Dec. 30, 1969 F. M. PERELMAN 3,487,396

INTRUSION VIBRATION DETECTOR WITH AMBIENT NOISE COMPENSATOR

Filed March 11, 1966 2 Sheets-Sheet 1

FIG. 1.

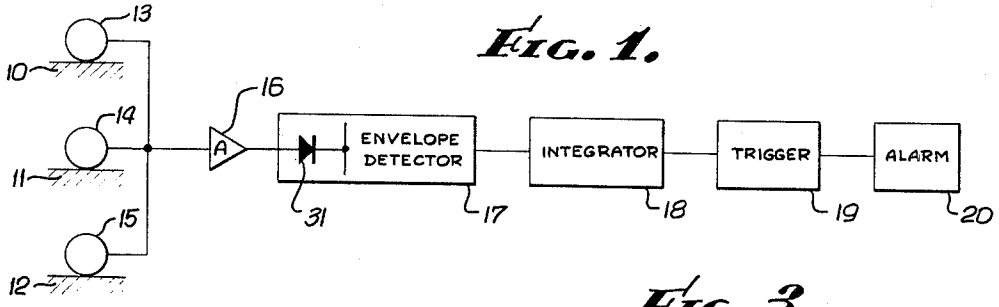


FIG. 2.

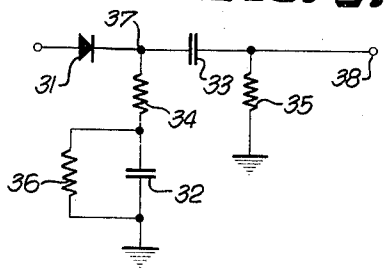


FIG. 3.

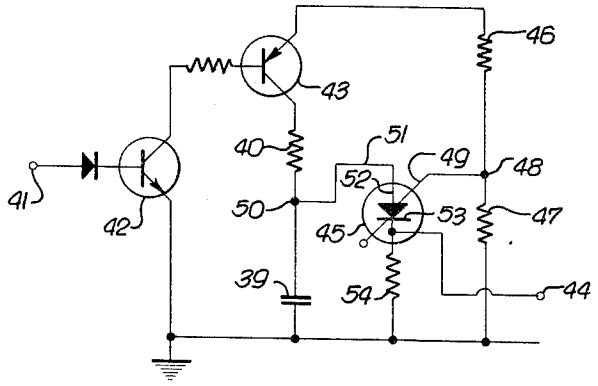


FIG. 4.

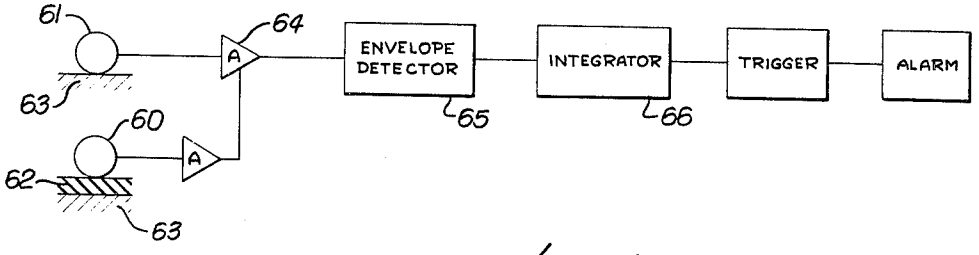
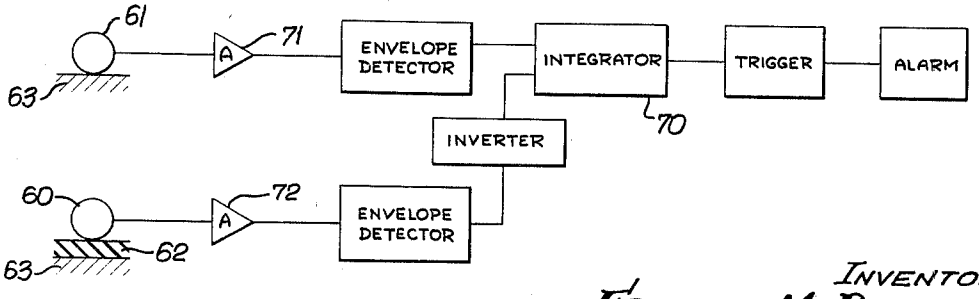


FIG. 5.



