, which might be of the type shown in Lindsay Patent 2,284,289, is shown by the block 60.

In the system 59, when the varying rectified voltage applied to the control grid of an amplifier tube 61 through a capacitor 62 increases or decreases sufficiently, the control grid potential of tube 61 will change enough so that the resulting change in current flow through the left-hand coil of a balanced relay 63 will energize the balanced relay, opening the connection afforded by armature 64 and back contact 65. This opened connection will remove a connection afforded through 64—65 between conductors 66 and 67.

The photoelectric system 60 is arranged to protect the same perimeter as the capacity fence 59. When the light reaching the system receiver from the system source is cut off, relay 68 will drop out, opening the connection between conductors 66 and 67 afforded by armature 69 and back contact 70.

Conductor 66 is connected to a source of positive potential at terminal 71 through resistor 72. Conductor 67, when connected to conductor 66 through either 64—65 or 69—70, supplies energizing current to a relay 73. When both relays 63 and 68 are deenergized, the connection between conductors 66 and 67 will be broken and relay 73 will drop out. The resulting operation of armature 74 away from front contact 75 and to back contact 76 will open and then ground the alarm signaling line to the central station, guard post, or other alarm-receiving station, as previously described. Operation of armature 77 to back contact 78 will also connect a capacitor 80 across the coil of relay 73 to delay reenergization of the latter for a predetermined minimum time.

When relay 68 drops out, armature 81 thereof makes with back contact 82, connecting a condenser 82' in parallel with condenser 62. This increase in input circuit capacity of the tube 61 will render the capacity fence system responsive to slower changes in capacity (varying D.C. voltage) and hence will increase system sensitivity.

The relays 63 and 68 will preferably be made of the slow-to-operate type so that reenergization of either upon cessation of an alarm condition will be delayed for at least a minimum time, thus affording the desired time overlap previously discussed.

The principles of the invention are, of course, applicable to more than two systems. Thus, three or more systems of different types doing essentially the same protection job could be combined, as described previously, for two systems. But situations in which more than two systems would be used are rare, since through the use of the invention great detection sensitivity and stability can be secured with two systems.

The principles of the invention are also applicable to other forms of electrical protection, for example, fire detection. For example, certain types of installations must be very carefully protected against fires because even the smallest fire can produce serious loss. Examples are automatic telephone exchanges, electronic computer rooms, and fur storage vaults. To maximize protection in such situations and still avoid spurious alarms, a pneumatic fire detection system, e.g., of the type described in United States Patent 2,275,949 to Evans, and a smoke detection system, e.g., of the type described in United States Patent 2,298,757 to Evans and Donelian, may be operated conjointly in the same area to afford protection. In such case, it is desirable that both systems be operated at much greater than usual sensitivity and that the non-alarm condition system have its sensitivity raised even higher when the other system registers an alarm, and that, even though a signal which will result in summoning fire equipment

will not be sent until both systems operate, local annunciation of a single system alarm registration will be given to alert local personnel to a possible fire danger.

While the invention has been described in connection with specific steps and in connection with specific systems and apparatus, various modifications thereof will occur to those skilled in the art without departing from the spirit and scope of the invention as set forth in the appended claims.

The term "substantially simultaneous" or comparable expressions used in the claims in connection with the requirement that two systems register or detect an alarm condition is intended to encompass both registration or detection which is actually overlapping in time and registration or detection which overlaps by virtue of the alarm sustaining feature of the invention, e.g., that produced by the capacitors 16 and 24 of FIG. 1.

What is claimed is:

1. The method of providing electrical protection of premises subject to varying ambient conditions, said premises being provided with first and second alarm systems each arranged to detect with a predetermined respective sensitivity the occurrence of an alarm condition at said premises and each of said systems being responsive in a respectively different manner to changes in at least one of said ambient conditions, comprising the steps of using the detection of an alarm condition by either one of said systems to increase the sensitivity of the other of said systems, and using only the substantially simultaneous detection of an alarm condition by both of said systems to transmit an alarm signal.

