



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
05.06.2019 Bulletin 2019/23

(51) Int Cl.:
G08B 13/04 (2006.01) **G08B 13/16 (2006.01)**
G08B 29/04 (2006.01)

(21) Application number: **17204945.4**

(22) Date of filing: **01.12.2017**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD TN

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(54) **ANTI-MASK FUNCTIONALITY FOR ACOUSTIC GLASS-BREAK DETECTORS**

(57) The present invention provides an acoustic glass-break detector having anti-masking functionality comprising:

- i) a first and a second microphone for capturing acoustic energy and converting it into a first electrical signal, the second microphone is an omnidirectional microphone for capturing acoustic energy and converting it into a second electrical signal; the detector further comprising;
- ii) conditioning circuitry to convert the first and second electrical signals into a form suitable to be captured by an analog to digital converter; and
- ii) a digital signal processor for capturing and analyzing

the first and second conditioned electrical signals; wherein the digital signal processor is configured to:

a) capture the first and second conditioned electrical signals characterized in that the apparatus is configured to perform the capture and analysis periodically and compare the signals and if:

A) the signals have a differential greater than a threshold to trigger a masking alarm;

B) the signals have a differential less than or equal to a threshold to continue operation.

The present invention is best illustrated by figure 3.

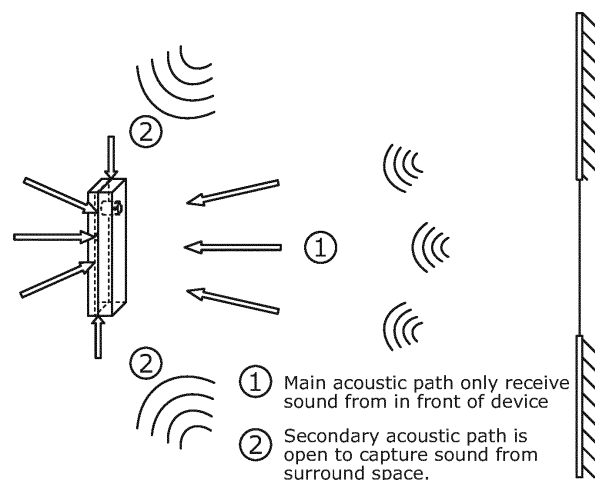


Figure 3

Description

[0001] The present invention relates to acoustic glass-break detectors. These are devices for detecting the breakage of glass by means of capturing and analysing acoustic signals from the breakage of glass, typically the signals associated with the breaking of a pane of glass. The detectors are used in security systems for the purposes of detecting a break-in associated with the breakage of a pane of glass, such as a window.

Background

[0002] Acoustic glass-break detectors (AGBD) utilize a microphone to capture sound from the breaking of glass against the background of ambient environmental sound. The output from the microphone is then filtered and, should the signal pass the filters, and the signal match a profile of a glass break then the signal can then be attributed to the breaking of glass and a suitable alarm can be triggered. The audio signature of the breakage of glass includes sound components in the range 10 to 50 Hz along with a relatively high intensity of sound at higher frequencies in the range 1kHz to 10kHz). US 5164703 discloses glass breakage detection by detection of two particular frequencies of sound. Many variations of the basic method are known, for example as provided in US 2016/0093178. This apparatus comprises a band pass amplifier connected to a microphone, the output of which is compared to a threshold, the passing of which is used to trigger a glass breakage alarm. A detailed description of acoustic analysis for glass breakage detection is disclosed in GB 2 370 118. This provides the functions of flex wave and higher frequency component detection including complex peak height analysis to avoid false triggering. Another approach is to limit signals to be analysed to those from a specific region of space, such as disclosed in US 5,471,195, where two microphones are used to triangulate the incoming signal and detect the relative position of the source. However, the simple expedient of pointing a microphone in the direction of the window being monitored is more straightforward and does not require the use of the matched microphones necessary to provide signals sufficiently similar to allow for triangulation.

