

Jan. 15, 1963

H. PEARSON

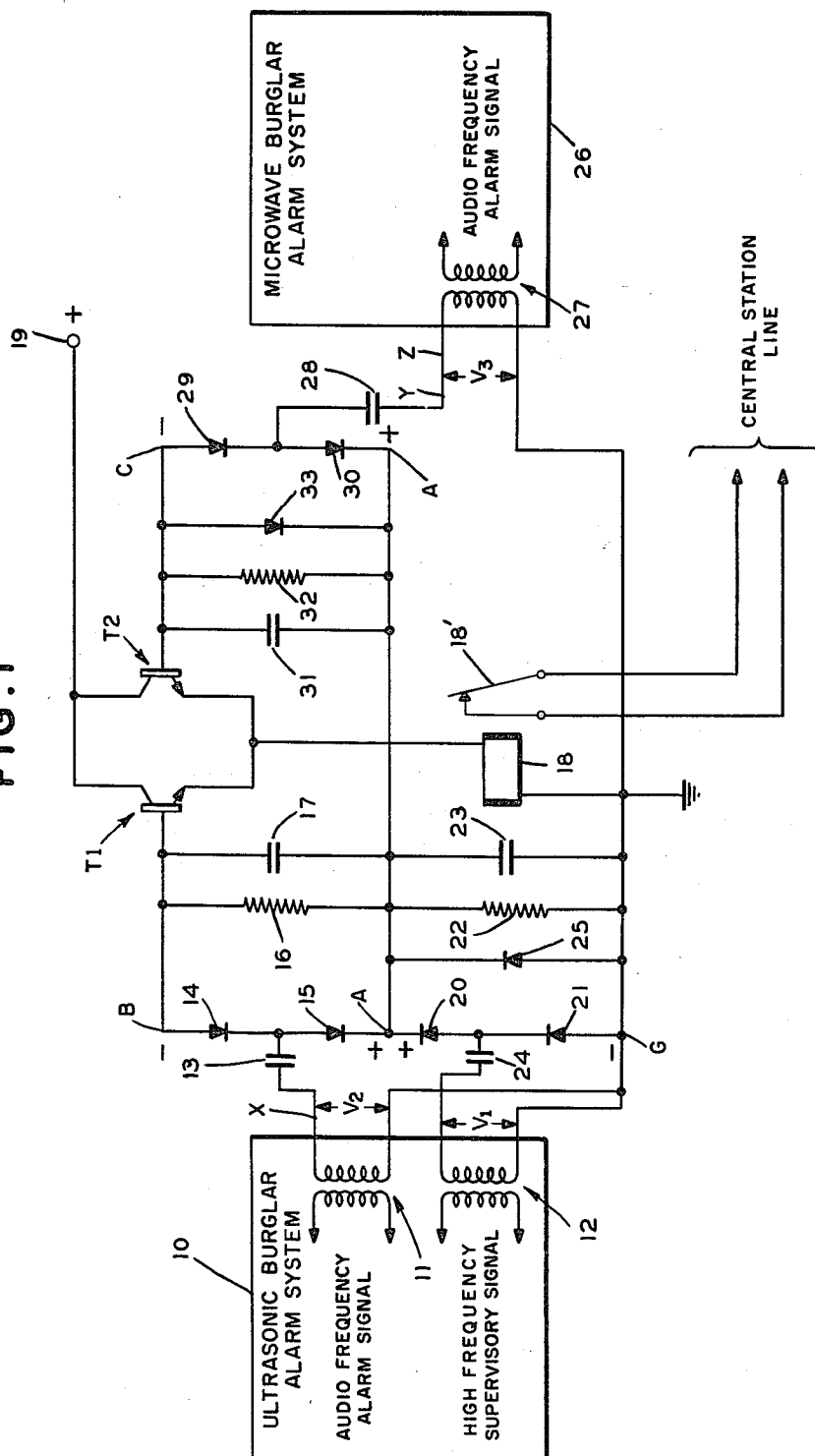
3,074,054

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

Filed Nov. 16, 1960

4 Sheets-Sheet 1

FIG. 1



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FIG. 2

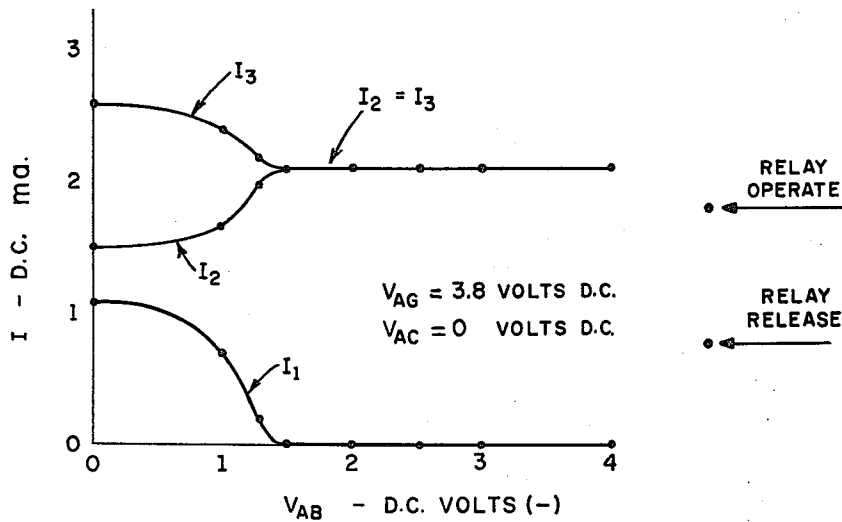
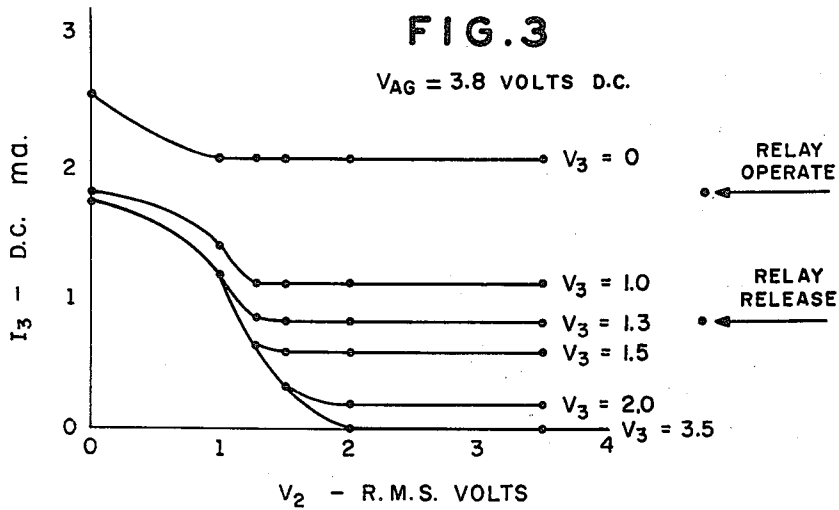


