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[54] VAULT ALARM SYSTEM AND METHOD

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[58] Field of Search. 340/261, 237 S, 227, 228, 228.1, 340/276, 420, 213, 412, 164 B, 168 CC

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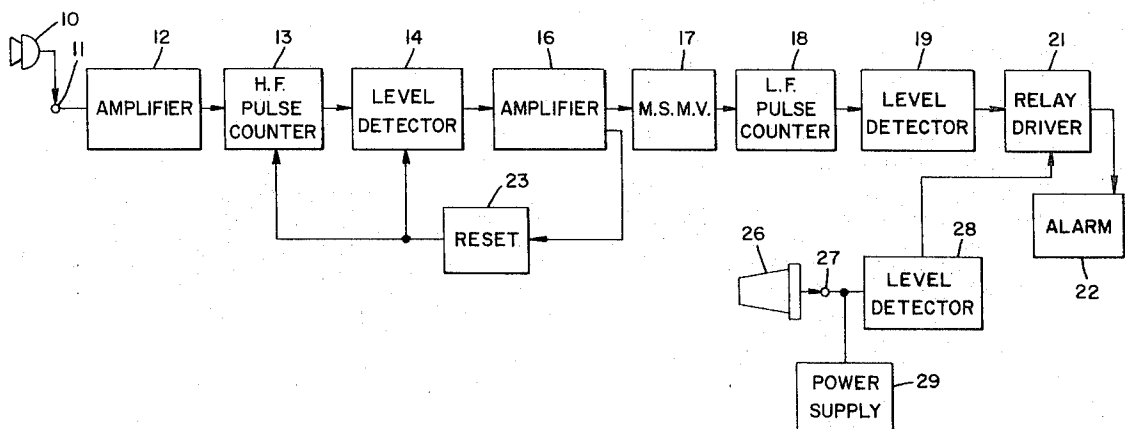
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[57] ABSTRACT

Alarm system including a microphone and an ion detector for detecting disturbances. The numbers of pulses and sound bursts in the signal produced by a disturbance are counted in order to distinguish disturbances such as burglars from other disturbances. An alarm is actuated when these counts exceed predetermined numbers. Means is included for simulating separate sound bursts to actuate the alarm in response to disturbance signals of extended duration. An ion detector is included for actuating the alarm in response to smoke and fire. The system is enclosed in a tamper-proof box and also includes tamper-proof cables and an emergency power supply.

