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## TIME INTEGRATION

**May 26, 1964**

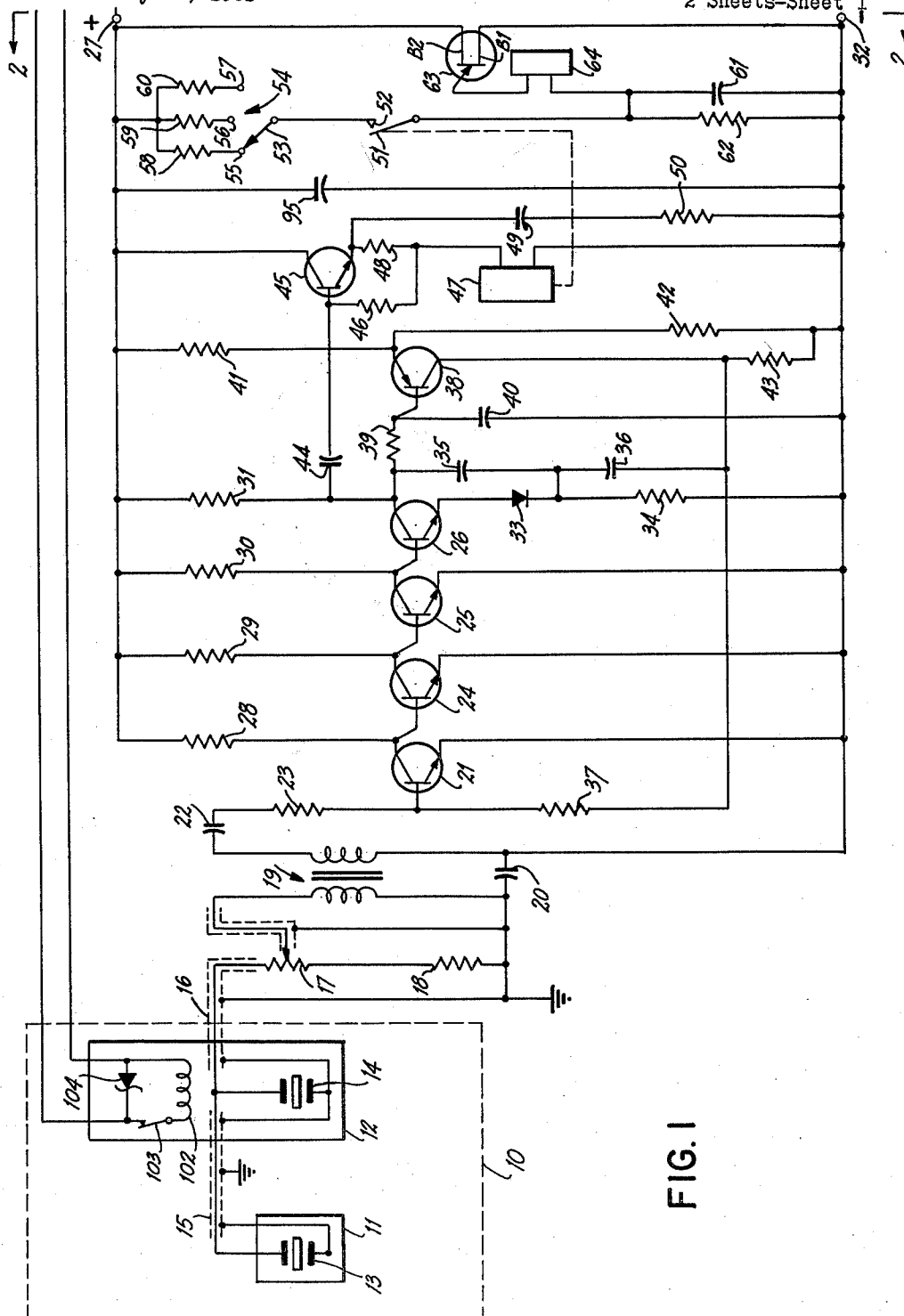
L. H. KELLY ETAL

**3,134,970**

## ALARM SYSTEM

Filed May 31, 1961

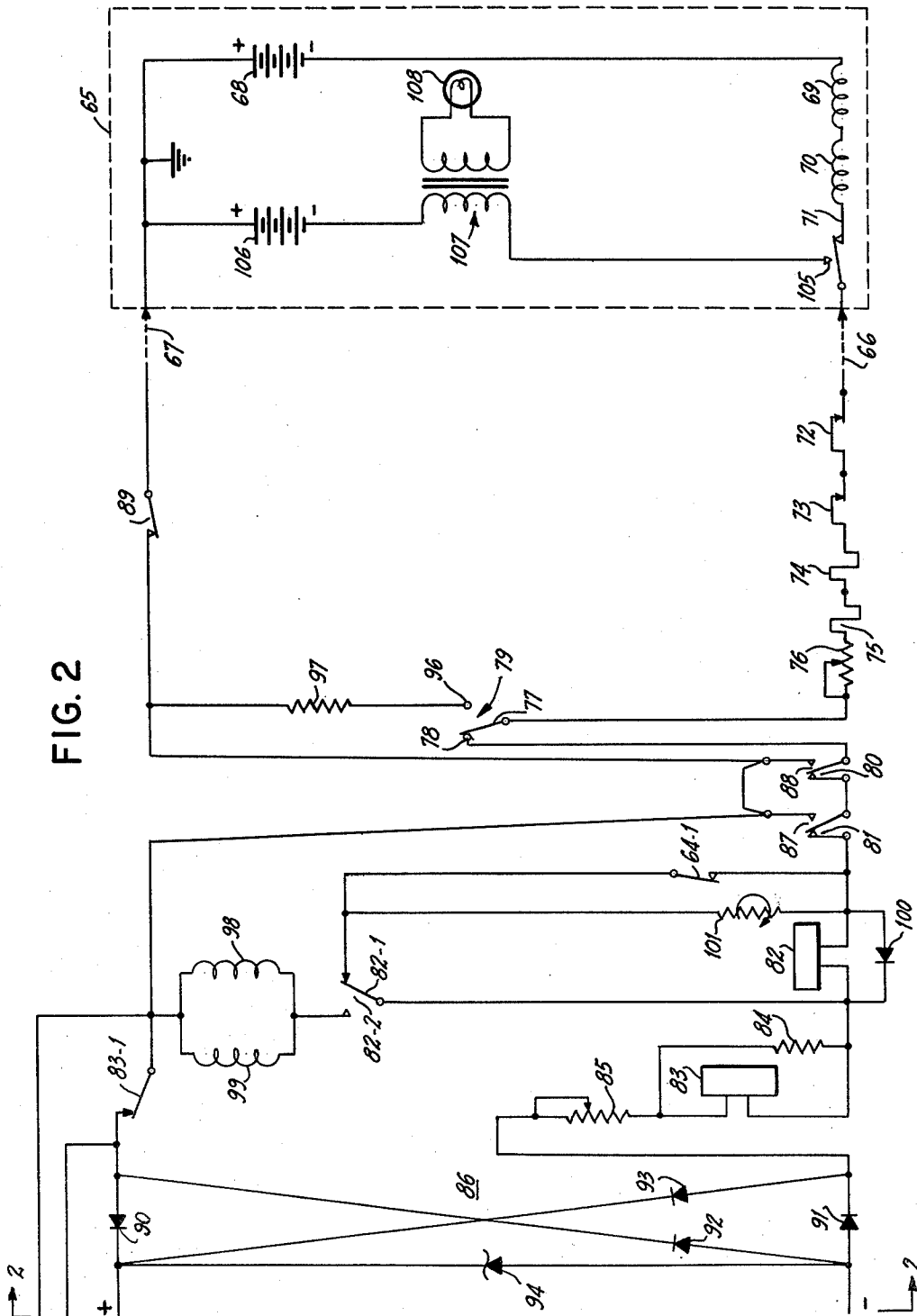
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**3,134,970**

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**FIG. 2**



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3,134,970

## ALARM SYSTEM

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6 Claims. (Cl. 340-261)

The present invention relates to burglar alarm systems, and more particularly to burglar alarm systems of the type especially adapted for the protection of vaults and similar enclosures.

Burglar alarm systems for vaults and the like operating on the principle of noise detection have been used for many years, and a variety of such systems have been proposed. An early example of such a system is found in United States Patent 1,192,312, issued July 25, 1916 to R. M. Hopkins and J. F. D. Hoge. The present invention is concerned primarily with systems of this general type and in particular with systems responsive to vibrations produced in attacks on vaults and similar structures.

The construction of vaults varies from essentially monolithic, steel-reinforced, poured concrete structures to masonry structures of bricks or blocks bonded together with mortar. And an attack on a vault may vary from the extreme of a dynamite blast to the scraping away of mortar with a pointed tool. Modern tools, and especially tools such as portable core drills with diamond cutters, have been used widely and effectively by burglars in conducting attacks on vault structures, and such tools produce relatively little noise. Sledge hammers and similar noisy instruments have been used by many burglars in the past to gain entry to some types of vaults, but the more efficient burglars have found the hydraulic jack to be a more effective and far less noisy tool for gaining entry to vaults.

It will be evident that providing an acoustical burglar alarm system usable with different types of vaults and effective in detecting the different possible modes of attack is a problem of some magnitude. Moreover, a satisfactory system must be operable at a relatively high sensitivity level without an undue occurrence of spurious alarms. Almost any of the systems heretofore used can be made sufficiently sensitive to detect the different modes of attack, but such high sensitivity has produced an intolerable false alarm rate. Thus, it has been the practice to compromise between sensitivity on the one hand and stability and freedom from false alarms on the other hand.

Ambient noise has been a serious problem in acoustical burglar alarm systems, and the problem of ambient noise has been greatly aggravated by noise producing machinery, trucks, and especially jet aircraft.

