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PATENTS ACT 1977
P9652GB-NF/jsd

DESCRIPTION OF INVENTION

"IMPROVEMENTS IN OR RELATING TO AN ALARM"

THE PRESENT INVENTION relates to an alarm and more particularly relates to a burglar alarm.

It has been proposed to provide a burglar alarm intended for use in a building, or in a vehicle, the alarm being responsive particular changes in air pressure caused by the opening of a door or window.

When a door or window is opened, the result is a change in the air pressure surrounding the door. As the door moves air pressure adjacent the leading side of the door rises, whereas air pressure adjacent the trailing side of the door decreases. The change in air pressure is transmitted, by the mechanism that transmits sound, through the building or vehicle in which the door is fitted, and typically the change in air pressure has a specific frequency signature. It has been found, for example, that typically a door or window opening has a narrow band frequency signature centred on approximately 3 Hz. Thus, the burglar alarms typically sense air pressure and respond to changes in air pressure above a predetermined threshold in a narrow band of frequencies centred on 3 Hz.

Burglar alarms of this type are known as "Volumetric" burglar alarms, and have been in use for some time.

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A difficulty that is sometimes encountered with a Volumetric burglar alarm can arise when the weather is very windy. This may cause loose fitting doors or windows to rattle slightly. As the doors or windows rattle they move in and out, thus creating regions of high or low pressure, with a frequency signature that includes a significant component at 3 Hz. Additionally, and possibly more importantly, changes in air pressure within a building may be caused, in windy conditions, by structural flexing of the building. The main contributors to this effect are large areas of glass, such as patio windows, for example, and also large structural areas that can deflect, such as ceilings. It is to be understood that ceilings may be subjected to movement as the wind applies differential pressures to the loft space and rooms within the building. Wind, can, for example, directly pressurise the loft space through vents or apertures which exist either by design or default. Due to the large areas involved, even small flexing of ceiling panels can cause large and quite rapid changes in internal building pressure. Consequently, if the Volumetric burglar alarm associated with the building or vehicle is very sensitive, the alarm may be activated. On the other hand, if the burglar alarm is very "insensitive" the alarm may not be activated in certain circumstances when a forced entry is effected.

The present invention seeks to provide an improved burglar alarm.

According to this invention there is provided an alarm for sensing opening of a door window or the like, the alarm comprising an acoustic wave sensor adapted to respond to acoustic waves having a frequency generated when a door or window is opened, means to pass a signal from the sensor to a comparator and means to provide the comparator with a

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reference signal, the output of the comparator being connected to an alarm such that the alarm is activated when the signal supplied to the comparator exceeds the reference signal, wherein the means to provide the reference signal comprise means adapted to respond to a signal from the sensor and to increase the reference signal, up to a predetermined limit, when the signal from the sensor exceeds a predetermined threshold, and to reduce the reference signal to a predetermined lower value, with a long time constant.

Preferably the means to provide the reference signal incorporate delay means so that the reference signal is increased after a predetermined delay when the signal from the sensor exceeds said threshold.

Conveniently the sensor comprises an electret sensor.

Advantageously the output signal of the sensor is passed to a low pass filter which selectively passes frequency of up to 7 Hz.

Preferably the low pass filter has a roll-off characteristic at higher frequencies, passing substantially all of the signal at 3 Hz passing lower proportions of the signal of higher frequency.

Advantageously part of the signal from the low pass filter is passed through a second filter which passes a relatively narrow band of frequency based on approximately 3 Hz to the comparator, and another part of the output from the low pass filter is passed to a peak detector adapted, when the threshold set by the peak detector is exceeded, to supply current to a capacitance constituting the variable

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reference to charge up the capacitance, means being provided to discharge the capacitance with a long time base when the capacitance is not being charged, the capacitance being connected by a delay as the reference input to the comparator.

Preferably a second comparator is provided, the second comparator receiving a signal generated by the sensor and also receiving the reference signal in an inverted form.

Conveniently the capacitance constituting the variable reference is connected by means of an inverter and a delay as a reference input to the second comparator.