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FIG. 6.

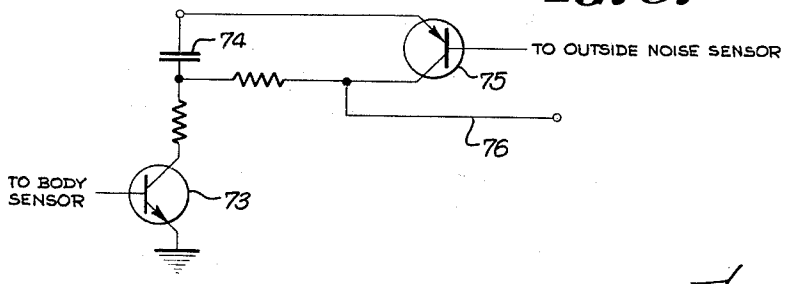


FIG. 7.

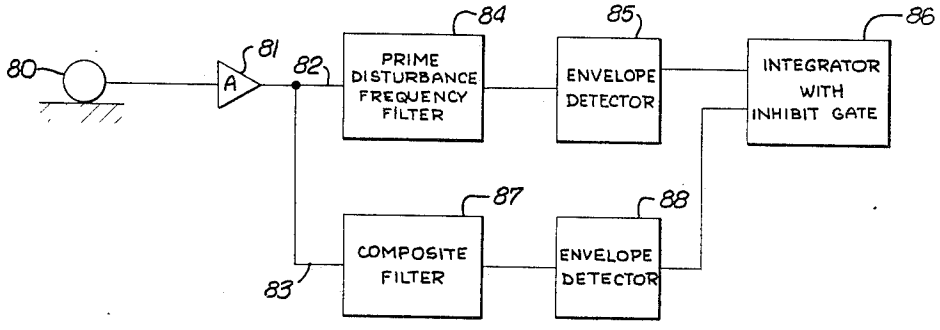
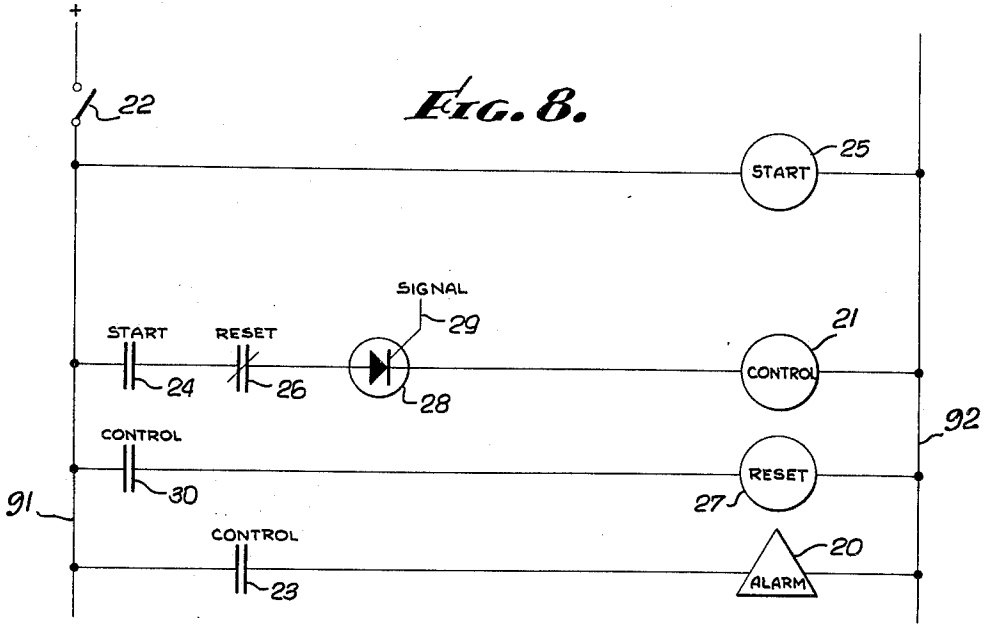


FIG. 8.