9 Claims, 5 Drawing Figures



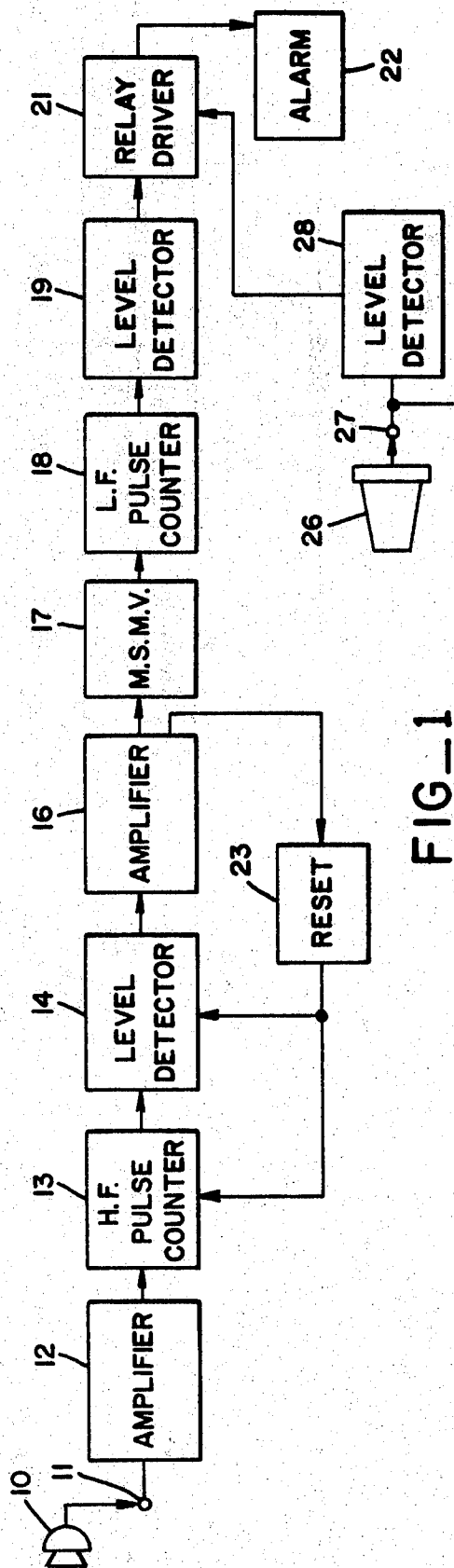


FIG-1

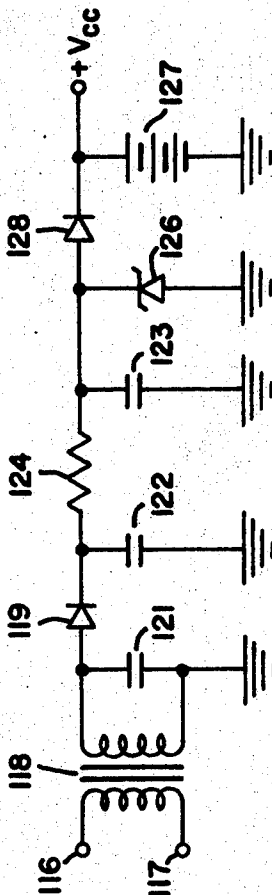


FIG-5

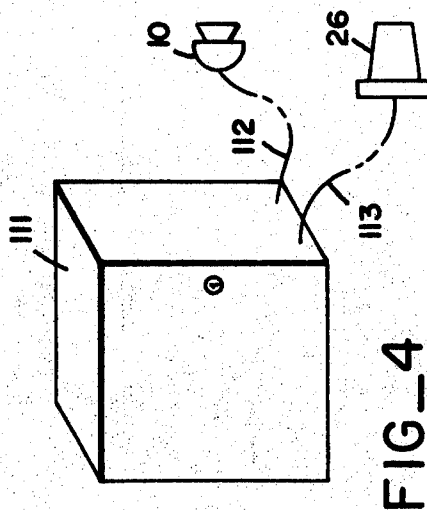
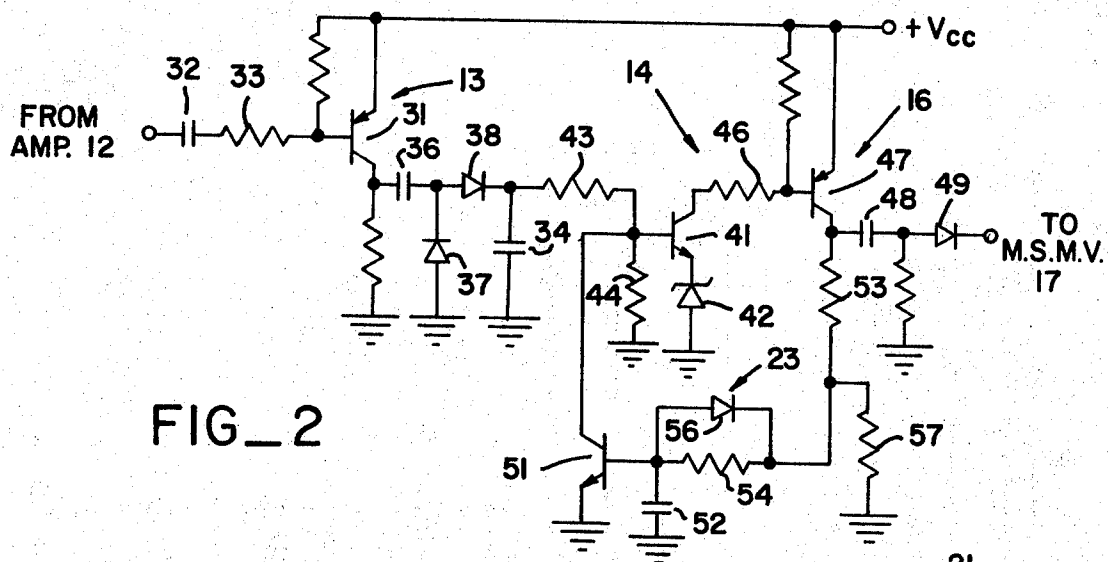
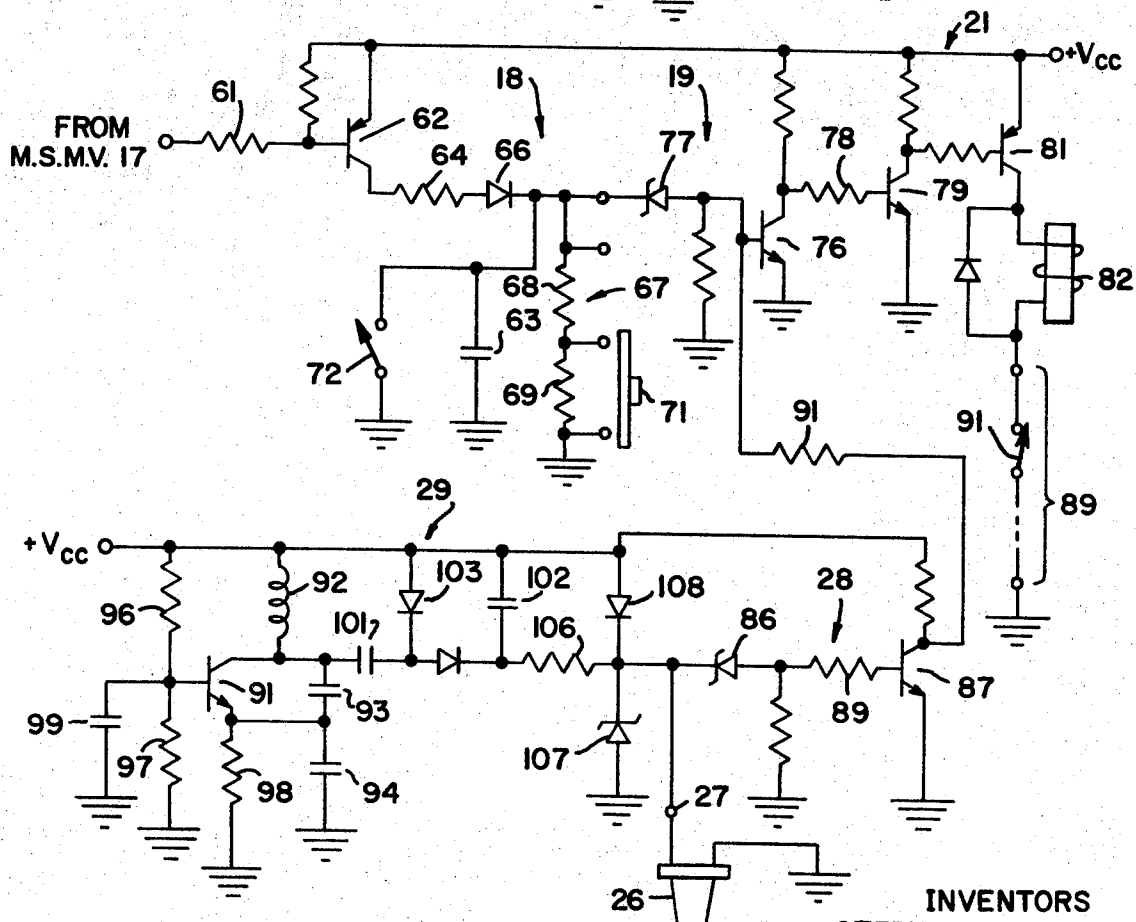


FIG-4

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VAULT ALARM SYSTEM AND METHOD

BACKGROUND OF THE INVENTION

This invention pertains generally to alarm systems and more particularly to an alarm system and method for detecting disturbances such as burglars, smoke, and fires in bank vaults.

Various systems have heretofore been provided for detecting burglars, fire, and/or smoke in bank vaults. These systems typically operate through media such as ultrasonic radiation and infra-red radiation. In the ultrasonic systems, ultrasonic energy is radiated into the vault or space to be protected and reflected by objects therein. The frequency of the reflected energy is compared with that of the radiated energy to determine whether the reflecting objects are moving. Some infra-red systems include means for transmitting and receiving infra-red energy, and others can simply include means for sensing the infra-red energy radiated by an intruder or a fire.