In order that the invention may be more readily understood, and so that further features thereof may be appreciated, the invention will now be described, by way of example, with reference to the accompanying drawings in which

FIGURE 1 is a graphical figure illustrating a typical frequency signature for air pressure waves generated by a door which is opened and a door which is rattling in the wind,

FIGURE 2 is a block diagram of one embodiment of the invention,

FIGURE 3 is a circuit diagram of the embodiment of the invention illustrated in Figure 2, and

FIGURE 4A to 4E are plots of input signal v. output phase for various components of Figure 3.



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Referring initially to Figure 1, the horizontal axis is frequency on a logarithmic scale, and the vertical axis is amplitude. When a door or window is opened, the pressure in the vicinity of the door or window changes, and that change in pressure spreads, by the mechanism that transmits sound, through the building or vehicle in which the door or window is provided. The typical frequency signature of such an event is a narrow band centred on approximately 3 Hz. This is the band illustrated at 1 in Figure 1.

When the door or window rattles in the wind, again there is a change of pressure in the region of the door or window, but the frequency signature of this change of pressure is rather broad band including not only a portion within the narrow band centred on 3 Hz, but also a portion at a lower frequency. It is to be understood that the frequency signatures illustrated in Figure 1 are given purely by way of example. The frequency signature 2 relates to the frequency signature experienced when doors or windows rattle. However, in a typical building, the frequency signature of all the pressure changes caused by the building itself due to wind, for example, may be skewed to a lower frequency or a higher frequency than that shown in Figure 1. However, it is generally understood that "spurious" signals generated by movement of the building itself caused by wind will be at a lower median frequency than the signature caused by opening of a door or window.

The present invention provides a burglar alarm which senses changes of air pressure at a frequency, or frequencies, within the typical frequency signature of a door or window when it is rattled by the wind. When that frequency is detected, the detected signal is amplified, and the amplified signal is passed to a peak detector.

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Whenever the amplified signal exceeds the peak level set by the peak detector, a threshold set by a variable reference is increased. Thus, if a door or window rattles, but only rattles slightly, the variable reference is increased slightly. As the door or window rattles more the variable reference is increased more.

The variable reference is used as a reference for a comparator. The comparator is adapted to receive a signal in the narrow band centred on 3 Hz should the door or window be opened. However, because the reference level is raised when the door or window rattles, there is only a reduced chance of the burglar alarm being activated solely by the wind.

Referring now to Figure 2 of the accompanying drawings, which is a block diagram, a sensor 3 is provided, which may comprise an electret acoustic wave sensor, which is positioned to be able to respond to changes in air pressure within a building or vehicle. The output of the sensor 3 is passed to a low pass filter 4. The low pass filter 4 passes low frequencies in a relatively broad band, typically frequencies in a band of 0 to 4.5 Hz.

The output from the low pass filter 4 is amplified by an amplifier 5. One output from the amplifier 5 passes through a filter 6, the filter 6 passing low frequencies in a relatively narrow frequency band centred on 3 Hz. The output of the filter 6 is provided to comparators 7 and 8, the comparators receiving, as will be described hereinafter, an adjusted reference signal. If the signal from the filter 6 exceeds the adjusted reference signal, an alarm 9 is activated.



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Another output from the amplifier 5 is passed to a precision rectifier 10, where the signal is rectified. The rectified signal is passed to a peak detector 11. The signal passed to the peak detector is substantially amplified as compared with the original input signal. When the rectified signal exceeds a predetermined reference which is set within the peak detector 11, a signal is passed to a variable reference 12. The variable reference increases when a signal is provided from the peak detector, but decreases, very slowly, when no signal is provided from the peak detector.

The output from the variable reference is passed, by a first delay circuit 13 to be the reference input to the comparator 7, and by an inverter 14 and a second delay 15 to be the reference input of the second comparator 8.

It is to be appreciated that the variable reference 12 provides a reference signal when the apparatus is in the initial or quiescent state. If a door or window is opened, a signal having the frequency characteristic 1 as shown in Figure 1 will be provided and this signal will pass through the low pass filter 4. The signal will be amplified. The signal will also pass through the filter 6 and will be fed to the comparators 7 and 8. The comparators 7 and 8 will, at that stage, only be receiving the reference signal for the quiescent state of the apparatus. If the signal from the filter 6 exceeds the reference signal then the alarm is activated. It is to be understood that when the door or window is opened, the amplifier 5 provides a signal which is passed to the precision rectifier 10. The signal from the precision rectifier 10 will, it is envisaged, exceed the peak level set by the peak detector 11, so that additional signal will



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be provided to the variable reference 12, causing the variable reference 12 to increase. However, the signal from the variable reference 12 must pass either through the delay 13 or through the inverter and the delay 15 before being provided to the comparator 7 and the comparator 8. The delay 13 and the delay 15 are both typically six seconds. Thus, when the change in the variable reference caused by the opening of a door or window actually reaches the comparator 7 or the comparator 8, the alarm will have already been activated in response to the opening of the door or the window.