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INTRUSION VIBRATION DETECTOR WITH AMBIENT NOISE COMPENSATOR

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U.S. Cl. 340—261 9 Claims

ABSTRACT OF THE DISCLOSURE

The alarm system detects tampering vibrations in a substantially rigid body by a vibration sensor attached to the body, an envelope detector connected across the rectified output of the sensor, and an integrator driven by the envelope detector that cumulates the rectified signals to operate an alarm trigger. The envelope detector includes a capacitor arranged to be charged by the rectified output and discharged through a large resistor whereby under constant or slowly changing ambient noise conditions, the noise signal is blocked. In other forms of the invention, paired sensors are provided in a subtracted network, with one of the sensors responsive only to ambient noises and the other sensor responsive not only to ambient noises but characteristic tampering vibrations.

BRIEF SUMMARY OF THE INVENTION

This invention relates to an alarm system for detecting vibrations in solid material occasioned by unauthorized tampering. The invention will be described with reference to an automobile; however, the alarm system is equally applicable to safes, doors, fences, files, etc.

Various alarm systems have been proposed. In general, such devices are either relatively insensitive or they respond spuriously to ambient noises or vibrations due to thermal contractions. The primary object of this invention is to provide an alarm system that is sensitive only to vibrations characteristic of tampering even though high level vibrations of similar frequencies may be generated by other sources.

Another object of this invention is to proivde a system of this character incorporating a novel system of time delays in which the system can be armed and disarmed by key means located within the secured compartment of the automobile without causing the alarm to operate. Accordingly, the disarming mechanism is itself protected from tampering.

Another object of this invention is to provide an alarm system of this character incorporating novel circuitry for preventing vibrations due to thremal contraction or the like from sounding an alarm. Another object of this invention is to provide novel circuitry by which operation of the alarm is inhibited by sudden or continual external noises without affecting the sensitivity of the system to physical tampering.

This invention possesses many other advantages, and has other objects which may be made more clearly apparent from the consideration of several embodiments of the invention. For this purpose, there are shown a few forms in the drawings accompanying and forming part of the present specification. These forms will now be described in detail, illustrating the general principles of the invention; but it is to be understood that this detailed description is not to be taken in a limiting sense, since the scope of the invention is best defined by the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a block diagram of an alarm system incorporating the present invention;

FIGS. 2 and 3 are circuit diagrams showing components illustrated in FIG. 1;

FIGS. 4 and 5 are block diagrams illustrating modified forms of the present invention;

FIG. 6 is a circuit diagram of one of the components illustrated in FIG. 5;

FIG. 7 is a block diagram of still another modified form of the present invention; and

FIG. 8 is a diagram of the trigger circuit.

DETAILED DESCRIPTION

The medium intended to be protected against unauthorized tampering includes certain substantially solid or relatively rigid parts **10**, **11** or **12** that would likely be contacted should unauthorized tampering occur. These parts in an automobile thus may be the doors, trunk lid, etc. Sensors **13**, **14** and **15** may be attached to each of these parts, depending upon the degree of security desired or the characteristics of the particular installation. The sensors may be contact microphones, such as made for example by Monarch Electronics of North Hollywood, Calif. (Part No. M.C.–51), which have provisions for being bolted to the solid body. Optionally, the microphone could be encapsulated in epoxy material, and clamped in contact with the rigid part. By encapsulating the sensor, external noises are attenuated. Different types of sensors could be used, as for example strain gauges or floating magnet assemblies, etc. The sensors may be connected in parallel or series.

The signal level of the sensors **13**, **14** and **15** is elevated by an amplifier **16**. Preferably the amplifier has a gain characteristic maximized at the prime disturbance frequency, that is, the frequency at which noises due to tampering tend to peak. The prime disturbance frequency or frequencies may be determined by testing. In a number of cases, the prime disturbance frequency is about 300 or 400 cycles per second or 900 or 1000 cycles per second.