With the systems heretofore provided, a problem exists in providing sufficient sensitivity to detect disturbances such as intruders, fire and smoke, while at the same time distinguishing these from other disturbances, such as transients, so that the other disturbances will not cause false alarms. The transient disturbances can be either conducted or radiated, and they may arise from sources such as office machines and other equipment switching on and off.

There is, therefore, a need for a new and improved bank vault alarm system and method which overcome the foregoing and other problems encountered with the systems heretofore provided.

SUMMARY AND OBJECTS OF THE INVENTION

In the alarm system of the present invention, microphones and ion detectors are placed in the bank vault or space to be protected for sensing disturbances such as intruders, smoke, and fire. It has been found that disturbances such as intruders entering an enclosure produce sound bursts containing a relatively high number of pulses, whereas transient disturbances produce bursts having a relatively low number. More specifically, disturbances due to intruders in an enclosure typically contain more than about 20 pulses, while bursts due to transient disturbances have less than about fifteen pulses. The system of the present invention includes means for counting the pulses in each burst and actuating the alarm only when the number of pulses is greater than about 20. Means is also provided for counting the number of sound bursts and inhibiting actuation of the alarm unless a predetermined number of bursts occur within a predetermined period of time. Means is provided for resetting the pulse counter when signals of unusually long duration are received so that continuous signals, such as those produced by a burglar using a drill, can cause the number of sound bursts required for actuation of the alarm. The system is enclosed in a tamper-proof box and provided with tamper-proof cables and an emergency battery supply.

It is in general an object of the present invention to provide a new and improved alarm system and method for protecting bank vaults and other enclosed spaces.

Another object of the invention is to provide an alarm system of the above character which includes means for distinguishing disturbances such as an in-

truder, from other disturbances on the basis of the number of pulses produced by the disturbance.

Another object of the invention is to provide an alarm system of the above character which includes means for distinguishing disturbances such as an intruder, from other disturbances on the basis of the number of sound bursts produced by the disturbance in a predetermined period of time.

Another object of the invention is to provide an alarm system of the above character which includes means for actuating the alarm in response to a continuous disturbance, such as the use of a drill by a burglar, which would not produce the required number of sound bursts for actuating the alarm.

Another object of the invention is to provide an alarm system of the above character which includes means for detecting smoke and fire.

Additional objects and features of the invention will be apparent from the following description in which the preferred embodiment is set forth in detail in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of one embodiment of an alarm system incorporating the present invention.

FIG. 2 is a schematic diagram of the high frequency pulse counter and level detector stages of the embodiment illustrated in FIG. 1, including the means for resetting this counter and level detector in response to continuous disturbance signals.

FIG. 3 is a schematic diagram of the low frequency pulse counter or sound burst counter and the second level detector of the embodiment illustrated in FIG. 1.

FIG. 4 illustrates the alarm system mounted in a tamper-proof box.

FIG. 5 is a circuit diagram of one embodiment of a power supply for the system illustrated in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The alarm system includes sensor means 10 adapted to be placed in the vault or space to be protected and connected to the remainder of the system through an input terminal 11. The signals received by the sensing means are amplified in an amplifier 12 and delivered to a high frequency pulse counter 13 which counts the number of pulses in each sound burst to distinguish disturbances due to intruders from other disturbances. The output of the pulse counter 13 is connected to a level detector 14 which fires when a predetermined number of pulses have been counted. The output of the level detector is amplified in an amplifier 16 and applied to the trigger input of a monostable or one shot multivibrator 17. This multivibrator produces a single pulse of predetermined magnitude and duration each time the level detector 14 fires, producing one pulse for each sound burst containing the predetermined number of pulses. The output of the multivibrator 17 is connected to a low frequency pulse counter 18 and a second level detector 19 which fires when a predetermined number of multivibrator pulses are counted in a predetermined time. The output of the level detector 19 is connected to a relay driver 21 which actuates an alarm 22 when the level detector 19 fires. Reset means 23 is connected between the output of the amplifier 16

and the high frequency pulse counter 13 and first level detector 14 for periodically resetting this counter and level detector when a continuous disturbance is present.