2. The method of providing electrical protection of premises subject to varying ambient conditions, said premises being provided with first and second alarm systems each arranged to detect with a predetermined respective sensitivity the occurrence of an alarm condition at said premises and each of said systems being responsive in a respectively different manner to changes in at least one of said ambient conditions, comprising the steps of using the detection of an alarm condition by one of said systems to increase the sensitivity of the other of said systems during the continued detection of said alarm condition by said one system, and using only the substantially simultaneous detection of an alarm condition by both of said systems to transmit an alarm signal.

3. In the method of providing electrical protection of premises subject to varying ambient conditions, said premises being provided with a plurality of alarm systems each arranged to detect with a predetermined respective sensitivity the occurrence of an alarm condition at said premises and each of said systems being responsive in a respectively different manner to changes in at least one of said ambient conditions, the step of transmitting an alarm signal only when at least two of said systems substantially simultaneously detect an alarm condition.

4. In the method of providing electrical protection of premises subject to varying ambient conditions, said premises being provided with first and second alarm systems each arranged to detect with a predetermined respective sensitivity the occurrence of an alarm condition at said premises and each of said systems being responsive in a respectively different manner to changes in at least one of said ambient conditions, the step of transmitting an alarm signal only when one of said systems detects an alarm condition during a time interval commencing with detection of an alarm condition by the other of said systems and ending a predetermined time after said other system ceases to detect said alarm condition.

5. The method of providing electrical protection of premises subject to varying ambient conditions, said premises being provided with first and second alarm systems each arranged to detect with a predetermined respective sensitivity the occurrence of an alarm condition at said premises and each of said systems being responsive in a respectively different manner to changes in at least one

of said ambient conditions, comprising the steps of using the detection of an alarm condition by either one of said systems to increase the sensitivity of the other of said systems, using only the substantially simultaneous detection of an alarm condition by both of said systems to transmit an alarm signal, and decreasing the sensitivity of said other system to said predetermined value thereof after said increased sensitivity has been effective for a predetermined time interval.

6. The method of providing electrical protection of premises subject to varying ambient conditions, said premises being provided with first and second alarm systems each arranged to detect with a predetermined respective sensitivity the occurrence of an alarm condition at said premises and each of said systems being responsive in a respectively different manner to changes in at least one of said ambient conditions, comprising the steps of using the detection of an alarm condition by either one of said systems to increase the sensitivity of the other of said systems, using only the substantially simultaneous detection of an alarm condition by both of said systems to transmit an alarm signal, and decreasing the sensitivity of said other system to a value intermediate said increased value thereof and said predetermined value thereof after said increased sensitivity has been effective for a predetermined time interval.

7. The method of providing electrical protection of premises subject to varying ambient conditions, said premises being provided with first and second alarm systems each arranged to detect with a predetermined respective sensitivity the occurrence of an alarm condition at said premises and each of said systems being responsive in a respectively different manner to changes in at least one of said ambient conditions, comprising the steps of using the detection of an alarm condition by either one of said systems to increase the sensitivity of the other of said systems, using only the substantially simultaneous detection of an alarm condition by both of said systems to transmit an alarm signal, decreasing the sensitivity of said other system to a selected value after said increased sensitivity thereof has been effective for a predetermined time interval, and thereafter periodically temporarily increasing the sensitivity of said other system above said selected value.

8. The method of protecting an enclosed space, comprising the steps of filling said enclosed space with sonic energy and with electromagnetic energy, detecting changes in distribution of said sonic energy and said electromagnetic energy, producing a first alarm signal when the detected change in sonic energy distribution exceeds a first predetermined value, producing a second alarm signal when the detected change in electromagnetic energy distribution exceeds a second predetermined value, automatically decreasing the predetermined value of a detected change in energy distribution required to produce one of said alarm signals when the other of said alarm signals is produced, and transmitting an alarm signal indication only when both of said alarm signals exist substantially simultaneously.

9. The method of protecting an enclosed space, comprising the steps of filling said enclosed space with sonic energy and with electromagnetic energy, receiving separately a portion of said sonic energy and a portion of said electromagnetic energy, detecting separately changes in said received sonic energy and said received electromagnetic energy, producing a first alarm signal when the detected change in said received sonic energy exceeds a first predetermined value, producing a second alarm signal when the detected change in said received electromagnetic energy exceeds a second predetermined value, and transmitting an alarm signal indication only when both of said alarm signals exist substantially simultaneously.