The signal is then operated upon by an envelope detector **17** and an integrator **18**, both hereinafter to be described, and applied as a unidirectional pulse to a trigger **19** that controls an alarm **20**. As shown in FIG. 8, the alarm **20** derives energization from leads **91** and **92**. One of the leads is controlled by a key switch **22** which may connect the lead **91** to an available power source such as the automobile battery. When the key switch **22** is closed, suitable power is made available to the amplifier **16** and other components of the system which derive energy from the lead **91**. The key switch may be located within the protected space, as for example on the automobile dashboard. The alarm **20**, which may be the automobile horn, radio transmitter or other suitable device, is operated only when a control relay relay **21** is operated. Normally open contacts **23** of the control relay are in series circuit with the alarm **20**. The control relay **21** has an energization circuit that serially includes, first, normally open contacts **24** of a start relay **25**; second, normally closed contacts **26** of reset relay **27**; and third, a controllable silicon switch **28**, multilayer diode or equivalent device. The start relay **25** is connected directly across the leads **91** and **92** and thus closes the contacts **24** after the key switch **22** is closed.

The switch **28** has a gate lead **29** to which the detected signal is applied. When a detected signal corresponding to unauthorized tampering is applied to the gate lead **29**, the switch **28** fires and operates the control relay **21** which, in turn, through contacts **23** operates the alarm **20**. Once, fired, the switch **28** remains closed until current is interrupted.

By using as the start relay **25** a device having a time delay characteristic, it is possible for the authorized user to close the key switch **22** in the protected compartment

and then lock the automobile, all before the start relay contacts **24** close. The time delay of the start relay **25** also precludes warm-up transients of the amplifier **16** or the other components from generating a false signal that otherwise might trip the alarm.

The control relay **21** also is of the time delay type so that the alarm operates ten or more seconds following the disturbance. This allows the authorized user to unlock the automobile and quickly operate the key switch **22** before the alarm **20** operates.

If the alarm is once operated, it continues to operate only for a predetermined time, as for example thirty seconds, whereupon the system is reset. The reset relay **27** accomplishes this purpose. It likewise has a time delay characteristic corresponding to the intended period of operation of the alarm. The time delay reset relay is initially energized through a circuit that includes normally open contacts **30** of the control relay **21**. Accordingly, the time delay period of the reset relay **27** is initiated just as soon as the alarm **20** begins to operate. After the set time period, the reset relay **27** opens the contacts **26**. Relay **21** is denenergized, and the alarm circuit is opened. The reset relay **27** is furthermore deenergized by opening of the control relay contacts **30**. This causes the reset contacts **26** immediately to reclose. If the signal persists or recurs, the alarm will operate for another cycle.

In order to convert the amplifier signal to pulse form, a rectifying diode **31** is provided (FIG. 1) that forms a part of the envelope detector **17**.

There may be certain background noises in the alarm system itself. The object intended to be secured against unauthorized tampering may be situated in the locality where there is substantial background noise. Accordingly, the envelope circuit is arranged to pass the signal only when its level sharply changes. The envelope detector **17**, shown in detail in FIG. 2, includes two parallel branches fed by the signal. Each branch includes a condenser **32** or **33** and charging resistors **34** and **35**. The condenser **32** has a leakage path provided by a large resistor **36**. The condensers **32** and **33** become equally charged under substantially steady noise conditions. The terminal **37** acquires a D.C. bias, and only small peaks of the signal pass to the condenser **32** to balance the leakage current. But this bias cannot suddenly change since the time constant of the charge circuit for the condenser **32** is large. Accordingly, if the signal level increases suddenly over the noise level, a signal corresponding to the excess is transmitted through the condenser **33** and appears at the output terminal **38** for operation of the alarm. However, if the noise level changes slowly, the bias increases correspondingly, and no signal of significance is transmitted through the condenser **33**. In practice, the condenser **33** is substantially smaller than the condenser **32**, and its charge circuit has a relatively short time consant.