The alarm system also includes smoke and fire sensing means 26 adapted to be placed in the protected enclosure and connected to the remainder of the system through an input terminal 27. The sensing means 26 controls the voltage applied to a level detector 28 from a power supply 29.

As illustrated in the drawing, the sensor means 10 comprises a microphone for detecting disturbances due to an intruder, and the sensing means 26 comprises an ion detector for detecting disturbances due to smoke or fire. The microphone can be a conventional device such as a crystal or dynamic microphone. In the preferred embodiment, the ion detector includes a pair of ionization chambers, one of which is sealed and one of which is exposed to the interior of the vault or space protected. Each of these chambers contain two electrically charged plates and a small amount of radium 226. Alpha rays produced by the radium ionize the atmosphere in each chamber, causing a small current flow between the charged plates. Under normal conditions, the flow of current between the plates in each chamber is equal, and a balanced state exists in the detector. When a combustion product enters the exposed chamber, it produces a decrease in the current flow between the plates in this chamber, thereby creating an imbalance in the current flows in the two chambers. A suitable ion detector is available from the Notifier Company, Lincoln, Neb. While only one microphone and one ion detector are shown in the drawings, it is to be understood that a plurality of such devices can be connected to the input terminals 11 and 27 if desired.

The amplifier 12 is a conventional amplifier having a frequency response on the order of 200 hertz to 8 kilohertz. In the preferred embodiment, this amplifier includes a gain control for adjusting the sensitivity of the system.

The high frequency pulse counter 13 includes a transistor 31. The base of this transistor is connected to the output of the amplifier 12 through a coupling capacitor 32 and resistor 33. This transistor operates as an inverting amplifier, with the output appearing at the collector. One terminal of a capacitor 36 is connected to the collector of the transistor 31. The other terminal of this capacitor is connected to the cathode of a diode 37 and to the anode of a diode 38. The anode of the diode 37 is connected to ground, and the cathode of the diode 38 is connected to one side of the capacitor 34. The other side of this capacitor is connected to ground. Each positive going pulse appearing at the collector of the transistor 31 charges the capacitors 36 and 34 through the diode 38. After each pulse, the capacitor 36 discharges through the diode 37, and the diode 38 prevents the capacitor 34 from being discharged. Thus, the voltage across the capacitor 34 increases in discrete steps with the positive going pulses at the collector of the transistor 31, producing a step ramp voltage having a positive slope.

The level detector 14 includes a switching transistor 41 with a zener diode 42 connected between its emitter and ground. The output of the first pulse counter 13 is connected to the base of the transistor 41 through a re-

sistor 43. A resistor 44 is connected between this base and ground. The transistor 41 remains turned off until the voltage across the capacitor 34 rises to the level set by the zener diode 42. The resistors 43 and 44 serve as a bleeder across the capacitor 34 and prevent the capacitor voltage from rising to the level required to fire the transistor 41 if the pulses in the disturbance signal occur too far apart. In the preferred embodiment, the capacitor 34, zener diode 42, and resistors 43, 44 are chosen to have values such that a disturbance signal sound burst must contain approximately twenty pulses to produce firing of the level detector.

The output of the level detector is connected to the input of the amplifier 16 through a resistor 46. This amplifier includes a transistor 47 with the resistor 46 connected to its base. The output of this amplifier is taken at the collector of the transistor 47 and is applied to the trigger input of the multivibrator 17 through a capacitor 48 and a diode 49.

The means for periodically resetting the pulse counter 13 and level detector 14 when continuous disturbance signals are present also derives its input from the collector of the transistor 47. This means includes a switching transistor 51 having its collector connected to the base of the transistor 41 and its emitter grounded. A timing capacitor 52 is connected between the base of the transistor 51 and ground. Charging current is supplied to this capacitor from the collector of the transistor 47 through resistors 53, 54. The transistor 51 remains turned off until the voltage across the capacitor 52 rises to the level required to turn it on. When turned on, the transistor 51 grounds the base of the transistor 41, turning it off, and it also grounds one end of the resistor 43, discharging the capacitor 34. A diode 56 is connected across the resistor 54 and in series with a bleeder resistor 57 for discharging the capacitor 52 when the disturbance signals do not have the duration desired for resetting the pulse counter 13 and level detector 14. In the preferred embodiment the components of the reset circuit 23 are chosen to have values such that the counter and level detector are periodically reset with disturbance signals having a duration on the order of 3 seconds or greater.