10. The method of protecting an enclosed space, comprising the steps of filling said enclosed space with sonic

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energy and with electromagnetic energy, receiving separately a portion of said sonic energy and a portion of said electromagnetic energy, detecting separately changes in said received sonic energy and said received electromagnetic energy, producing a first alarm signal when the detected change in said received sonic energy exceeds a first predetermined value, producing a second alarm signal when the detected change in said received electromagnetic energy exceeds a second predetermined value, automatically decreasing the predetermined value of a change in received energy required to produce one of said alarm signals when the other of said alarm signals is produced, and transmitting an alarm signal indication only when both of said alarm signals exist substantially simultaneously.

11. The method of protecting premises, comprising the steps of separately providing at said premises two different forms of energy, separately receiving said forms of energy in manners such that changes in said received forms of energy greater than respective predetermined values will be produced by an intruder at said premises, producing a first alarm signal when the received change in one of said forms of energy exceeds the corresponding predetermined value, producing a second alarm signal when the received change in said other form of energy exceeds the corresponding predetermined value, automatically decreasing the predetermined value of a detected change in energy distribution required to produce one of said alarm signals when the other of said alarm signals is produced, and transmitting an alarm signal indication only when both of said alarm signals exist substantially simultaneously.

12. An electrical protection system for protecting premises subject to varying ambient conditions, comprising first and second items of electrical protection apparatus at said premises disposed so as to be subject to said ambient conditions and to alarm conditions, each of said items including electrical protection means to produce an electrical alarm signal upon detection of an alarm condition, each of said last mentioned means having respectively different response characteristics to changes in at least one of said ambient conditions, and signal responsive means electrically connected to both of said electrical protection means, said signal responsive means being responsive only to substantially simultaneous production of an alarm signal by both of said electrical protection means to transmit an alarm signal indication.

13. An electrical protection system for protecting premises subject to varying ambient conditions, comprising first and second items of electrical protection apparatus at said premises disposed so as to be subject to said ambient conditions and to alarm conditions, each of said items including electrical protection means to produce an electrical alarm signal upon detection of an alarm condition, each of said last mentioned means having respectively different response characteristics to changes in at least one of said ambient conditions, means to adjust the sensitivity of each of said electrical protection means, said sensitivities normally being set at respective predetermined levels, first signal responsive means electrically connected to said electrical protection means and being responsive to production of an alarm signal by either one of said electrical protection means to increase temporarily the sensitivity of the other of said electrical protection means, and second signal responsive means electrically connected to both of said electrical protection means, said second signal responsive means being responsive only to substantially simultaneous production of an alarm signal by both of said electrical protection means to transmit an alarm signal indication.

14. An electrical protection system as set forth in claim 13, comprising means electrically connected to said first signal responsive means to reduce said temporarily increased sensitivity after the same has been in said increased condition for a predetermined time interval.

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15. An electrical protection system as set forth in claim 14, comprising means periodically to increase temporarily said reduced sensitivity, said last mentioned means being operative only during continued production of an alarm signal by said one electrical protection means.

16. An electrical protection system for protecting premises subject to varying ambient conditions, comprising first and second items of electrical protection apparatus at said premises disposed so as to be subject to said ambient conditions and to alarm conditions, each of said items including electrical protection means to produce an electrical alarm signal upon detection of an alarm condition, each of said electrical protection means having an adjustable sensitivity normally set at a respective predetermined level, each of said electrical protection means having respectively different response characteristics to changes in at least one of said ambient conditions, first signal responsive means electrically connected to said electrical protection means and being responsive to production of an alarm signal by either one of said electrical protection means to increase temporarily the sensitivity of the other of said electrical protection means, second signal responsive means electrically connected to both of said electrical protection means and being responsive only to substantially simultaneous production of an alarm signal by both of said electrical protection means to transmit an alarm signal indication, and means electrically connected to said second signal responsive means to sustain transmission of an alarm signal indication for a predetermined minimum time interval.