In the apparatus of Figure 2, should it be a windy day with doors and windows in the building rattling, the sensor 3 will receive a signal having the frequency signature shown as 2 in Figure 1. If windows or ceilings are deflecting the sensor 3 will receive a signal having a similar (but different) frequency signature. The whole of this signal will pass through the low pass filter 4 and will be amplified by the amplifier 5. Part of the signal will pass through the filter 6 or be provided to the comparator 7 and the comparator 8, but in the initial state of the device, the level of signal provided to the comparator 7 and the comparator 8 in these circumstances will not be sufficient to activate the alarm. However, part of the amplified signal is passed through the precision rectifier 10 to the peak detector 11. It is envisaged that as the level of wind gradually increases, the peak level initially set in the peak detector will be exceeded, and signal will then be supplied to the variable reference 12, causing the variable reference to increase. Should the wind terminate, however, if no further signal is provided from the peak detector 11 to the variable reference 12, the variable reference 12 will gradually



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return to its initial level, over a period of time that may be measured in minutes rather than seconds.

However, should the wind remain a constant feature of the day, the variable reference will be maintained at a level which is above its ordinary or quiescent level. The variable reference is passed, by the six-second delay 13 and by the inverter and six-second delay 15 to be the reference input to the comparator 7 and the comparator 8.

Thus, as wind levels rise, so the reference level supplied to the comparators 7 and 8 rises, meaning that a larger amplitude signal will have to be detected by the sensor 3 to activate the alarm. Thus, on a windy day, there is only a minimal chance that the alarm will be activated solely by the effect of the wind, while on a calm day, when the apparatus has returned to the quiescent state, the device will have its initial sensitivity when responding to break-in.

It is to be appreciated that the apparatus described above effectively incorporates a "prediction" circuit.

It is assumed that a predetermined gust of wind, for example a gust of wind at 60 KMPH, would cause structural flexing that could initiate an alarm, it would not be appropriate to wait for a gust of this severity to occur before adjusting the reference level. Consequently, the described arrangement senses structural flexing caused by lesser gusts of wind, for example, gusts of wind of 20 KMPH, and then amplifies that effect to simulate that of a gust of wind of a greater velocity. Thus, the peak detector and the associated circuitry operate to raise the reference level, and thus the threshold, of the alarm.



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The peak detector has a long delay time constant, typically of approximately 100 seconds for lower levels of disturbance, and consequently the reference level remains adjusted for a relatively long period of time following any specific gust of wind.

The change in the reference level, which can be substantial, might appear to lead to the consequence that the alarm is totally ineffective on windy days. However, it has been found that when it is very windy, the effect of opening a door or window is much greater than on a calm day, due to the presence of the wind. Most people will be familiar with the difficulty of opening a door or window in windy conditions, when either there is substantial resistance to the door or window being opened or, alternatively, the door or window is effectively pulled open by the wind.

Referring now to Figure 3 of the accompanying drawing, which is a circuit diagram of the arrangement shown in Figure 1, the circuit is powered by a 9v battery, which also powers stabilised sources of potential at +2 volts and at +5 volts, the stabilised sources powering certain parts of the illustrated circuit. An electret acoustic wave sensor LS1, adapted to respond to all frequencies, is connected in series between a plus 2 volt regulated source and ground, with a fixed resistance R44 and the resistive winding of a rheostat RV2. The wiper of the rheostat RV2 is connected by means of a capacitance C26 to one input of a pre-amplifier U8:B. Various resistances R58, R53, R45 and an adjusting rheostat RV5 are associated with the pre-amplifier U8B to enable the sensitivity of the device to be adjusted. The capacitance C26 is an isolating capacitance, but also serves to limit the band width passed to the pre-amplifier.