The principal object of the invention has been to provide a novel and improved burglar alarm system of the acoustical type. While the invention may be applied with advantage in the protection of the various types of vault structures and under various ambient conditions, the invention has been found especially useful in the protection of monolithic concrete vaults located in areas having a high airborne ambient noise level. Typical of such a protection situation would be a narcotics vault located in an area where jet aircraft or other loud noise producing agencies create a high but varying ambient noise level.

Accordingly, an important object of the invention has been the provision of an acoustical type of vault burglar alarm system which affords high protection sensitivity without being oversensitive to high airborne noise levels.

Another object of the invention has been the provision of such a system which is highly responsive to any of

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the various modes of attack but which is resistant to spurious alarms due to ambient noises, even though the ambient noises may be of greater intensity than the attacking noises.

A feature of the invention has been the provision of such a system which may be used in a central station protection system without a local power source.

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

FIGS. 1 and 2, when joined along the line 2-2, form a schematic diagram illustrating one embodiment of the invention.

Referring now to the drawings, the dashed line box 10 represents a vault which might be, for example, a concrete narcotics storage or other high security vault structure. One or more sensitive vibration transducers may be affixed to the walls and/or ceiling of the vault 10 and are connected electrically in parallel. In the arrangement shown, a transducer 11 and a transducer 12 are provided and are affixed to the vault walls or ceiling at spaced points. The vibration transducers are installed in close contact with the walls and/or ceiling so as to be subjected to such vibrations as may occur in the vault structure.

The vibration transducers are preferably microphones of the piezoelectric type and may each comprise direct actuated Rochelle salt crystal elements arranged in bimorph construction and housed in a die-cast metallic casing. To ensure reliable sensitivity over large ambient temperature and humidity ranges, the vibration transducer case may be sealed in a suitable potting compound such as an epoxy resin with a hardening agent so that vibratory energy will be transmitted to the case and from the case to the crystal elements within the case. Enclosing the vibration detecting elements also serves to shield these elements from airborne sounds except as the latter may produce vibrations in the vault structure.

Vibration transducers other than those of a crystal type may be used, although the crystal type is preferred. Contact microphones of the type used on electrical guitars, banjos or other stringed instruments with sounding boards are in general suitable for use in the system of the invention. A crystal-type vibration transducer with frequency response peaks at about 2, 4 and 9 kilocycles has been found desirable in the system of the invention.

The arrangement of the vibration transducers in the vault structure is largely determined by the vault material composition, i.e., hardness and density, the vault structure design, the ambient noise (vibration) level within the vault walls, and the desired sensitivity. By vault structure design is meant primarily the presence or absence of discontinuities in the monolithic walls, e.g., expansion joints. It has been found that in a reinforced concrete vault a single vibration transducer per 1000 square feet of vault inside surface area will generally provide satisfactory detection of attempts to penetrate the vault. Where accidental damage is possible, e.g., by materials handling equipment, the vibration transducers may with advantage be mounted on the vault ceiling.

Crystal vibration detection element 13 of vibration transducer 11 and crystal vibration detection element 14 of vibration transducer 12 are connected in parallel by a shielded cable 15, the shield of which may be grounded as shown. The crystal elements 13 and 14 are connected through a shielded cable 16 to a sensitivity control formed by a potentiometer 17 and a resistor 18 connected in series between the central conductor of shielded cable 16 and ground. The slider of potentiometer 17 is connected to the high side of the primary winding of an input transformer 19. The low side of the primary winding of transformer 19 is connected to ground. Provision of resistor

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18 prevents the sensitivity from being reduced below a predetermined level.

When either or both of crystal elements 13 and 14 are subjected to vibration, an alternating voltage is produced which appears across potentiometer 17 and resistor 18, and a portion of this voltage is supplied to the primary winding of transformer 19.

The low sides of both windings of transformer 19 are coupled together by a capacitor 20 to provide a common A.C. ground and thereby reduce A.C. hum while maintaining D.C. isolation.

The high side of the secondary winding of transformer 19 is coupled to the base of a transistor 21 through a coupling capacitor 22 and a resistor 23. Coupling capacitor 22 may be selected to discriminate against relatively low frequencies which are characteristic of ambient noise in the vault walls. Preferably, transformer 19 is designed also to suppress the low frequency noise components.

Transistor 21 is the first stage of a four-stage direct coupled transistor amplifier comprising transistor 21 and transistors 24, 25 and 26, each of which might be NPN transistors of the 2N1849 type. The collectors of transistors 21 and 24-26 are coupled to positive D.C. terminal 27 through resistors 28, 29, 30 and 31, respectively. The collectors of transistors 21, 24 and 25 are connected directly to the bases of transistors 24, 25 and 26, respectively. The emitters of transistors 21, 24 and 25 are each connected to a negative D.C. terminal 32. The emitter of transistor 26 is coupled to terminal 32 through a rectifier 33, which might be of the 2E4 type, and a resistor 34.