17. An electrical protection system for protecting premises subject to varying ambient conditions, comprising first and second items of electrical protection apparatus at said premises disposed so as to be subject to said ambient conditions and to alarm conditions, each of said items including electrical protection means to produce an electrical alarm signal upon detection of an alarm condition, each of said electrical protection means having an adjustable sensitivity normally set at a respective predetermined level, each of said electrical protection means having respectively different response characteristics to changes in at least one of said ambient conditions, first and second relay circuits each having first and second conditions, coupling means to supply said alarm signals from said first and second electrical protection circuits to said first and second relay circuits, respectively, whereby production of an alarm signal by either one of said electrical protection means causes a temporary change in condition of the one of said relay circuits coupled thereto from said first to said second condition thereof, means electrically connected to said relay circuits and being responsive to said temporary change in condition of either of said relay circuits in response to production of an alarm signal by a corresponding one of said electrical protection means to increase temporarily the sensitivity of the other of said electrical protection means, means to delay by a predetermined time interval return of said relay circuits from said second to said first conditions thereof upon termination of the corresponding alarm signal applied thereto, and signal responsive means electrically connected to both of said relay circuits and being operative to transmit an alarm signal indication only when both of said relay circuits are in said second conditions thereof.

18. Apparatus for protecting an enclosed space against intruders, comprising an ultrasonic burglar alarm system disposed in said space and having means to produce an alarm signal upon detection of an intruder, an electromagnetic wave burglar alarm system disposed in said space and having means to produce an alarm signal upon detection of an intruder, first and second releasable means each electrically connected to a respective one of said systems for operation when the corresponding system produces an alarm signal, means to delay release to each of said releasable means for a respective time in-

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terval after the corresponding one of said systems ceases to produce an alarm signal, and means electrically connected to both of said releasable means and being responsive only to operation of both of said releasable means during a common time interval to transmit an alarm signal indication.

19. Apparatus for protecting an enclosed space against intruders, comprising an ultrasonic burglar alarm system disposed in said space and having means to produce an alarm signal upon detection of an intruder, an electromagnetic wave burglar alarm system disposed in said space and having means to produce an alarm signal upon detection of an intruder, means in each of said systems to adjust the sensitivity thereof to respective predetermined levels, means electrically connected to both of said systems and responsive to production of an alarm signal by said ultrasonic system to increase temporarily the sensitivity of said electromagnetic wave system, means electrically connected to both of said systems and responsive to production of an alarm signal by said electromagnetic wave system to increase temporarily the sensitivity of said ultrasonic system, first and second releasable means each electrically connected to a respective one of said systems for operation when the corresponding system produces an alarm signal, means to delay release of each of said releasable means for a respective time interval after the corresponding one of said systems ceases to produce an alarm signal, means electrically connected to both of said releasable means and operative only when both of said releasable means are operated during a common time interval to transmit an alarm signal indication, and means electrically connected to both of said releasable means and to both of said systems and being responsive to continuance of at least one of said alarm signals for more than a given time interval to reduce the increased sensitivity of the system whose sensitivity has been increased by production of said one alarm signal.

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20. Apparatus as set forth in claim 19, comprising means responsive to continuance of said one of said alarm signals for a further preset time interval beyond said given time interval periodically to increase again temporarily the sensitivity of said system whose sensitivity has been reduced.

21. Apparatus for protecting a perimeter against intruders, comprising an electronic fence system and a photoelectric fence system each having sensing means disposed along at least a common portion of said perimeter, means in each of said systems to produce an alarm signal upon actuation of the corresponding sensing means by an intruder, means in said electronic fence system to adjust the sensitivity thereof, means electrically connected to both of said systems and responsive to production of an alarm signal by said photoelectric fence system to increase temporarily the sensitivity of said electronic fence system, first and second releasable means each electrically connected to a respective one of said systems for operation when the corresponding system produces an alarm signal, means to delay release of each of said releasable means for a respective time interval after the corresponding one of said systems ceases to produce an alarm signal, and means electrically connected to both of said releasable means and being responsive only to operation of both of said releasable means during a common time interval to transmit an alarm signal indication.

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