Creaks or strains in the solid body, due to thermal effects or high power impulse noises in the surrounding medium such as backfire, will create pulses at the output terminal **38** of the envelope detector. However, such noises subside quickly as contrasted with tampering signals. To distinguish between tampring and such noises, the integrator **18** is provided. The pulses applied to the integrator **18** from the envelope detector (FIG. 3) charge the condenser **39** through a resistor **40**. The input terminal **41** of the integrator is operatively connected to the resistor **40** through buffering transistor amplifiers **42** and **43** in a conventional manner. A single pulse is produced at the output terminal **44** only when a number of pulses have been applied to the input terminal **41** sufficient to cause the condenser **39** to charge to a preset value.

For this purpose, a controled rectifier **45** is provided that compares the voltage on the condenser **39** to a reference value. The reference value is derived by the aid of voltage dividing resistors **46** and **47**. The mid-terminal **48** is connected to the anode gate **49** of the rectifier **45**. The condenser terminal **50** remote from ground is connected by a lead **51** to the anode **52** of the switch **45**. When the condenser reaches a value adequate to pass gate current, the switch **45** fires and the condenser charge is passed to the cathode **53** and to ground via resistor **54**. The output terminal **44** is connected to the cathode **53** and thus transmits the pulse corresponding to firing of the switch **45**. The output terminal **44** of the integrator may be applied to the gate lead **29** of the triggering device **28** (FIG. 8). Other integrating circuits may be provided.

In the form of the invention illustrated in FIG. 4, sudden sustained external noises are prevented from operating the alarm. In order to accomplish this objective, a second sensor **60** is provided that is mounted adjacent the main sensor **61**. However, acoustic damping material **62** is interposed between the sensor **60** and the body **63**, whereas the sensor **61** is intimately connected to the body **63**. Accordingly, the sensor **60** reponds primarily to outside noises while the sensor **61** responds both to external and internal noises.

By suitably scaling and subtracting the signals, the resultant signal corresponds to internal noises only. For this purpose, the output of the sensor **61** is applied to the gain control of the amplifier **64** to reduce the signal by an amount corresponding to noise. Only internal disturbance signals pass to the envelope detector **65**, integrator **66**, etc.

A preferred method for subtracting sudden sustained external noises is shown in FIG. 5, where the amplifier gain remains at set value whatever the noise level may be. Accordingly, maximum sensitivity to internal disturbances is retained. In this arrangement, the subtraction process is accomplished in the integrator circuit **70**. Sensors **60** and **61** are provided as in the previous form, but each has its own amplifier **71** and **72**. The junction is shown in FIG. 6.

The signal from the body sensor **61** is applied to the base of an amplifying transistor **73** whereby charges are applied to a cumulating condenser **74** similar to the condenser **39**. A second transistor **75** controls a leakage path for the condenser **39**, and is operated by the signal from the outside noise sensor **60**. Thus the condenser charges at a rate corresponding to the sum of the external noise and internal disturbances, and discharges at a rate corresponding to the external noises. The result is that the condenser charges in accordance with internal disturbances alone. The condenser terminal is connected via a lead **76** to a comparison switch as in the form illustrated in FIG. 3.

The form of the invention illustrated in FIG. 7 is essentially similar to that shown in FIG. 5 except that a single sensor **80** is used that is rigidly connected to the body. The output of the amplifier **81** is split into two branch leads **82** and **83**. A filter **84** tuned to the prime disturbance frequency conducts the restricted signal to an envelope detector **85**. Outside noises may also contain the prime disturbance frequency. If the outside noises are sufficiently constant, or of sufficient short duration, the envelope detector **85** and an integrator will adequately distinguish the unauthorized disturbance signal. However, if outside noises suddently increase and dwell, a signal indicative of such fact is applied to the inhibit gate of a differential integrator **86** similar to that shown in FIG. 6.