The junction of rectifier 33 and resistor 34 is coupled to the collector of transistor 26 through a capacitor 35. A portion of the amplified output of transistor 26 appears across resistor 34 and is supplied through a capacitor 36 and a resistor 37 to the base of transistor 21, the coupling affording a negative feedback from the amplifier output to the amplifier input.

The collector of transistor 26 is also coupled to the base of a transistor 38 through a resistor 39. The transistor 38 might be a PNP transistor of the 2N522A type. A capacitor 40 is coupled between the base of transistor 38 and negative terminal 32. The emitter of transistor 38 is connected to the junction of resistors 41 and 42 forming a voltage divider between terminals 27 and 32. The collector of transistor 38 is coupled to terminal 32 through a resistor 43. The voltage appearing across resistor 43 is applied to the base of transistor 21 through resistor 37.

Transistor 38 is not part of the amplifying circuit as such, but instead is intended to control the operating point of transistor 26. Thus, changes in the collector current of transistor 26 occurring at a slow rate change the voltage across resistor 43, which in turn changes the input to the base of transistor 21 in a sense to oppose the change in collector current of transistor 26. This arrangement affords a stability in amplifier operation by compensating for parameter variations caused by aging and changes in temperature. The capacitor 40 is provided to prevent transistor 38 compensating for rapid changes in the collector current of transistor 26 resulting from detection of an alarm condition.

The signal output of the four-stage transistor amplifier appears at the collector of transistor 26 and is supplied through a coupling capacitor 44 to the base of a transistor 45, which might be an NPN transistor of the 2N78 type. The base of transistor 45 is coupled to negative terminal 32 through a resistor 46 and the coil of a relay 47. The emitter of transistor 45 is coupled to terminal 32 through a resistor 48 and the coil of relay 47 and through the series connection of a capacitor 49 and a resistor 50. The collector of transistor 45 is connected to positive terminal 27.

Transistor 45 is biased so as to be normally nonconductive. When the amplified output signal at the collector of transistor 26 is of sufficient magnitude, transistor 45 becomes conductive and the emitter current

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flowing through relay coil 47 will energize relay 47, causing armature 51 thereof to make with front contact 52. When the amplifier output signal drops below a value sufficient to maintain conduction, transistor 45 will become nonconductive and relay 47 will drop out, opening armature 51 and front contact 52.

Contact 52 is connected to the armature 53 of a three-position manual selector switch 54, having contacts 55, 56 and 57 which are connected to positive terminal 27 through resistors 58, 59 and 60, respectively. Armature 51 is coupled to negative terminal 32 through a capacitor 61 which is shunted by a resistor 62.

Capacitor 61 is also coupled to the emitter of a unijunction transistor or double-base diode 63 through the coil of an alarm relay 64. Unijunction transistor 63 might be of the 2N489 type. Base B1 of unijunction transistor 63 is connected to negative terminal 32, while base B2 thereof is connected to positive terminal 27. Unijunction transistor 63 will not conduct until the voltage between its emitter and base B1 equals a predetermined percentage of the voltage between bases B1 and B2, which might be 60%. The B1-B2 voltage is fixed by the supply potential 27-32 and might be, for example, 14 volts. Hence, under these conditions, unijunction transistor 63 will not conduct until the emitter-base B1 voltage thereof reaches 8.4 volts.

The emitter-base B1 voltage of unijunction transistor 63 is dependent solely on the charge across capacitor 61 since, with unijunction transistor 63 nonconducting, there will be no emitter current to produce a voltage drop across the coil of relay 64. Capacitor 61 starts to charge toward the supply voltage level whenever relay 47 is energized, since energization of relay 47 closes armature 51 and contact 52, completing a charging circuit for capacitor 61 through one of the resistors 58-60, dependent on the position of armature 53. The values of resistors 58-60 are respectively different to provide an adjustable charging rate for capacitor 61.

If the charge across capacitor 61 does not reach a value sufficient to cause unijunction transistor 63 to conduct before relay 47 drops out, the charge across capacitor 61 will start to dissipate through resistor 62 when relay 47 drops out. However, if the charge on capacitor 61 increases to a value sufficient to cause unijunction transistor 63 to conduct, the resulting emitter current will energize alarm relay 64. Alarm relay 64 will remain energized so long as the supply potential persists across terminals 27-32.

Typically, capacitor 61 might be 250 microfarads and resistors 58, 59 and 60 might be 390, 1000 and 2200 ohms, respectively, yielding charging time constants of about 0.098, 0.25 and 0.55 second, respectively. Resistor 62 might have a value of 5.6 megohms, yielding a discharging time constant of about 23.3 minutes.