The monostable or one-shot multivibrator 17 is of conventional design. In the preferred embodiment it produces a negative-going pulse of predetermined duration and magnitude each time a positive going pulse is applied to its trigger input. Thus, it produces one such pulse each time the level detector 14 fires, or one pulse for each sound burst containing twenty or more pulses.

The output of the multivibrator 17 is applied to the low frequency pulse counter 18 through a coupling resistor 61. This pulse counter includes an inverting transistor 62 having its base connected to the resistor 61. The output of the inverter appears the collector of the transistor 62 and is applied to a timing capacitor 63 through a resistor 64 and a diode 66. The voltage across the capacitor 63 is a positive-going ramp which is increased in discrete steps by each pulse from the multivibrator 17. A bleeder resistor network 67 is connected across the capacitor 63. This network includes resistors 68, 69, and a switch 71 for selectively

discharging the capacitor 63 through either or both of the resistors 68, 69. A normally open switch 72 is also connected across the capacitor 63 to provide means for manually discharging the capacitor to reset the counter 18.

The level detector 19 includes a switching transistor 76. The output of the low frequency pulse counter 18 is applied to the base of this transistor through a zener diode 77. This transistor remains turned off until the voltage across the capacitor 63 reaches the level determined by the zener diode 77 for firing the transistor. In the preferred embodiment, the values of the capacitor 63, resistors 68 and 69, and zener diode 77 are chosen such that the transistor 76 does not fire until two pulses are received from the multivibrator 17 in a period of either 15, 30, or 45 seconds, depending upon the position of the switch 71.

The output of the level detector 19 is applied to the input of the relay driver 21 through a resistor 78. This relay driver includes an amplifying transistor 79 and a switching transistor 81. The emitter of the transistor 81 is connected to the positive terminal $+V_{cc}$ of a source of direct current, and the collector is connected to one end of a relay trip coil 82. The other end of this coil is returned to the negative terminal of the source of direct current in a manner hereinafter described. The transistor 81 is normally turned on, energizing the relay coil 82. The relay is connected to the alarm device 22 in such manner that the alarm is actuated by de-energization of the relay coil. The alarm can be any conventional device such as an alarm bell.

The output of the level detector 28 which is associated with the ion detector 26 is also applied to the relay driver 21 through the transistor 76. The level detector 28 includes a zener diode 86 and a transistor 87. The zener diode is connected in series with the base of this transistor through a resistor 89, and the emitter of the transistor is grounded. The output of the level detectors at the collector of the transistor 87 and is applied to the base of the transistor 76 through a resistor 91.

The ion detector power supply 29 is adapted for alternatively supplying operating voltages to the ion detector at two different DC levels. This supply includes an oscillator comprising a transistor 91 and operating at a frequency on the order of 200 kilohertz. The frequency of the oscillator is determined by an inductor 92 connected between the collector of the transistor 91 and $+V_{cc}$ and by a voltage divider consisting of capacitors 93 and 94. The capacitor 93 is connected between the collector and emitter of the transistor 91, and the capacitor 94 is connected between the emitter and ground. Biasing where the oscillator is provided by means of resistors 96-98, and a capacitor 99 is connected between the base of the transistor 91 and ground to maintain the base at AC ground. The output of the oscillator is rectified and doubled by a doubling circuit consisting of capacitors 101, 102 and diodes 103, 104. The output of the voltage doubler is connected through a resistor 106 to the input terminal 27 and to the cathode of the zener diode 86. The zener diode 107 is connected between the input terminal 27 and ground to maintain the rectified output of the oscillator at a constant DC voltage on the order of 15 volts. A diode 108 is connected between the positive terminal

$+V_{cc}$ of a source of direct current and the junction of the cathode of the zener diode 107, the input terminal 27, and the cathode of the zener diode 86.