FIG. 3



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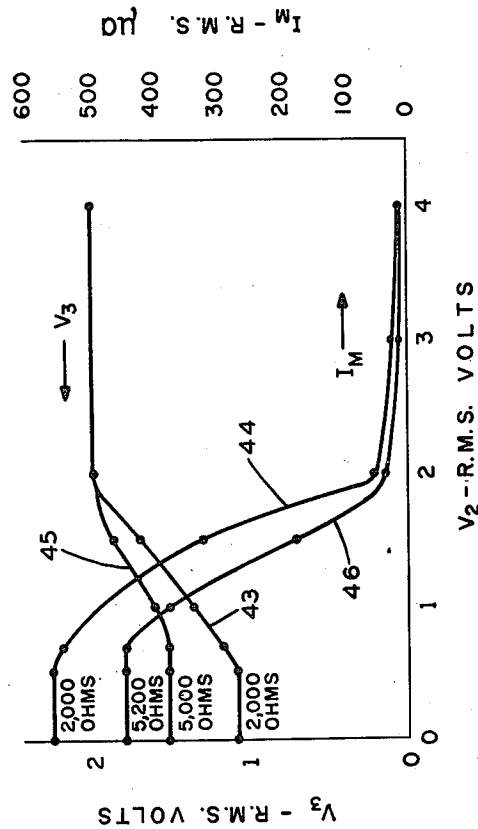
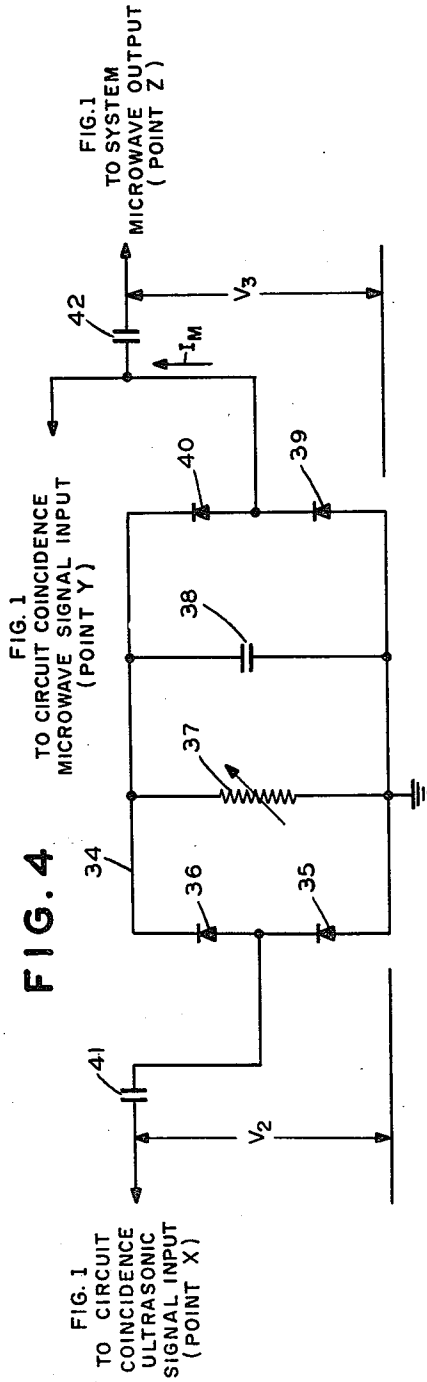
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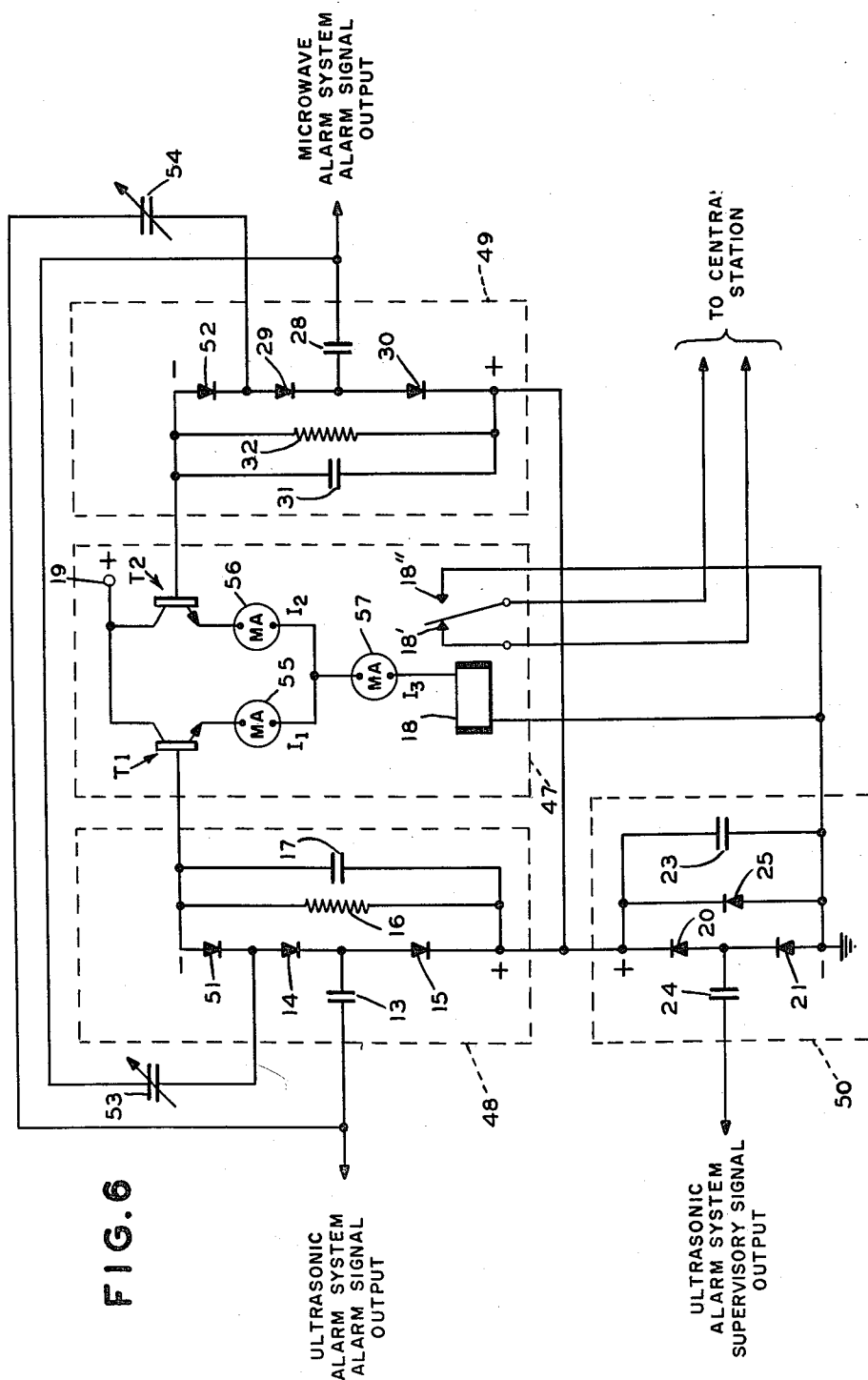
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SUBJECT TO VARYING AMBIENT CONDITIONS

Filed Nov. 16, 1960

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3,074,054

ELECTRICAL SYSTEM AND METHOD FOR PROTECTING PREMISES SUBJECT TO VARYING AMBIENT CONDITIONS**Howard Pearson, New York, N.Y., assignor to American District Telegraph Company, Jersey City, N.J., a corporation of New Jersey**

Filed Nov. 16, 1960, Ser. No. 69,643

23 Claims. (Cl. 340-258)

This application is in part a continuation of application Serial No. 12,043, filed March 1, 1960 by Vincent T. McDonough, Howard Pearson and Francis C. Evans.