When vibrations of sufficient amplitude to energize transistor 45 are detected by the vibration transducers, relay 47 will be energized and capacitor 61 will be charged toward the supply voltage. However, if the detected vibrations are not of sufficient duration to permit capacitor 61 to charge up to a value corresponding to the operating potential of unijunction transistor 63, transistor 45 will become nonconductive and relay 47 will drop out, stopping the charging of capacitor 61 at an intermediate level. The capacitor 61 then starts to discharge at a slow rate. Thus, charge on capacitor 61 resulting from sporadic vibration activity will be dissipated and will not result in false alarms. It will be observed that the amplitude of the detected vibrations, so long as they are sufficient to energize transistor 45, will not affect the charging rate of capacitor 61. Hence, vibrations resulting from very loud ambient noises and other high intensity causes are not more likely to produce false alarms than vibrations produced by lower intensity causes so long as the latter are equal to or over the threshold value at which transistor 45 becomes conductive. Considered in another way, capacitor

61 acts to integrate the detected vibrational energy equal to or over the threshold value, the integration being dependent only on the duration of the vibrational energy, except that vibrations having amplitudes below the threshold value do not contribute to the integration.

The minimum time duration of vibrational energy required to energize alarm relay 64 is determined on the charging time constant of capacitor 61. However, vibrational energy over the threshold value detected over a considerably longer period of time can be effective to produce energization of the alarm relay 64. This longer period of time is determined by the discharging time constant of capacitor 61. Depending on local ambient conditions, it has been found that the minimum time interval for achieving an alarm relay energizing charge level across capacitor 61 is desirably in the range of about 0.09 to 0.6 second, values in this range affording substantial freedom from false alarms under varying conditions. It has also been found that a discharging time constant for the capacitor 61 of the order of 20 minutes will assure detection of attacks and yet permit dissipation of charge due to most sporadic ambient vibrations.

Since the vibration transducers are arranged to detect vibrations in the vault walls (the term "walls" being used also to include ceiling and floors), airborne sounds, even the loud sounds produced by nearby jet aircraft, do not produce any substantial signal output from the vibration transducers unless the sounds also result in substantial vibrations in the walls. Low frequency vibrational energy in the vault walls, such as may result from heavy trucks rumbling past, does not result in a substantial signal input to the amplifier, in part because of the frequency response characteristics of the vibration transducers, and in part because of the low frequency suppression characteristics of transformer 19 and capacitors 22 and 44.

When an attack is made on the vault, the energy of the attacking medium produces vibrations in the vault walls which result in a signal output from the vibration transducers. This signal output is amplified and the amplified signal is supplied to transistor 45, rendering the latter conductive and resulting in energization of relay 47 and charging of capacitor 61. When a sufficient charge is built up across capacitor 61, unijunction transistor 63 becomes conductive and energizes alarm relay 64, resulting in transmission of an alarm signal. The system will respond even to the relatively quiet attacks which may be made with modern tools such as high speed core drills.

Energization of alarm relay 64 may be used to produce a local or remote alarm signal, as desired. However, it is preferable that the alarm signal be given at a remote point, and in general the most satisfactory protection will be achieved when the signal is transmitted to a remote central station, as will be described.

A remote central station is shown at 65 and may be connected to the protected premises at which the vault 10 is located by means of a metallic conductor 66 and ground return 67. The central station battery 68, galvanometer-type break and ground drops 69 and 70, and back contacts 71 of a test switch are connected in series between conductor 66 and ground return 67.

The central station battery supplies operating power for the detector of the invention over a circuit extending from conductor 66 through system cabinet pry-off tamper switch 72, cabinet door tamper switch 73, cabinet lining protection circuits 74 and 75, current adjusting resistor 76, armature 77 and front contact 78 of an on-off switch 79, door protection contacts 80 and 81 (which may be provided on the vault door and/or other doors of the protected premises), contacts 64-1 of alarm relay 64, back contacts 82-1 of a relay 82, the coil of a relay 83 (shunted by a resistor 84), a current adjusting resistor 85, and a rectifier circuit 86 to terminal 32. The return path from terminal 27 extends through rectifier circuit 86, back contacts 83-1 of relay 83, door contacts 87 and 88, and test bell contacts 89 to ground return path 67.

Rectifier circuit 86 is of the bridge type and comprises rectifiers 90, 91, 92 and 93 poled to maintain terminals 27 and 32 positive and negative, respectively, irrespective of the polarity of conductor 66 and ground return path 67. Rectifiers 90-93 might be of the 2E4 type. A zener diode 94 is coupled between terminals 27 and 32 to maintain a constant voltage between terminals 27 and 32 in the event of voltage surges in the supply line. A capacitor 95 is coupled between terminals 27 and 32 to help maintain a constant voltage between terminals 27 and 32.

When switch 79 is in its off position, armature 77 is made with contact 96 and the only protection is afforded by the tamper elements 72-75, the central station circuit being completed through a resistor 97. Resistor 76 should be adjusted to provide the desired line current with switch 79 in the off position. Proper line current with switch 79 in the on position is then achieved by adjustment of resistor 85.

When an alarm condition is detected, relay 64 becomes energized, resulting in contacts 64-1 thereof opening, which in turn opens the central station circuit, resulting in operation of break drop 69 which alerts the central station operator to the existence of an alarm condition. Relay 64 locks up through unijunction transistor 63, maintaining the alarm signal until the central station operator removes power from the line, allowing unijunction transistor 63 to cease conduction.