All of the alarm system except the microphone 10 and ion detector 26 is mounted in a tamper-proof box 111. The microphone and ion detector are placed in the vault or space to be protected and are connected to the remainder of the system through tamper-proof cables 112, 113. The system is made tamper-proof by means of a tamper loop 114 connected between one end of the relay coil 82 and to the negative terminal of the source of direct current. This loop includes conductors which extend through each of the cables 112, 113 and a normally closed switch 116 which is opened by opening of the box 111. Thus, cutting either of the cables 112, 113 or opening the box 111 will interrupt the flow of current in the relay coil 82, de-energizing the relay and actuating the alarm.

Operating power for the alarm system is normally provided by a direct current power supply operating from a conventional source of alternating current, such as 120 volts, 60 hertz. This power supply includes a pair of input terminals 116, 117 adapted for connection to the AC source, a power transformer 118, and a half wave rectifier 119. The bypass capacitor 121 is connected across the secondary winding of the transformer, and the output of the rectifier is connected to an RC filter consisting of capacitors 122, 123 and a resistor 124. The output of the supply is regulated by means of a zener diode 126 connected between the output of the filter and ground.

An emergency supply is provided for supplying operating power to the alarm system upon interruption of the power from the AC operated supply. This emergency supply includes a battery 127 connected across the output terminals of the power supply. A diode 128 is connected between the zener diode 126 and the battery 127 to prevent the battery from being discharged by the zener diode. The value of the resistor 124 is chosen such that during normal operating conditions the AC operated supply provides the operating power for the alarm system and also provides a trickle charge for the battery 101.

Operation and use of the alarm system can now be described briefly. Let it be assumed that the system has been installed in a bank vault and that an intruder is attempting to pick the lock of the vault. This picking produces a series of sound bursts each containing more than 20 pulses. The sound waves are picked up by the microphone 26 and converted to an electrical signal which is amplified by the amplifier 12. The pulses in each burst are counted by the high frequency pulse counter 13, and after 20 pulses are counted, the output of this counter reaches the level which fires the level detector 14. Each time the level detector fires, the multivibrator 17 fires, delivering a pulse to the low frequency pulse counter 18. When two pulses are received from the multivibrator within the time period set by the switch 71, the level detector 19 fires. This deenergizes the relay coil 82 actuating the alarm.

Next let it be assumed that a low frequency transient disturbance occurs and is picked up by the microphone 26. This disturbance causes the capacitor 34 to be charged to a voltage less than that required for tripping the level detector 14. Consequently, there is no alarm.

The capacitor 34 is gradually discharged by the bleeder action of the resistors 43, 44.

Next let it be assumed that the disturbance is a high frequency shock noise such as the knocking of pipes which produces a single sound burst having 20 pulses. This disturbance will fire the level detector 14 and multivibrator 17 one time, placing a charge on the capacitor 63. This charge is not sufficient to fire the level detector 19, and in the absence of a second pulse from the multivibrator 17 within the time set by the switch 71, the capacitor 63 will be discharged.

Finally, let it be assumed that the intruder is using an electric drill on the door of the vault. This disturbance produces a continuous train of pulses which is picked up by the microphone 10 and amplified by the amplifier 12. The first 20 pulses are counted by the pulse counter 13 and cause the level detector 14 to fire. After 3 seconds, the signal at the output of the amplifier 16 charges the capacitor 52 in the reset means 23 to the level which fires the transistor 51, resetting the pulse counter 13 and level detector 14. This counter then counts the next 20 pulses in the disturbance signal and fires the level detector 14 to simulate a second sound burst. This simulated sound burst causes the multivibrator 17 to fire again, charging the capacitor 63 to the level required for firing the level detector 19 and actuating the alarm.

Operation of the smoke and fire detecting portion of the system can also be described briefly. In the absence of smoke and fire, the ion detector operates on the output of the 200 kilohertz oscillator, drawing on operating current on the order of 0.5 ma. The zener diode 107 is chosen to have a zener voltage which is greater than the supply voltage $+V_{cc}$, and consequently during normal conditions the diode 108 is reverse biased by the voltage across the zener diode 107. When smoke or fire is detected, the ion detector draws a heavier current than the oscillator is capable of supplying. This causes the output of the oscillator to collapse, and when the voltage across the zener diode 107 drops below the level of $+V_{cc}$, the diode 108 begins to conduct, and the ion detector draws its operating current from the lower voltage source. This change in level is detected by the level detector 28 and applied to the relay driver 21 through the transistor 76, producing actuation of the alarm.