In order to provide such signal, a composite filter **87** is provided that cooperates with lead **83** to pass frequency components that normally would be produced by outside noise and which are significantly different from the selected prime disturbance frequency. These noise signals are also operated upon by an envelope detector **88** so that only the sudden ones are passed. By suitably scaling the circuit components, the output of the integrator corresponds to internal sustained disturbances. Thus the sudden sustained outside noise components passing through the filter **84** are balanced out by the equivalent signals from the composite filter **87**.

The inventor claims:

1. In an alarm system for detecting characteristic tampering vibrations in a substantially rigid body: a sensor attached to said rigid body; an envelope detector having an input connected to said sensor; an integrator driven by said envelope detector and having cumulating means for providing an output signal only after repeated or continued signals have been applied to said integrator; a trigger circuit operated by said integrator; said sensor being responsive to outside noises as well as tampering signals; said integrator including a cumulating device; a controllable subtracting circuit for said cumulating device; a controllable adding circuit for said cumulating device; means operatively connecting one of said circuits to said sensor for storing positive information in said cumulating device in accordance with the existence of characteristic tampering signals and outside noises; means producing a signal corresponding to outside noises substantially free of tampering signals; and means operatively connecting said outside noise signal means to the other of said circuits for storing negative information in said cumulating device in accordance with the existence of outside noises; said integrator providing an output signal when the store in said cumulating device reaches a predetermined level.

2. The alarm system as set forth in claim 1 in which said outside noise signal means comprises a filter system operated by said sensor, and an envelope detector, said filter system passing signals corresponding to the characteristic tampering frequency as well as other frequencies characteristic of outside noise.

3. The alarm system as set forth in claim 1 in which said outside noise signal means comprises a second sensor attached to said body by the aid of acoustic damping means.

4. In an alarm system for detecting characteristic tampering vibrations in a substantially rigid body: a sensor attached to said rigid body; an envelope detector having an input connected to said sensor; an integrator driven by said envelope detector and having cumulating means for providing an output signal only after repeated or continued signals have been applied to said integrator; a trigger circuit operated by said integrator; said sensor being responsive to outside noises as well as tampering signals; said integrator including a cumulating condenser; a controllable discharge circuit for said condenser; a controllable charge circuit for said condenser; means operatively connecting one of said circuits to said sensor for changing the charge on said condenser in one direction in accordance with the existence of characteristic tampering signals and outside noises; means producing a signal corresponding to outside noises substantially free of tampering signals; and means operatively connecting said outside noise signal means to the other of said circuits whereby the charge on said condenser changes in the other direction in accordance with the existence of outside noises; said integrator providing an output signal when the charge on said condenser reaches a predetermined level.

5. The alarm system as set forth in claim 4 in which said outside noise signal means comprises a filter system operated by said sensor, and an envelope detector, said filter system passing signals corresponding to the characteristic tampering frequency as well as other frequencies characteristic of outside noise.

6. The alarm system as set forth in claim 4 in which said outside noise signal means comprises a second sensor attached to said body by the aid of acoustic damping means.

7. In an alarm system for detecting characteristic tampering vibrations in a substantially rigid body; a sensor attached to said rigid body; an envelope detector having an input connected to said sensor; an integrator driven by said envelope detector and having cumulating means for providing an output signal only after repeated or continued signals have been applied to said integrator; a trigger circuit operated by said integrator; a second sensor attached to said body by the aid of acoustic damping means; and an amplifier for said first sensor; said amplifier having a variable gain control operated by said second sensor to reduce the gain of said amplifier as the level of signal from said second sensor increases.

8. In an alarm system: means subject to external noise for producing a signal corresponding to unauthorized tmapering; means producing a signal corresponding to external noise and substantially insensitive to unauthorized tampering; a condenser having a charge circuit operated by said first named signal; a transistor paralleling said condenser to form a discharge path therefor; and means controlling said transistor by said second named signal whereby said condenser acquires a charge corresponding to unauthorized tampering independently of external noise; and a trigger circuit for operating an alarm, including a comparison device that fires upon the existence of a predetermined charge on said condenser.

9. The alarm system as set forth in claim 8 in which said device serves to discharge said condenser and reset said condenser for further signals.

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