When contacts 64-1 open, the shunt formed by these contacts around the coil of relay 82 is opened, causing relay 82 to energize. Contacts 82-1 then open and contacts 82-2 close, locking in relay 82 across the line through coils 98 and 99 of a test bell. The current flow will be insufficient to ring the test bell, but will be sufficient to operate ground drop 70, producing a locked in ground. The central station operator thus has a double drop signal with a locked in ground, which is the usual central station system alarm signal.

A rectifier 100 is provided across the coil of relay 82 to delay operation of this relay for a short time after operation of alarm relay 64 thereby insuring that the break drop 69 will have operated in response to a decrease in line current before the line current increases upon operation of relay 82. A varistor 101 is shunted across contacts 64-1 to quench any arc which may form when opening of these contacts opens the central station line.

Restoration of the alarm circuit to normal after the alarm-producing condition has been eliminated may be effected by opening switch 71 at the central station and thereby removing power from central station line 66-67. The power removal should be for a sufficient interval so that discharge of capacitor 95 will have proceeded to a point at which unijunction transistor 63 will have become deenergized. Unijunction transistor 63 will remain deenergized until the charge across capacitor 61 becomes sufficient to again energize unijunction transistor 63.

It is desirable periodically to test the integrity of the system under control of the central station. For this purpose, one or more of the vibration transducers may have associated therewith a vibration producing element which simulates vibrations detected under attack conditions. As illustrated, a buzzer 102 having interrupter contacts 103 is mounted in the same case as vibration detecting element 14. A zener diode 104, which might be of the 1M6.8z10 type, is connected across the coil of buzzer 102. The series connection of buzzer 102 and contacts 103 is connected across back contacts 83-1 of test relay 83. When contacts 83-1 open, the shunt formed by those contacts is opened and buzzer 102 and contacts 103 are connected in series with the ground return path of the central station line and the line current will operate the buzzer and simulate an attack on the vault.

To initiate a test, the central station operator transfers the test switch 71 armature to contact 105, disconnecting

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battery 68 and drops 69 and 70 from line 66—67 and substituting therefor test battery 106 and the primary winding of a transformer 107. The voltage of battery 106 is substantially higher than that of battery 68 and is sufficient to operate relay 83, resulting in opening of contacts 83—1.

If the system is in proper operating condition, the vibrations produced by buzzer 102 will result in rapid charging of capacitor 61 to a level at which unijunction transistor 63 becomes energized, causing alarm relay contacts 64—1 to open and energizing relay 82. When relay 82 operates, contacts 82—2 thereof close, supplying power to test bell coils 98 and 99. Because of the higher voltage of test battery 106, under system test conditions the line current is substantially higher than under normal conditions. Hence the current through bell coils 98 and 99 will be sufficient to operate the bell and produce a local audible signal indication of a successful test. Moreover, operation of bell 98—99 intermittently opens bell contact 89, resulting in intermittent opening of the central station line. Intermittent opening of the central station line will cause a neon lamp 108 connected to the secondary winding of transformer 107 to flash. The flashing of lamp 108 shows the central station operator that the test has been successful, whereupon he opens test switch 71 to remove power from the central station line and allow unijunction transistor 63 to deenergize. The operator then closes switch 71 in its normal position, reconnecting battery 68 and drops 69 and 70 to the line.

While the invention has been described in connection with a specific embodiment thereof and in a specific use, 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. An electrical protection system for detecting physical attacks on vaults and like structures, comprising at least one vibration transducer mounted in close physical contact with an interior surface of said structure and including a vibration detecting element arranged to produce an alternating signal voltage in response to detection of vibrations transferred to said detecting element from said surface, said vibration transducer being relatively insensitive to airborne vibrations in the space within said structure, an amplifier having an input circuit coupled to said detecting element, an electronic switch element having an input circuit coupled to the output circuit of said amplifier and being arranged to transfer from one conduction condition to another conduction condition when the amplified signal voltage output of said amplifier exceeds a predetermined value, a first relay means having a coil included in the output circuit of said electronic switch element and arranged to transfer between its energized and nonenergized states upon transfer of said electronic switch element from said one conduction condition thereof to said other conduction condition thereof, a capacitive element, a charging circuit for said capacitive element including a source of potential of fixed magnitude and contacts controlled by said first relay means and arranged to be closed upon said transfer of state of said first relay means thereby to charge said capacitive element toward said potential while the output of said amplifier exceeds said predetermined value, a discharging circuit coupled to said capacitive element and having a time constant substantially greater than the time constant of said charging circuit, a unijunction transistor having the respective bases thereof coupled to a source of operating potential, a second relay means having the coil thereof intercoupling the emitter of said unijunction transistor and said capacitive element whereby said unijunction transistor will become conductive when the charge across said capacitor exceeds a predetermined level, said second relay means becoming energized when said unijunction transistor becomes conductive, and means including contacts of said second relay

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means to produce an alarm signal when said unijunction transistor is conductive.