The present invention relates to electrical protection systems and more particularly to such systems in which a compromise 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 compromise must be struck between high sensitivity and stability with respect to changing ambient conditions. In order to afford adequate security, this compromise 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.

Other examples of systems in which a substantial problem of compromise 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, affected by activity outside of the protected space. On the other hand, sonic energy, being airborne (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.

The system of the invention is primarily an improvement on the system described and claimed in the aforementioned application Serial No. 12,043, and a specific object of the present invention has been to provide a system wherein the coupling between the two different types of protection devices or protection systems is primarily electronic in nature.

Various specific objects, features and advantages of the invention will be apparent from the following description taken in connection with the drawings, in which:

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

FIG. 2 is a set of curves illustrating certain voltage and current relationships in the circuit of FIG. 1;

FIG. 3 is another set of curves illustrating certain voltage and current relationships in the circuit of FIG. 1;

FIG. 4 is a schematic diagram illustrating a sensitivity adjusting circuit for use with the circuit of FIG. 1;

FIG. 5 is a set of curves illustrating certain voltage and current relationships in the combined circuits of FIGS. 1 and 4; and

FIG. 6 is a schematic diagram, partly in block form, illustrating another embodiment of the invention.

Referring now to the drawings and more particularly to FIG. 1, there is illustrated one embodiment of the invention. The block 10 represents an ultrasonic burglar alarm system which might be of the type shown in United States Patent 2,769,972 which issued November 6, 1956 to L. A. MacDonald. In this ultrasonic system the premises to be protected are filled with sonic energy at a suitably high frequency, e.g., 21,000 cycles per second. Motion of an intruder within the protected premises produces frequency modulation components in a receiver. These modulation components are detected and the detected signal is filtered so as to suppress frequency components likely to result from nonalarm causes. In the system of the MacDonald patent, the filtered signal, which might have frequency components lying in the range of about 30 to 100 cycles, is rectified and the rectified signal is used to cut off a thyatron thereby actuating the system alarm circuit. In FIG. 1 hereof the filtered audio frequency alarm signal is supplied to the primary winding of a transformer 11.

In the MacDonald patent there is provided a supervisory voltage obtained by rectifying a portion of the high frequency energy (modulated or unmodulated). This supervisory voltage is used inter alia to provide a

signal indication of failure of a receiver component or loss of the carrier signal. In FIG. 1 hereof a portion of the supervisory high frequency signal is supplied to the primary winding of a transformer 12.

Thus in FIG. 1 the transformer 11 receives an audio frequency voltage, e.g. 30-100 cycles, when the sonic energy picked up by the system receiver is modulated, and the amplitude of this voltage will vary with the strength and frequency distribution of the modulation components. Ideally the amplitude of this alarm signal voltage should reach a predetermined alarm value only upon occurrence of a true alarm condition. However, in order to maintain the operating characteristics required by good protection practice, the system should be adjusted to a higher sensitivity. Thus non-alarm conditions, if sufficiently strong, can produce an alarm signal voltage of alarm amplitude. Such a spurious alarm is often caused by thermal air currents.

The high frequency supervisory voltage, e.g., 21,000 cycles, received by transformer 12 is proportional to the energy of the received signal and hence if the system is operating properly this voltage will remain within a predetermined range of values. But should a system component fail or should the receiver be blocked as by a hat or coat placed over the receiving transducer, the supervisory voltage will fall off to a value below this range and usually to zero. Momentary changes in the supervisory voltage should be suppressed to enhance system stability.

The alarm signal voltage appearing across the secondary of transformer 11 (designated voltage V₂) is supplied through a coupling capacitor 13 to a voltage doubler circuit comprising series connected rectifiers 14 and 15. The rectifiers 14 and 15, which might be of the 1N54 type, are poled so as to make point A positive and point B negative. Load resistor 16 and capacitor 17 connected in parallel between points A and B, and capacitor 13, complete the voltage doubler circuit. The low end of the secondary winding of transformer 11 is connected to ground.

Point B is connected to the base of a transistor T₁, which might be of the 2N167 type. The emitter of transistor T₁ is coupled to ground (point G) through the coil of an alarm relay 18. The collector of transistor T₁ is connected to a source of positive potential designated 19. This positive potential might be 7 volts with respect to ground. Current and voltage values and the values or types of circuit components set forth herein are given by way of example only.

A voltage doubler comprising series connected rectifiers 20 and 21, acting with load resistor 22 and capacitor 23, is coupled between points A and G. The high frequency supervisory signal appearing across the secondary winding of transformer 12, designated voltage V₁, is supplied to this voltage doubler through a coupling capacitor 24, which also forms part of the voltage doubler circuit. Rectifiers 20 and 21, which might be of the 1N54 type, are poled so as to make point A positive and point G negative. A rectifier 25 is coupled between points A and G and acts to maintain a constant voltage difference between points A and G so long as the supervisory voltage is adequate. Rectifier 25 is preferably a Zener diode and might be, for example, of the 3.9 volt type.

In accordance with the invention, the premises protected by the ultrasonic system 10 are also protected by a microwave burglar alarm system 26, which might be of the type shown in United States Patent 2,247,246, issued June 24, 1941 to M. H. A. Lindsay and K. Woloschak, or of the type described in United States Patent 2,826,753, issued March 11, 1958 to R. S. Chapin. In the microwave system described in these patents the premises to be protected are filled with ultra high frequency radio energy. A portion of this energy is received and detected. Rapid changes in the received energy resulting from changes in

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the standing wave pattern caused by motion of an intruder will result in an audio frequency output of the detector, which output is amplified and used to actuate an alarm circuit. In FIG. 1 hereof this audio frequency alarm signal is supplied to the primary winding of a transformer 27. The system described in the aforementioned Lindsay et al. patent is not directly usable with the circuit of FIG. 1 since this patent detects changes in amplitude level of the received energy and this level may increase or decrease. However, since motion of an intruder also causes frequency modulation of the received signal, changes in frequency of the received signal may be detected and the detected signal, which will lie in the audio frequency range, may be amplified and supplied to the transformer 27. The low frequency alarm signal of the aforementioned Chapin patent may be supplied to the transformer 27. This low frequency signal is said to result from phase changes caused by detected motion.

Microwave burglar alarm systems are not nearly so sensitive to ambient conditions within the protected premises as are ultrasonic systems but, such microwave systems are far more sensitive to external ambient conditions than are ultrasonic systems because the radio energy is normally not confined to the protected premises but radiates outwardly therefrom. Hence a passing car or truck often initiates a spurious alarm in a microwave system where they would have no effect on an ultrasonic system in which the energy is confined to the protected premises.

The audio frequency alarm signal appearing across the secondary winding of transformer 27, designated voltage V3, is supplied through a capacitor 28 to series connected rectifiers 29 and 30. The rectifiers 29 and 30, which might be of the 1N54 type, are connected between point A and a point C and act, with a capacitor 31, a load resistor 32 and capacitor 28 as a voltage doubler circuit. The rectifiers 29 and 30 are poled so that point A is positive and point C is negative. The low end of the secondary winding of transformer 27 is connected to ground. A rectifier 33, which is preferably a Zener diode and which might be, for example, of the 4.3 volt type, acts to clip excessively strong signals from the microwave system 26.