The method of the present invention can be summarized as comprising the steps of receiving a pulsating signal indicative of a disturbance, counting the number of pulses in the received signal to distinguish signals due to intruders, from signals due to other disturbances, counting the number of times the number of pulses reaches a predetermined count, and actuating an alarm when the number of times counted reaches a predetermined number in a predetermined period of time. The method also includes the additional step of periodically restarting the counting of pulses in the received signal when the duration of the signal exceeds a predetermined time.

It is apparent from the foregoing that a new and improved alarm system and method have been provided. While only one presently preferred embodiment has been described herein, as will be apparent to those familiar with the art, certain changes and modifications can be made without departing from the scope of the invention as defined by the following claims.

We claim:

1. In an alarm system for protecting an enclosed space such as a bank vault against disturbances such as burglary and fire, sensing means for detecting a disturbance and producing a pulsating disturbance signal in response thereto, first counting means connected for receiving the signal from said sensing means and counting the number of pulses in said signal, means responsive to the disturbance signal for resetting said counting means in the event that the disturbance is longer than a predetermined minimum duration, additional counting means for counting the number of times the number of pulses exceeds a predetermined number in a predetermined time and means for actuating said alarm means when said number of times exceeds a predetermined number.

2. An alarm system as in claim 1 wherein all of said system except said sensing means is mounted in a tamper-proof box and wherein said sensing means is connected to the remainder of said system by means of a tamper-proof cable.

3. An alarm system as in claim 1 together with power supply means for supplying operating power to said system from a conventional alternating current source and battery means for supplying the operating power upon interruption of the power from said supply means.

4. An alarm system as in claim 1 together with ion detector means for sensing smoke and fire and means connecting said ion detecting means intermediate said additional counting means and said alarm means for energizing said alarm means in response to smoke and fire.

5. An alarm system as in claim 4 wherein said ion detector means includes an ion detector, a power supply adapted for supplying an operating voltage at one level to said ion detector during normal conditions and for supplying an operating voltage at a different level when smoke and fire are sensed, and level detector means connected to said ion detector for detecting the level of the voltage supplied to said ion detector.

6. In a vault alarm system, an input terminal adapted for connection to a sensing device for receiving a pulsating signal caused by a disturbance detected by the sensing device, first pulse counting means connected for receiving the signal from said input terminal and producing a first step ramp signal having a magnitude corresponding to the number of pulses in the received signal, first level detector means connected to the output of said first pulse counting means and adapted for firing when the magnitude of said first step ramp signal reaches a predetermined level, means responsive to the signal produced by a disturbance for resetting the first pulse counting means and level detector means in the event that the disturbance is longer than a predetermined minimum duration, second pulse counting means responsive to the output of said first level detector means for producing a second step ramp signal having a magnitude corresponding to the number of times said first level detector means fires in a predetermined period of time, second level detector means connected to the output of said second pulse counting means and adapted for firing when the magnitude of said second step ramp signal reaches a predetermined level, and means connected to said second level detector means for actuating an alarm in response to the firing of said detector means.

7. An alarm system as in claim 6 together with a one-shot multivibrator connected intermediate the output of said first level detector means and the input of said second pulse counting means, said multivibrator being triggered by the firing of said first level detector means and producing a pulse of predetermined magnitude and duration in response thereto.

8. An alarm system as in claim 7 wherein said second pulse counting means includes a capacitor across which said second step ramp signal is produced and means for selectively connecting a resistive element across said capacitor to discharge the same at a desired rate to determine the period of time in which successive firings of said first level detector means and said multivibrator must occur to produce a signal of sufficient magnitude to cause firing of said second level detector means and

actuation of the alarm.

9. In a method for protecting an enclosed space such as in alarm against disturbances such as intruders the steps of receiving a pulsating signal indicative of a disturbance, counting the number of pulses in the received signal to distinguish signals due to intruders and fires from signals due to other disturbances, restarting the counting of pulses in the received signal in the event that the disturbance is longer than a predetermined minimum duration, counting the number of times the number of pulses reaches a predetermined count, and actuating an alarm when the number of times counted reaches a predetermined number.

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