2. An electrical protection system for detecting physical attacks on vaults and like structures, comprising at least one vibration transducer mounted in close physical contact with an interior surface of said structure and including a vibration detecting element arranged to produce an alternating signal voltage in response to detection of vibrations transferred to said detecting element from said surface, said alternating signal voltage being proportional to the magnitude of said transferred vibrations, said vibration transducer being relatively insensitive to airborne vibrations in the space within said structure, a plural stage transistor amplifier having an input circuit coupled to said detecting element, a transistor element having an input circuit coupled to the output circuit of said amplifier and being arranged to transfer from a nonconductive condition to a conductive condition when the amplified signal voltage output of said amplifier exceeds a predetermined value, a first relay having a coil included in the output circuit of said transistor element and arranged to become energized upon transfer of said transistor element to said conductive condition thereof, a capacitive element, a charging circuit for said capacitive element including a source of potential of fixed magnitude and contacts controlled by said first relay and arranged to be closed upon energization of said first relay thereby to charge said capacitive element toward said potential while the output of said amplifier exceeds said predetermined value, means to adjust the time constant of said charging circuit over a range of about 0.09 to 0.6 second, a discharging circuit coupled to said capacitive element and having a time constant of the order of 20 seconds, a unijunction transistor having the respective bases thereof coupled to said source of potential, a second relay having the coil thereof intercoupling the emitter of said unijunction transistor and said capacitive element whereby said unijunction transistor will become conductive when the charge across said capacitor exceeds a predetermined level, said second relay becoming energized when said unijunction transistor becomes conductive, and means including contacts of said second relay to produce an alarm signal when said unijunction transistor is conductive.

3. An electrical protection system for detecting physical attacks on vaults and like structures, comprising at least one vibration transducer mounted in close physical contact with an interior surface of said structure and including a vibration detecting element arranged to produce an alternating signal voltage in response to detection of vibrations transferred to said detecting element from said surface, said alternating signal voltage being proportional to the magnitude of said transferred vibrations, said vibration transducer being relatively insensitive to airborne vibrations in the space within said structure, a plural stage transistor amplifier having an input circuit coupled to said detecting element, a transistor element having an input circuit coupled to the output circuit of said amplifier and being arranged to transfer from one conduction condition to another conduction condition when the amplified signal voltage output of said amplifier exceeds a predetermined value, a negative feedback connection between the output and input circuits of said amplifier, means including a second transistor element coupled to the output and input circuits of said amplifier and arranged to alter the input to said amplifier in a sense to compensate for relatively slow changes in the output of said amplifier, a first relay having a coil included in the output circuit of said transistor element and arranged to transfer between its energized and nonenergized states upon transfer of said transistor element from said one conduction condition thereof to said other conduction condition thereof, a capacitive element, a charging circuit for said capacitive element including a source of potential of fixed magnitude

and contacts controlled by said first relay and arranged to be closed upon said transfer of state of said first relay thereby to charge said capacitive element toward said potential while the output of said amplifier exceeds said predetermined value, means to adjust the time constant of said charging circuit, a discharging circuit coupled to said capacitive element and having a time constant many times greater than any time constant of said charging circuit, a unijunction transistor having the respective bases thereof coupled to said source of potential, a second relay having the coil thereof intercoupling the emitter of said unijunction transistor and said capacitive element whereby said unijunction transistor will become conductive when the charge across said capacitor exceeds a predetermined level, said second relay becoming energized when said unijunction transistor becomes conductive, and means including contacts of said second relay to produce an alarm signal when said unijunction transistor is conductive.

4. A central station electrical protection system for signalling at a central station the occurrence of a physical attack on a vault or like structure located at a place remote from said central station, comprising at least one vibration transducer mounted in close physical contact with an interior surface of said structure and including a vibration detecting element arranged to produce an alternating signal voltage in response to detection of vibrations transferred to said detecting element from said surface, said vibration transducer being relatively insensitive to airborne vibrations in the space within said structure, a plural stage transistor amplifier having an input circuit coupled to said detecting element, a transistor element having an input circuit coupled to the output circuit of said amplifier, means to bias said transistor element normally to a nonconductive condition and to cause said transistor element to become conductive when the amplified signal output of said amplifier exceeds a predetermined value, a first relay having the coil thereof included in the output circuit of said transistor element and arranged to be energized when said transistor element is conductive, a source of normal direct current potential at said central station, a direct current path intercoupling said central station and said remote place and arranged to supply said normal potential to said remote place, means to derive operating potentials for said transistor amplifier and said transistor element from said direct current path, a capacitive element, circuit means including normally open contacts of said first relay to supply said normal potential to said capacitive element to charge the latter when said first relay is energized, a discharging circuit coupled to said capacitive element and having a time constant substantially greater than the charging time constant thereof, a unijunction transistor, means to supply said normal potential to the respective bases of said unijunction transistor, a second relay having the coil thereof intercoupling the emitter of said unijunction transistor and said capacitive element thereby to render said unijunction transistor conductive and to energize said second relay when the charge stored in said capacitive element reaches a predetermined level, said second relay having contacts arranged to alter the current flow in said direct current path when said second relay is energized, and means including said contacts of said second relay and current responsive means at said central station for signalling at said central station energization of said second relay.