Point C is connected to the base of a transistor T2 which might be of the 2N167 type. The emitter and collector of transistor T2 are connected to the emitter and collector, respectively, of transistor T1.

For normal conditions at the protected premises the voltages V2 and V3 will either be zero or else will have relatively low values dependent on ambient conditions. The voltage V1 will have a normal substantial value which will tend to produce a voltage between point A and ground (V_{AG}) in excess of the regulated value of this voltage as determined by Zener diode 25. Capacitor 23 preferably has a large value, e.g., 250 mfd., to smooth out small voltage variations caused by minor changes in the ultrasonic system supervisory signal voltage.

The voltage V_{AG} across resistor 22 is supplied to the bases of transistors T1 and T2 through resistors 16 and 32, respectively, as a biasing potential. Hence with voltages V2 and V3 zero (a no-alarm signal condition) the voltage V_{AG} determines the emitter currents of transistors T1 and T2. The combined emitter currents with no alarm signal present should be somewhat in excess of the operating current of relay 18. Thus if relay 18 operates at 1.8 ma., the combined emitter currents in the absence of voltages V2 and V3 might be 2.3 ma. Should the supervisory voltage V1 drop below a predetermined point, the emitter currents will be insufficient to maintain relay 18 energized and the latter will drop out. Normally this drop out current for relay 18 will be substantially lower than the energizing current, e.g., 0.8 ma., hence a substantial drop in voltage V1 will be needed to deenergize relay 18. Since most equipment failures or signal obstructions which would be likely to occur would

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drop voltage V1 to zero or at least to a very low value, relay 18 will drop out under these conditions despite its relatively low drop-out current and irrespective of voltages V2 and V3.

By way of example, the circuit components of FIG. 1 might have the following values:

Resistor:	Value in ohms
16 -----	56K
22 -----	56K
32 -----	56K
Capacitor:	Value in mfd.
13 -----	20
17 -----	4
23 -----	250
24 -----	0.1
28 -----	20
31 -----	8
	Ohms
20 Relay 18 -----	1000

When the alarm signal voltage V2 of the ultrasonic system reaches an appreciable value, the resulting D.C. voltage (positive at A and negative at B) tends to drive transistor T1 toward emitter current cutoff. However, this drop in the emitter current of transistor T1 reduces the voltage drop in the common emitter circuits and hence the collector and emitter currents of transistor T2 tend to increase. Thus even when the emitter current of transistor T1 goes to zero, the emitter current of transistor T2 will be sufficient to keep alarm relay 18 energized.

Similarly, an alarm signal voltage from the microwave system 26 develops a negative voltage at point C and a positive voltage at point A which tends to drive transistor T2 toward emitter current cutoff. But this drop in emitter current of transistor T2 will tend to increase the emitter current of transistor T1, maintaining alarm relay 18 energized.

It will be evident that the current through the alarm relay cannot drop below the relay release point unless the D.C. voltages resulting from rectification of voltages V2 and V3 cooperate to reduce the alarm relay current. In other words, both points B and C must be negative at the same time to drop out relay 18. The values of these voltages need not be equal and, in general, will not be equal since detected motion will not result in equal response of both the ultrasonic and microwave systems.

The values of the voltages V2 and V3 which will drop out relay 18 should be appreciable, but in view of the requirement of coincidence of response each system may be adjusted to a higher sensitivity level than otherwise permissible. This is because a voltage output of one system sufficient to cause an alarm will not have this result unless the other system also senses an alarm condition. And since ambient conditions likely to effect one system are not likely to affect the other, at least to the same degree, the chances of a spurious alarm are decreased. This advantage can be used to afford higher overall system stability, higher overall sensitivity, or a combination of both benefits by appropriate adjustment of the sensitivity levels of the respective systems.

Relay 18 (or equivalent current sensitive device) has contacts 18' which open when relay 18 drops out to open the central station line, transmitting an alarm. Any convenient local and/or remote alarm signalling arrangement may be used, as well known in the art.

The operation of the circuit of FIG. 1 (with circuit values and elements as mentioned above) is illustrated in FIGS. 2 and 3. FIG. 2 shows the effect of varying the negative potential supplied to the base of transistor T1 with voltage V3 (and hence also voltage V_{AG}) zero. I_1 represents emitter current of transistor T1, I_2 represents emitter current of transistor T2 and I_3 represents the alarm relay current and is equal to I_1 plus I_2 . It will be

seen that as V_{AB} increases between zero and about -1.5 volts, the emitter current of transistor T1 falls off toward zero, while the emitter current of transistor T2 increases from its normal value of 1.5 ma. to slightly over 2 ma. The alarm relay current, being the algebraic sum of I_1 and I_2 , falls off until it coincides with I_2 for the value of V_{AB} at which I_1 equals zero. The alarm relay current I_3 never falls to the relay release value of 0.8 ma. and indeed is at all times above the relay operate current of 1.8 ma. Thus, with no signal voltage V_3 , alarm relay 13 will remain energized irrespective of the value of voltage V_2 (so long as supervisory voltage V_1 is adequate).

A similar set of curves may be drawn for variation in V_{AC} with a zero value for V_{AB} . The shape of such curves will not necessarily be the same as those obtained by variation in V_{AB} unless the transistors are closely matched.

FIG. 3 shows the effect on alarm relay current of varying the value of V_2 for different values of V_3 . In this figure V_2 and V_3 are R.M.S. values for audio frequency signals across the secondaries of transformers 11 and 27, respectively.

It will be observed from FIG. 3 that for low values of V_3 (low alarm signal voltage output of the microwave system) the alarm relay current will not fall below the relay release value. However, for values of V_3 above about 1.3 volts the alarm relay current will fall below the relay release point when V_2 reaches about 1.2 volts.

In many cases it will be desirable to cause the presence of an alarm signal voltage on one of the systems to increase the sensitivity of the other system. A circuit in accordance with the invention for accomplishing this result is shown in FIG. 4. The circuit of FIG. 4, when connected to the circuit of FIG. 1, imposes an adjustable load on both the ultrasonic and microwave system inputs to the coincidence circuit of FIG. 1, which load is reduced or removed when an alarm signal input of substantial strength is received from the other system.

The circuit of FIG. 4 comprises four parallel branches connected between ground and a conductor 34. The first branch is formed by series connected rectifiers 35 and 36, the second branch by adjustable resistor 37, the third branch by a capacitor 38, and the fourth branch by series connected rectifiers 39 and 40. The junction of rectifiers 35 and 36 is coupled to the coincidence circuit ultrasonic signal input, point X of FIG. 1, through a coupling capacitor 41. The junction of rectifiers 39 and 40 is coupled to the microwave system output, point Z of FIG. 1, through a coupling capacitor 42. The junction of rectifiers 39 and 40 is also connected to the coincidence circuit microwave signal input, point Y of FIG. 1. For this purpose, the direct connection between points Y and Z shown in FIG. 1 is removed. By way of example, rectifiers 35, 36, 39 and 40 might be of the 1N539 type, while resistor R might be adjustable between zero and 50K ohms.