The output of the pre-amplifier U8:B, is passed, through a resistance R62, to one input of an active low pass filter constituted by the amplifier U8:C and associated capacitances and resistances R61, C27, C33, R67, R68 and R77. The active low pass filter operates to pass only signals within a frequency spectrum below a predetermined upper limit, that predetermined upper limit typically being between 4 Hz and 10 Hz. The preferred active low pass filter has a roll-off characteristic, so that all of the signal at 4 Hz is passed, but a reducing proportion of the signal is passed with increasing frequency until no significant signal having a frequency in excess of 10 Hz is passed.

The output of the active low pass filter passes through a network constituted by the resistance R70, and a further resistance R65, together with a capacitance C34 which connected from the node between the two resistors to a stabilised source of +2 volts, this network fine-shaping the passed waveform.

The active low pass filter feeds a further operational amplifier U8:A which is associated with various resistors and capacitors comprising resistors R64 and R69 and capacitor C19, the arrangement being connected to earth and to the stabilised sources potential at +5 volts and +2 volts. A decoupling capacitance C23 is connected to the amplifier U8:A. This particular amplifier has a high frequency "roll-off" characteristic, meaning that the amplifier does not pass a signal having a frequency just in excess of 0 Hz, but then passes increasing proportions of the signal until a maximum pass at approximately 3 Hz. The output of the amplifier U8:A is the amplified output of the low pass filter.

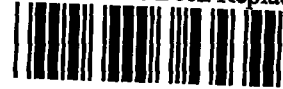
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The amplified output of the active low pass filter is passed to two separate parts of the described circuit. One part of the output is passed by means of a network consisting of two capacitances C20, C21 and resistance R52, which removes the initial DC component of the signal so that solely the AC signal is passed to a precision rectifier, to a precision rectifier. The precision rectifier comprises two operational amplifiers U6:D and U6:B which are associated with diodes D17 and D24 and which are also associated with a resistive and capacitative network comprising resistors R36, R41, R46, R47, R48, R66 and R51 together with capacitance C13. The operational amplifier serves to rectify one part of the signal, double that part of the signal and then subtract the doubled part of the signal from the complete original signal, thus providing an accurate rectified complete signal. Such an arrangement is conventional in the art.

The output of the precision rectifier is passed, through a variable resistor RV3 and a resistive network R84, R85 to an input of a peak detector constituted by the operational amplifier U6:C. The variable resistor RV3 may be adjusted to optimise performance to allow compensation for the differing wind susceptibility of various buildings. The operational amplifier is associated with a resistive and capacitative network constituted by the resistor R49 and the capacitance C42 and is adapted to turn on a transistor Q6 which is connected by resistance 29 to a first capacitance C16.

The arrangement is such that when the voltage passed by the variable resistor RV3 to the operational amplifier U6:C exceeds a threshold, the transistor Q6 is turned on, thus enabling current to flow to begin to charge up the resistance C16 with a short time constant. When the



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transistor Q6 is switched off, the capacitance C16 can be discharged, with a very long time constant, to earth through the resistance R29, the transistor Q6 and the resistor R49 together with the capacitance C22.

Consequently, the charge on the capacitance C16 rises towards an upper limit defined by the regulated potential of +5 volts supplied to the controlled current path of the transistor Q6, whenever the transistor Q6 is rendered conductive, and is gradually discharged, over a period that can be measured in terms of minutes rather than seconds, when the transistor Q6 is not conductive.

The charge on capacitance C16 thus rises towards its peak level in response to signals passed from the active low pass filter - such as signals caused by wind - in excess of the peak value set by the peak detector. However, when not being charged in this way, the capacitance C16 is discharged with a long time constant. Thus, should a wind die down, over the course of several minutes, the capacitance C16 will be gradually discharged through R34 and U6:A.

The capacitance C16 is connected by means of a resistance R35 to a second capacitor C28. The "R-C" network constituted by the resistance R35 in the capacitance C28 is such that the capacitance C28 charges up to have a charge equivalent to that present on the capacitance C16, but after a predetermined time delay, for example, six seconds.