5. A central station electrical protection system for signalling at a central station the occurrence of a physical attack on a vault or like structure located at a place remote from said central station, comprising at least one vibration transducer mounted in close physical contact with an interior surface of said structure and including a vibration detecting element arranged to produce an alternating signal voltage in response to detection of vibrations transferred to said detecting element from

said surface, said vibration transducer being relatively insensitive to airborne vibrations in the space within said structure, a plural stage transistor amplifier having an input circuit coupled to said detecting element, a transistor element having an input circuit coupled to the output circuit of said amplifier, means to bias said transistor element normally to a nonconductive condition and to cause said transistor element to become conductive when the amplified signal output of said amplifier exceeds a predetermined value, a first relay having the coil thereof included in the output circuit of said transistor element and arranged to be energized when said transistor element is conductive, a source of normal direct current potential at said central station, a direct current path intercoupling said central station and said remote place and arranged to supply said normal potential to said remote place, means to derive operating potentials for said transistor amplifier and said transistor element from said direct current path, a capacitive element, circuit means including normally open contacts of said first relay to supply said normal potential to said capacitive element to charge the latter when said first relay is energized, means to adjust the charging time constant for said capacitive element, a discharging circuit coupled to said capacitive element and having a time constant substantially greater than any charging time constant thereof, a unijunction transistor, means to supply said normal potential to the respective bases of said unijunction transistor, a second relay having the coil thereof intercoupling the emitter of said unijunction transistor and said capacitive element thereby to render said unijunction transistor conductive and to energize said second relay when the charge stored in said capacitive element reaches a predetermined level, means including contacts controlled by said second relay for changing the current flow in said direct current path when said second relay becomes energized, current responsive means at said central station for signalling at said central station energization of said second relay, vibration producing means in close physical proximity to said vibration detecting element and arranged when energized to produce vibrations simulating an attack on said structure, normally unoperated relay means coupled to said direct current path at said remote place, means at said central station selectively to apply a test potential to said path, said test potential being sufficient to cause operation of said normally unoperated relay means, means controlled by said normally unoperated relay means and effective when the latter is operated to energize said vibration producing means, and means effective when said test potential is supplied to said direct current path to produce a distinctive current variation in said path upon energization of said second relay.

6. A central station electrical protection system for signalling at a central station the occurrence of a physical attack on a vault or like structure located at a place remote from said central station, comprising a plurality of vibration transducers each mounted in close physical contact with an interior surface of said structure and each including a vibration detecting element arranged to produce an alternating signal voltage in response to detection of vibrations transferred to said detecting element from said surface, said vibration transducers being relatively insensitive to airborne vibrations in the space within said structure, a plural stage transistor amplifier having an input circuit coupled to said detecting elements, a transistor element having an input circuit coupled to the output circuit of said amplifier, means to bias said transistor element normally to a nonconductive condition and to cause said transistor element to become conductive when the amplified signal output of said amplifier exceeds a predetermined value, a first relay having the coil thereof included in the output circuit of said transistor element and arranged to be energized when said transistor element is conductive, a source of normal direct current potential at said central station, a direct

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current path intercoupling said central station and said remote place and arranged to supply said normal potential to said remote place, means to derive operating potentials for said transistor amplifier and said transistor element from said direct current path, a capacitive element, circuit means including normally open contacts of said first relay to supply said normal potential to said capacitive element to charge the latter when said first relay is energized, means to adjust the charging time constant for said capacitive element, a discharging circuit coupled to said capacitive element and having a time constant substantially greater than any charging time constant thereof, a unijunction transistor, means to supply said normal potential to the respective bases of said unijunction transistor, a second relay having the coil thereof intercoupling the emitter of said unijunction transistor and said capacitive element thereby to render said unijunction transistor conductive and to energize said second relay when the charge stored in said capacitive element reaches a predetermined level, means including contacts controlled by said second relay for changing the current flow in said direct current path when said second relay becomes energized, current responsive means at said central station for signalling at said central station energization of said second relay, vibration producing means in close physical proximity to at least one of said vibration detecting elements and arranged when energized to produce vibrations simulating an attack on said structure, normally unoperated relay means coupled to said direct current path at said remote place, means at said central

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station selectively to apply a test potential to said path, said test potential being greater than said normal potential by an amount sufficient to operate said normally unoperated relay means, means controlled by said normally unoperated relay means and effective when the latter is operated to energize said vibration producing means, means effective when said test potential is supplied to said direct current path to produce a distinctive current variation in said path upon energization of said second relay, and means to maintain normal operating potentials for said transistor amplifier, said transistor element, said capacitive element and said unijunction transistor when said test potential is supplied to said path.

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