When the ultrasonic system alarm voltage V_2 is below a critical value dependent on circuit constants, voltage V_2 will not affect the operation of the circuit of FIG. 4. For such low values of voltage V_2 , the voltage developed across resistor 37 and the power dissipated in resistor 37 will be derived exclusively from the microwave system output voltage V_3 as rectified by rectifiers 39 and 40. Under these conditions (zero or low value of V_2), the negative peak of the microwave system output is clamped to ground by rectifier 39, while the positive peak is clipped by rectifier 40. A reduction in the peak-to-peak value of voltage V_3 will thus occur. The reduction in peak-to-peak voltage will be imperceptible for large values of resistor 37, e.g., 50K ohms, but will become important as the resistance afforded by resistor 37 is decreased.

As voltage V_2 is increased beyond the critical value, the rectified voltage produced by rectifiers 35 and 36 contributes to the voltage across resistor 37 in a sense to reduce the clipping action of rectifier 40. When voltage

V_2 equals the initial setting of voltage V_3 , the clipping action will be negligible. For example, with V_3 initially set at 2 volts R.M.S. (with V_2 at zero), the clipping action will become negligible when V_2 is increased to about 2 volts (R.M.S.). Similarly, with V_3 initially set at 3 or 4 volts (with V_2 at zero), clipping action will become negligible when V_2 is increased to about 3 or 4 volts, respectively. This relationship between V_2 and V_3 will not hold for values of V_3 near the voltage at which the rectifiers start to conduct. The clipping action is reduced as V_2 increases because of the biasing action on rectifier 40 of the voltage developed across resistor 37 by rectifiers 35 and 36. As voltage V_2 is increased above the initial value of V_3 , rectifier 40 loses its clamping action. The critical value of voltage V_2 at which this voltage becomes effective in reducing clipping action of rectifier 40 becomes lower as the value of resistor 37 is reduced.

As the clipping action of rectifier 39 is decreased, the power drawn from the microwave system alarm signal and dissipated in resistor 37 is reduced. The effect of this reduction in power drain is to increase the value of V_3 . But, as will be recalled from the discussion of FIG. 1, an increase in voltage V_3 will tend to increase the negative voltage at point C, tending to drive transistor T2 toward emitter current cutoff. Thus, an increase in ultrasonic system alarm signal voltage V_2 (beyond the critical value thereof at which clipping action of rectifier 40 begins to decrease) will act to increase microwave alarm signal voltage V_3 so that the effective sensitivity of the microwave system will be increased. In other words an increase in ultrasonic system alarm output signal will result in greater sensitivity of the overall system because the motion detection required of the microwave system to produce an alarm for a given ultrasonic system alarm output will be decreased.

The increase in overall system sensitivity may be expected to have some minor adverse effect on the rate of spurious alarms, but this effect generally will not be substantial because it is unlikely that there will be coincidence of spurious alarm producing effects for both systems. In other words, when a non-alarm motion effect detected by the ultrasonic system raises voltage V_2 , it is not likely that there will simultaneously occur a non-alarm motion effect detected by the microwave system even though the sensitivity of the latter is temporarily increased.

The circuit of FIG. 4 operates in the same way to impose an adjustable load on the ultrasonic system input to the coincidence circuit, which load varies with the microwave system output.

The effect of changes in V_2 on V_3 and on I_M , the latter being the current flow from the microwave system to the load circuit of FIG. 4, is shown graphically in FIG. 5. In FIG. 5 curve 43 illustrates the effect on V_3 of increasing V_2 from 0 to 4 volts with resistor 37 set at 2000 ohms. Curve 44 shows the corresponding variation in I_M . Curve 45 is similar to 43 but with resistor 37 set at 5200 ohms. Curve 46 shows the variation in I_M corresponding to curve 45. FIG. 5 represents data taken with the circuit of FIG. 4 with V_2 and V_3 at 1000 cycles per second, and capacitors 38, 41 and 42 at 12, 20 and 0.1 microfarads, respectively. It will be seen that with resistor 37 at 2000 ohms, voltage V_3 starts to rise abruptly and current I_M starts to fall when V_2 has increased to about 0.5 volt. The rise in V_3 and drop in I_M commence at V_2 equal to about 0.7 volt with resistor 37 at 5200 ohms. For still higher values of resistor 37, greater values of V_2 are needed to start dropping the electronic load imposed on the microwave system by the circuit of FIG. 4. Thus, by adjusting the value of resistor 37, the critical value of ultrasonic system alarm voltage at which sensitivity of the microwave system starts to be increased can conveniently be adjusted. Adjust-

ment of this resistor similarly adjusts the critical value of the microwave system alarm voltage at which sensitivity of the ultrasonic system starts to be increased.

FIG. 6 illustrates a coincidence circuit similar to that of FIG. 1 but arranged so that changes in the ultrasonic system alarm signal voltage and in the microwave system alarm signal voltage alter the effective sensitivities of the microwave and ultrasonic systems, respectively.

In FIG. 6, elements corresponding to those in FIG. 1 are identified by like reference numerals. For convenience, various portions of the circuit of FIG. 6 have been enclosed in dashed boxes. Thus, the basic coincidence circuit formed by transistors T1 and T2 and relay 18 are enclosed in the box 47, the ultrasonic and microwave alarm system bias circuits are enclosed in the boxes 48 and 49, respectively, and the ultrasonic system supervisory bias voltage circuit is enclosed in the box 50.

A rectifier 51 is connected between rectifier 14 and the base of transistor T1, while a rectifier 52 is connected between rectifier 29 and the base of transistor T2. Rectifiers 51 and 52 may be of the 1N539 type. The rectifiers 14 and 15 are included in a voltage doubler circuit for the ultrasonic system alarm voltage, while the rectifiers 14 and 51 are included in a voltage doubler circuit for the microwave system alarm signal voltage. The rectifier arrangement serves to add the rectified voltages applied to the base of transistor T1. The relationship between rectifiers 29, 30 and 52 is similar to that between rectifiers 14, 15 and 51.

A variable capacitor 53 is connected between capacitor 28 and the junction of rectifiers 14 and 51 to supply a portion of the microwave system alarm signal to the ultrasonic bias circuit 48, this portion of the signal being rectified in a sense to increase the negative bias voltage at the base of transistor T1. A variable capacitor 54 is connected between capacitor 13 and the junction of rectifiers 29 and 52 to supply a portion of the ultrasonic system alarm signal to the microwave bias circuit 49, this portion of the signal being rectified in a sense to increase the negative bias voltage at the base of transistor T2. Capacitors 53 and 54 might each be variable up to 1 microfarad.

Milliammeters 55, 56 and 57 are shown connected to read transistor T1 emitter current I_1 , transistor T2 emitter current I_2 , and alarm relay current I_3 , respectively. By way of illustration, relay 18 is shown as having front contacts 18' and back contacts 18'' arranged to apply first an open and then a ground to the central station line when relay 18 drops out.

As in the case of FIG. 1, the transistors T1 and T2, with the alarm relay 18 acting as a common element in the emitter circuits, form the coincidence circuit. A normally present high frequency, e.g., 21 kc., supervisory signal from the ultrasonic system is rectified in bias circuit 50 and furnishes a positive D.C. bias, e.g., 3.9 volts, for the bases of transistors T1 and T2. The ultrasonic system alarm signal voltage is rectified in bias circuit 48 and produces a negative bias at the base of transistor T1 which, under alarm conditions, overrides the positive bias supplied to the base of transistor T1 from bias circuit 50. Thus, presence of the ultrasonic system alarm voltage causes emitter current I_1 of transistor T1 to decrease from its normal value, which might be, for example, 1.3 ma. Similarly, an alarm signal from the microwave system causes the emitter current I_2 of transistor T2 to decrease from its normal value, which might likewise be 1.3 ma.