The capacitance C16 is also connected to an inverter constituted by the operational amplifier U6:A which is associated with diodes D20, D21 and resistances R33 and R34. The forward bias of diode D20 limits the

change on capacitance C16 and diode D4 forms a quick charge path to place a predetermined charge on the capacitance at switch on. The inverted output of the operational amplifier U6A is fed to a resistance R32 and a capacitance C14. These two components again form a "R-C" network having a delay of approximately six seconds. Consequently, the charge present on capacitance C14 is effectively the inverse of the charge present on capacitance C16, but with a six second delay.

The capacitance C28 is connected as a reference input to an operational amplifier U5A which constitutes one comparator and the capacitance C14 is connected as an input to a further operational amplifier U5B which constitutes another comparator.

A second part of the amplified output of the active low pass filter is passed through a high pass filter formed by a capacitive and resistive network comprising capacitances C17, C18 and resistors R38, R39 and R40 to each of the two comparators U5A, U5B. The output of the comparators U5A, U5B are connected in an "OR" configuration through a resistive and capacitive network constituted by resistors R24 and R42 and capacitance C11 to an operational amplifier U5D which is associated with resistors R25 and R26 and which actuates an alarm.

It is envisaged that on a windy day, the reference inputs to the comparators will rise in such a way that the signals passed by the low pass filter directly from the active low pass filter will not be sufficient to trigger the alarm. However, once the wind dies down, the arrangement returns to an initial quiescent state.

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Figures 4A to 4E comprise frequency analysis charts illustrating the response of the circuit at various positions of the design as illustrated in Figure 3. The title of each trace is shown above the graph, indicating the precise point of the circuit where the trace has been taken. Each trace shows a "G" trace which represents Gain and a "P" trace which represents the Phase.

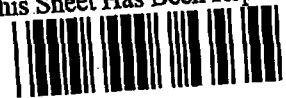
It is to be appreciated that in a modified embodiment of the invention, only one comparator would be provided, making it possible to omit the precision rectifier and also making it possible to omit the inverter associated with the variable reference and the delay associated with that inverter, together with the second comparator. Such an arrangement would have the advantage of economy, but would not have as good a performance characteristic as that of the circuit described.

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CLAIMS:



1. An alarm for sensing opening of a door window or the like, the alarm comprising an acoustic wave sensor adapted to respond to acoustic waves having a frequency generated when a door or window is opened, means to pass a signal from the sensor to a comparator and means to provide the comparator with a reference signal, the output of the comparator being connected to an alarm such that the alarm is activated when the signal supplied to the comparator exceeds the reference signal, wherein the means to provide the reference signal comprise means adapted to respond to a signal from the sensor and to increase the reference signal, up to a predetermined limit, when the signal from the sensor exceeds a predetermined threshold, and to reduce the reference signal to a predetermined lower value, with a long time constant.
2. An alarm according to Claim 1 wherein the means to provide the reference signal incorporate delay means so that the reference signal is increased after a predetermined delay when the signal from the sensor exceeds said threshold.
3. An alarm according to Claim 1 or 2 wherein the sensor comprises an electret sensor.
4. An alarm according to Claim 1, 2 or 3 wherein the output signal of the sensor is passed to a low pass filter which selectively passes frequency of up to 10 Hz.
5. An alarm according to Claim 4 wherein the low pass filter has a roll-off characteristic at higher frequencies,



passing substantially all of the signal at 3 Hz passing lower proportions of the signal of higher frequency.

6. An alarm according to Claim 4 or Claim 5 wherein part of the signal from the low pass filter is passed through a second filter which passes a relatively narrow band of frequency based on approximately 3 Hz to the comparator, and another part of the output from the filter is passed to a peak detector adapted, when the threshold set by the peak detector is exceeded, to supply current to a capacitance constituting the variable reference to charge up the capacitance, means being provided to discharge the capacitance with a long time base when the capacitance is not being charged, the capacitance being connected by a delay as the reference input to the comparator.

7. An alarm according to any one of the preceding Claims wherein a second comparator is provided, the second comparator receiving a signal generated by the sensor and also receiving the reference signal in an inverted form.

8. An alarm according to Claim 7 as dependent upon Claim 6 wherein the capacitance constituting the variable reference is connected by means of an inverter and a delay as a reference input to the second comparator.

9. An alarm substantially as herein described with reference to and as shown in the accompanying drawings.

10. Any novel feature or combination of features disclosed herein.

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