The normal alarm relay current I_3 is equal to $I_1 + I_2$ and thus might be 2.6 ma. If I_1 goes to zero (an ultrasonic system alarm condition), the resulting lower voltage drop across alarm relay 18 tends to change the emitter bias on transistor T2 so that its emitter current I_2 will tend to increase, say, from 1.3 ma. to 2.1 ma. The alarm relay current I_3 hence would be 2.1 ma., a value greater than the drop out current of relay 18. A similar situation will occur if I_2 goes to zero, which is an alarm

condition for the microwave system. For the current values suggested, the drop out current of relay 18 might be 0.8 ma. Thus, excluding the action of capacitors 53 and 54, an alarm signal from one system only will not cause relay 18 to drop out and transmit an alarm. However, if alarm signal voltages of sufficient strength are produced simultaneously by both the ultrasonic and microwave systems, the currents I_1 and I_2 will both drop sufficiently low that I_3 will be below the drop out point of relay 18 and an alarm will be transmitted. The current I_2 will similarly drop below the relay drop out current value when the bias voltage derived from the ultrasonic system supervisory voltage falls below a predetermined value. If desired, a similar supervisory bias voltage could be derived from the microwave system.

A portion of the ultrasonic system alarm signal is supplied through variable capacitor 54 to the microwave bias circuit 49. The resulting negative bias voltage supplied to the base of transistor T2 is added to the negative bias voltage derived from the microwave alarm signal voltage present (if any) and hence a smaller microwave alarm signal voltage will be effective to reduce the emitter current of transistor T2 to a value at which (having regard to the value of I_1) the alarm relay will drop out. In other words, presence of an ultrasonic system alarm voltage will increase the effective sensitivity of the microwave system by reducing the value of the microwave system alarm voltage necessary for an alarm. The capacitor 53 acts in the same way to increase the effective sensitivity of the ultrasonic system when a microwave system alarm signal voltage is present.

The effectiveness of the alarm signal voltage of either system in increasing the sensitivity of the other will be increased by increasing the size of the corresponding coupling capacitor 53 or 54. If either of the capacitors is made too large, an alarm signal voltage of alarm magnitude from the corresponding system might reduce both I_1 and I_2 sufficiently to drop out relay 18. Such a coupling would generally be undesirable since it would eliminate the coincidence requirement. However, it may be desirable that capacitors 53 and 54 be adjustable to such high levels to provide a convenient means for continuing protection with one system after failure of the other. However, for normal operation, the capacitors 53 and 54 will be adjusted well below this value. It has been found preferable to adjust the magnitude of capacitors 53 and 54 to values at which the tendency of I_2 to increase when I_1 decreases and vice versa is substantially offset. For a circuit with parameters as previously described, this desirable value for capacitors 53 and 54 is somewhat less than 0.5 mfd.

The principles of the invention as described above are especially applicable to combined and interrelated operation systems. However, the principles of the invention can be applied with advantage to other types of protection systems, including fire detection and perimeter protection systems where the sensitivities of the systems must be adjusted to limit spurious alarms from changes in ambient conditions. Moreover, the principles of the invention are not limited to combining two systems but may be used with more than two systems, although most protection situations will not require such a complicated arrangement.

While the invention has been described in connection with specific embodiments thereof and in specific uses, 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.

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 having electrical protection means to detect with a predetermined respective sensitivity the occurrence of an alarm condition at said premises and to produce a

signal output in response to said detection and proportional to the magnitude of the detected condition, 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 deriving a first potential from said signal output of said first alarm system, deriving a second potential from said signal output of said second alarm system, producing first and second electrical control quantities, using said first potential to vary the magnitude of said first electrical control quantity in a predetermined direction with changes in said first potential resulting from an increase in the magnitude of said detected condition, using said second potential to vary the magnitude of said second electrical control quantity in said predetermined direction with changes in said second potential resulting from an increase in the magnitude of said detected condition, using a change in magnitude of either of said first and second electrical control quantities in said predetermined direction to alter the magnitude of the other of said first and second electrical control quantities in the opposite direction, combining said first and second electrical control quantities to produce a third electrical control quantity proportional to the magnitudes of said first and second electrical control quantities, and using a change in the magnitude of said third electrical control quantity in said predetermined direction to a preselected magnitude to produce an alarm signal indication.

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 having electrical protection means to detect with a predetermined respective sensitivity the occurrence of an alarm condition at said premises and to produce a signal output in response to said detection and proportional to the magnitude of the detected condition, 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 deriving a first biasing potential from said signal output of said first alarm system, deriving a second biasing potential from said signal output of said second alarm system, producing first and second electrical currents, using said first biasing potential to control the magnitude of said first electrical current, the magnitude of said first electrical current being varied in a predetermined direction with changes in said first biasing potential resulting from an increase in the magnitude of said detected condition, using said second biasing potential to control the magnitude of said second electrical current, the magnitude of said second electrical current being varied in said predetermined direction with changes in said second biasing potential resulting from an increase in the magnitude of said detected condition, using a change in magnitude of either of said first and second electrical currents in said predetermined direction to alter the magnitude of the other of said first and second electrical currents in the opposite direction, combining said first and second electrical currents to produce a third electrical current proportional to the magnitudes of said first and second electrical currents, and using a change in the magnitude of said third electrical current in said predetermined direction to a preselected magnitude to produce an alarm signal indication.

3. The method of providing electrical protection of premises subject to varying ambient conditions, said premises being provided with first and second alarm systems each having electrical protection means to detect with a predetermined respective sensitivity the occurrence of an alarm condition at said premises and to produce a signal output in response to said detection and proportional to the magnitude of the detected condition, 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 deriving a first

biasing potential from said signal output of said first alarm system, deriving a second biasing potential from said signal output of said second alarm system, producing first and second electrical currents, using said first biasing potential to control the magnitude of said first electrical current, the magnitude of said first electrical current being varied in a predetermined direction with changes in said first biasing potential resulting from an increase in the magnitude of said detected condition, using said second biasing potential to control the magnitude of said second electrical current, the magnitude of said second electrical current being varied in said predetermined direction with changes in said second biasing potential resulting from an increase in the magnitude of said detected condition, using a change in magnitude of either of said first and second electrical currents in said predetermined direction to alter the magnitude of the other of said first and second electrical currents in the opposite direction, adding said first and second electrical currents to produce a third electrical current, using a change in the magnitude of said third electrical current in said predetermined direction to a preselected magnitude to produce an alarm signal indication, and using a change in magnitude of said first signal output to vary the magnitude of said second biasing potential in the same sense as produced by a like change in magnitude of said second signal output thereby to change the effective sensitivity of said second alarm system.

4. The method of providing electrical protection of premises subject to varying ambient conditions, said premises being provided with first and second alarm systems each having electrical protection means to detect with a predetermined respective sensitivity the occurrence of an alarm condition at said premises and to produce a signal output in response to said detection and proportional to the magnitude of the detected condition, 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 deriving a first biasing potential from said signal output of said first alarm system, deriving a second biasing potential from said signal output of said second alarm system, producing first and second electrical currents, using said first biasing potential to control the magnitude of said first electrical current, the magnitude of said first electrical current being varied in a predetermined direction with changes in said first biasing potential resulting from an increase in the magnitude of said detected condition, using said second biasing potential to control the magnitude of said second electrical current, the magnitude of said second electrical current being varied in said predetermined direction with changes in said second biasing potential resulting from an increase in the magnitude of said detected condition, using a change in magnitude of either of said first and second electrical currents in said predetermined direction to alter the magnitude of the other of said first and second electrical currents in the opposite direction, adding said first and second electrical currents to produce a third electrical current, using a change in the magnitude of said third electrical current in said predetermined direction to a preselected magnitude to produce an alarm signal indication, electronically dissipating a portion of the energy in said second signal output, and using a change in magnitude of said first signal output to vary the magnitude of the dissipated portion of the energy in said second signal output thereby to change the effective sensitivity of said second alarm system.

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 having electrical protection means to detect with a predetermined respective sensitivity the occurrence of an alarm condition at said premises and to produce a signal output in response to said detection and proportional to the magnitude of the detected condition, 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 deriving a first biasing potential from said signal output of said first alarm system, deriving a second biasing potential from said signal output of said second alarm system, producing first and second electrical currents, using said first biasing potential to control the magnitude of said first electrical current, the magnitude of said first electrical current being varied in a predetermined direction with changes in said first biasing potential resulting from an increase in the magnitude of said detected condition, using said second biasing potential to control the magnitude of said second electrical current, the magnitude of said second electrical current being varied in said predetermined direction with changes in said second biasing potential resulting from an increase in the magnitude of said detected condition, using a change in magnitude of either of said first and second electrical currents in said predetermined direction to alter the magnitude of the other of said first and second electrical currents in the opposite direction, adding said first and second electrical currents to produce a third electrical current, using a change in the magnitude of said third electrical current in said predetermined direction to a preselected magnitude to produce an alarm signal indication, deriving a third biasing potential from said signal output of said first alarm system, and additively combining said second and third biasing potentials thereby to change the effective sensitivity of said second alarm system with changes in said signal output of said first alarm system.

6. In the method set forth in claim 5, the steps of deriving a fourth biasing potential from said signal output of said second alarm system, and additively combining said first and fourth biasing potentials thereby to change the effective sensitivity of said first alarm system with changes in said signal output of said second alarm system.

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 having electrical protection means to detect with a predetermined respective sensitivity the occurrence of an alarm condition at said premises and to produce a signal output in response to said detection and proportional to the magnitude of the detected condition, each of said systems being responsive in a respectively different manner to changes in at least one of said ambient conditions, at least said first system having means to produce a supervisory signal output failure of which is representative of failure of said first system, comprising the steps of deriving a first biasing potential from said signal output of said first alarm system, deriving a second biasing potential from said signal output of said second alarm system, deriving a third biasing potential from said signal output of said first alarm system, producing first and second electrical currents, using said first biasing potential to control the magnitude of said first electrical current, the magnitude of said first electrical current being varied in a predetermined direction with changes in said first biasing potential resulting from an increase in the magnitude of said detected condition, using said second biasing potential to control the magnitude of said second electrical current, the magnitude of said second electrical current being varied in said predetermined direction with changes in said second biasing potential resulting from an increase in the magnitude of said detected condition, using a change in magnitude of either of said first and second electrical currents in said predetermined direction to alter the magnitude of the other of said first and second electrical currents in the opposite direction, combining said first and second electrical currents to produce a third electrical current proportional to the magnitudes of said first and second electrical currents, using a change in the magnitude of said third electrical current in said predetermined direction to a preselected magnitude to produce an alarm signal indication, and using said third biasing potential to

control the magnitudes of both said first and second electrical currents, said third biasing potential being arranged to change the magnitudes of said first and second electrical currents in said predetermined direction and in quantity sufficient to cause said third electrical current to reach said preselected magnitude thereof upon failure of said first alarm system.

8. The method of detecting motion of an intruder within a protected space, comprising the steps of filling said space with both sonic and electromagnetic energy; separately detecting changes in said sonic and electromagnetic energy in said space resulting from motion effects and producing first and second alarm signals proportional to detected changes in said sonic and electromagnetic energies, respectively; producing first and second biasing potentials having magnitudes proportional to the magnitudes of said first and second alarm signals, respectively; producing first and second electrical currents; using said first and second biasing potentials to control the magnitudes of said first and second currents, respectively; changes in the magnitudes of said first and second biasing potentials resulting from detection of increased motion effects in said sonic and electromagnetic energies, respectively, producing changes in the magnitudes of said first and second currents, respectively, in a predetermined direction; combining said first and second currents to produce a third electrical current; using said changes in the magnitudes of said first and second biasing potentials resulting from said detection of increased motion effects to change the magnitudes of said second and first currents, respectively, in a direction opposite to said predetermined direction, and using a change in magnitude of said third current in said predetermined direction and beyond a predetermined value to produce an alarm signal indication.

9. The method of detecting motion of an intruder within a protected space, comprising the steps of filling said space with both sonic and electromagnetic energy; separately detecting changes in said sonic and electromagnetic energy in said space resulting from motion effects and producing first and second alarm signals proportional to detected changes in said sonic and electromagnetic energies, respectively; producing first and second biasing potentials having magnitudes proportional to the magnitudes of said first and second alarm signals, respectively; producing first and second electrical currents; using said first and second biasing potentials to control the magnitudes of said first and second currents, respectively; changes in the magnitudes of said first and second biasing potentials resulting from detection of increased motion effects in said sonic and electromagnetic energies, respectively, producing changes in the magnitudes of said first and second currents, respectively, in a predetermined direction; combining said first and second currents to produce a third electrical current; using said changes in the magnitudes of said first and second biasing potentials resulting from said detection of increased motion effects to change the magnitudes of said second and first currents, respectively, in a direction opposite to said predetermined direction; using changes in the magnitude of at least one of said first and second alarm signals to produce proportional changes in magnitude of the one of said first and second biasing potentials corresponding to the other of said alarm signals thereby to produce a corresponding change in the effective sensitivity of detection of the energy producing said other alarm signal; and using a change in magnitude of said third current in said predetermined direction and beyond a predetermined value to produce an alarm signal indication.

10. In the method set forth in claim 9, the step of electronically dissipating a portion of the energy in said other alarm signal; and using said one alarm signal to vary the proportion of said dissipation of the energy in said other signal thereby to effect said corresponding change in the effective sensitivity of detection of the energy producing said other alarm signal.

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11. The method of detecting motion of an intruder within a protected space, comprising the steps of filling said space with both sonic and electromagnetic energy; separately detecting changes in said sonic and electromagnetic energy in said space resulting from motion effects and producing first and second alarm signals proportional to detected changes in said sonic and electromagnetic energies, respectively; producing first and second biasing potentials having magnitudes proportional to the magnitudes of said first and second alarm signals, respectively; producing first and second electrical currents; using said first and second biasing potentials to control the magnitudes of said first and second currents, respectively; changes in the magnitudes of said first and second biasing potentials resulting from detection of increased motion effects in said sonic and electromagnetic energies, respectively, producing changes in the magnitudes of said first and second currents, respectively, in a predetermined direction; combining said first and second currents to produce a third electrical current; using said changes in the magnitudes of said first and second biasing potentials resulting from said detection of increased motion effects to change the magnitudes of said second and first currents, respectively, in a direction opposite to said predetermined direction; using changes in the magnitudes of said first and second alarm signals to produce proportional changes in magnitude of said second and first biasing potentials, respectively, thereby to produce corresponding changes in the effective sensitivity of detection of said electromagnetic and sonic energies, respectively; and using a change in magnitude of said third current in said predetermined direction and beyond a predetermined value to produce an alarm signal indication.

12. In the method set forth in claim 11, the steps of producing third and fourth biasing potentials having magnitudes proportional to the magnitudes of said first and second alarm signals, respectively; and additively combining said first and fourth biasing potentials and additively combining said second and third biasing potentials to produce said corresponding changes in the effective sensitivity of detection of said electromagnetic and sonic energies.

13. Electrical protection apparatus for detecting the occurrence of an alarm condition in a place subject to varying ambient conditions, comprising a first electrical protection system having first electrical protection means to detect in a first manner and with a first sensitivity the occurrence of said alarm condition at said place and to produce a first alarm signal proportional to the magnitude of said detected alarm condition, a second electrical protection system having second electrical protection means to detect in a second manner and with a second sensitivity the occurrence of said alarm condition at said place and to produce a second alarm signal proportional to the magnitude of said detected alarm condition, said systems each being responsive in a respectively different manner to at least a particular ambient condition at said place whereby any change in said particular ambient condition produces a correspondingly different effect on said first and second alarm signals, first and second electronic devices having separate input circuits and having output circuits at least a portion of which is common to said devices, means to derive first and second biasing potentials from said first and second alarm signals, respectively, and to apply said first and second biasing potentials to the input circuits of said first and second devices, respectively, thereby to alter the current flow in said common portion, means in said common portion of said output circuits to cause a change in said biasing potential applied to the input circuit of either one of said devices to alter the current flow of the other of said devices in a direction opposite to the corresponding change in current flow of said one device, and means in said common portion to detect changes in current flow in said common

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portion and responsive to a predetermined magnitude of current flow to produce an alarm signal indication.

14. An electrical protection circuit as set forth in claim 13, comprising means to alter the biasing potential applied to the input circuit of at least one of said devices by an amount proportional to the alarm signal corresponding to the biasing potential applied to the input circuit of the other of said devices.

15. Electrical protection apparatus for detecting the occurrence of an alarm condition in a place subject to varying ambient conditions, comprising a first electrical protection system having first electrical protection means to detect in a first manner and with a first sensitivity the occurrence of said alarm condition at said place and to produce a first alarm signal proportional to the magnitude of said detected alarm condition, a second electrical protection system having second electrical protection means to detect in a second manner and with a second sensitivity the occurrence of said alarm condition at said place and to produce a second alarm signal proportional to the magnitude of said detected alarm condition, said systems each being responsive in a respectively different manner to at least a particular ambient condition at said place whereby any change in said particular ambient condition produces a correspondingly different effect on said first and second alarm signals, first and second transistors having separate input circuits and having output circuits at least a portion of which is common to said transistors, means to derive first and second biasing potentials from said first and second alarm signals, respectively, and to apply said first and second biasing potentials to the input circuits of said first and second transistors, respectively, thereby to alter the current flow in said common portion, means in said common portion of said output circuits to cause a change in said biasing potential applied to the input circuit of either one of said transistors to alter the current flow of the other of said transistors in a direction opposite to the corresponding change in current flow of said one transistor, and current sensitive means in said common portion to detect changes in current flow in said common portion and responsive to a predetermined magnitude of current flow to produce an alarm signal indication.

16. An electrical protection circuit as set forth in claim 15, comprising an electronic load circuit, having input terminals and having a variable impedance dependent on the magnitude of a signal applied to said input terminals, means to couple said load circuit as an energy dissipating element to the alarm signal output of one of said systems, and means to supply a portion of the alarm signal output of the other of said systems to said input terminals whereby the impedance of said load circuit varies with changes in said alarm signal output of said other system, said load circuit providing an increasing impedance with increases in said alarm signal output of said other system thereby to increase the effective sensitivity of said other system with increases in said alarm signal output of said other system.

17. Electrical protection apparatus as set forth in claim 15, comprising means to derive a third biasing potential from one of said alarm signals and to combine additively said third biasing potential and the one of said first and second biasing potentials corresponding to the other of said alarm signals.

18. Electrical protection apparatus for detecting the occurrence of an alarm condition in a place subject to varying ambient conditions, comprising a first electrical protection system having first electrical protection means to detect in a first manner and with a first sensitivity the occurrence of said alarm condition at said place and to produce a first alarm signal proportional to the magnitude of said detected alarm condition, a second electrical protection system having second electrical protection means to detect in a second manner and with a second sensitivity the occurrence of said alarm condition at said place and to

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produce a second alarm signal proportional to the magnitude of said detected alarm condition, said systems each being responsive in a respectively different manner to at least a particular ambient condition at said place whereby any change in said particular ambient condition produces a correspondingly different effect on said first and second alarm signals, first and second transistors, means intercoupling the output electrodes of said transistors in parallel to form a common output circuit, said output circuit including a source of transistor operating potential and a relay device arranged when deenergized to transmit an alarm signal, first and second rectifier circuits coupled to the input electrodes of said first and second transistors, respectively, and means to apply said first and second alarm signals to said first and second rectifier circuits, respectively, whereby said first and second alarm signals provide biasing potentials for the input electrodes of said first and second transistors, respectively, means in said rectifier circuits to cause said biasing potentials to reduce the current flow through the corresponding transistors when the corresponding alarm signals increase, means in said output circuit to cause a decrease in the output circuit current of either one of said transistors to in turn cause an increase in the output circuit current of the other of said transistors whereby an increase in both of said alarm signals is required to deenergize said relay.

19. Electrical protection apparatus as set forth in claim 18, comprising third and fourth rectifier circuits coupled to the input electrodes of said first and second transistors, respectively, means to apply a portion of said first alarm signal to said fourth rectifier circuit, and means to apply a portion of said second alarm signal to said third rectifier circuit, means to combine additively the rectified outputs of said first and third rectifier circuits and said second and fourth rectifier circuits, respectively, whereby an increase in either of said alarm signals increases the effective sensitivity of the system corresponding to the other of said alarm signals.

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20. Electrical protection apparatus as set forth in claim 19 in which said means to apply a portion of said first alarm signal to said fourth rectifier circuit and said means to apply a portion of said second alarm signal to said third rectifier circuit each comprises a respective variable capacitor.

21. Electrical protection apparatus as set forth in claim 18, comprising an electronic adjustable load circuit coupled to said second rectifier circuit to dissipate a portion of the energy in said second alarm signal, and means to apply a portion of said first alarm signal to said load circuit as a control potential, said control potential decreasing said energy dissipation upon increases in said first alarm signal thereby to increase the effective sensitivity of said second protection system.

22. Electrical protection apparatus as set forth in claim 18, comprising means in said first protection system to produce a supervisory signal failure of which is representative of failure of said first protection system, a third rectifying circuit, means to apply said supervisory signal to said third rectifying circuit to rectify said supervisory signal, and means intercoupling said third rectifying circuit and the input electrodes of both said first and second transistors so that a drop in said supervisory signal below a predetermined level will reduce the output circuit currents of both said transistors at least to the value at which said relay will be deenergized.

23. Electrical protection apparatus as set forth in claim 18 in which said first electrical protection system is an ultrasonic system and said second electrical protection system is an electromagnetic system.

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