[0003] A number of standards have been developed for acoustic glass break detectors. A relevant standard is European standard EN 50131-2-7-1:2012, titled: alarm systems - intrusion and hold-up systems - part 2-7-1: intrusion detectors - glass-break detectors (acoustic), published 2012/9/14. The standard provides a number of grades with grade 4 being the most stringent. A brief summary of the standard is tabulated below.

Table 1. Events to be processed by grade of alarm

Event	Grade			
	1	2	3	4
intrusion	M	M	M	M
No Stimulus	M	M	M	M
Masking	Op	Op	M	M
Tamper	Op	M	M	M
Low Supply Voltage	Op	Op	M	M
Total loss of power supply	Op	M	M	M
Local Self Test	Op	Op	M	M
Remote Self Test	Op	Op	Op	M
M = Mandatory Op = Optional				

[0004] The present invention addresses the requirement for the Masking standard. This requires that the apparatus be capable of responding to tampering which has the effect of masking sound input. This can occur when a potential intruder tampers with the apparatus so as to disable the alarm, such as by covering an aperture through which sound may enter the device, or alternatively by covering the whole device with a sound absorbent material.

[0005] There is therefore a need for methods for providing anti-masking capability for acoustic glass-break detectors. There is a particular need to provide an apparatus capable of passing the EN 50131-2-7-1:2012 criteria for masking.

Summary

[0006] The present invention in its various aspects is as set out in the appended claims.

The invention

[0007] An acoustic glass-break detector having anti-masking functionality, comprising:

- i) a first and a second microphone, wherein the first microphone is configured for capturing acoustic energy and converting it into a first electrical signal, wherein the second microphone is an omnidirectional microphone configured for capturing acoustic energy and converting it into a second electrical signal; the acoustic glass-break detector further comprising;
- ii) conditioning circuitry configured to convert the first and second electrical signals into first and second conditioned electrical signals in a form suitable to be

processed by an analog to digital converter; and
 ii) a digital signal processor for capturing and analysing the first and second conditioned electrical signals;

wherein the digital signal processor comprises an analog to digital converter; and
 wherein the digital signal processor is configured to thereby:

capture the first and second conditioned electrical signals,

characterized in that the acoustic glass-break detector is configured to perform the capture periodically, perform analysis of the captured signals, including comparing the signals and if:

A) the signals have a differential greater than a threshold the digital signal processor will trigger a masking alarm;

B) the signals have a differential less than or equal to a threshold the digital signal processor will not trigger a masking alarm and will continue operation.

[0008] Where, to continue operation, includes the operation of detecting a glass-break and triggering a glass-break alarm. Operation may also be continued after triggering a masking alarm. The alarm may be integral to the detector, may be a signal to remote station or both. A signal to remote station is preferred so as not to alert an intruder to detection. The detector may comprise two analogue to digital converters, one for each channel so as to allow simultaneous conversion and hence provide a higher sampling rate to provide greater resolution. The DSP and analog to digital converters may be part of a master processing unit (MPU). The MPU and DSP may utilize the same processor such as when provided in the form of a single chip microcontroller.

By "capture the first and second conditioned electrical signals" is preferably meant: to digitize the signals using an analog to digital converter and store the resulting values. Analysing provides a data processing function, such as fast Fourier transform and provides a comparison function so as to provide a measure of differential of the signals (i.e. difference between, rather than the meaning in calculus).

The differential (e.g. main minus secondary) of the signals may be selected from one or more of:

I) differential signal amplitude - this signals that one microphone is providing a low amplitude signal compared to that from the other microphone and is indicative of masking. This is expressed by comparing the first and second conditioned electrical signals. The signal amplitude may be instantaneous, or preferably as a function of time, such as averaged over a period of 1ms to 10ms. The differential of the signal

amplitude may be averaged over 10ms, preferably over 100ms to avoid time of arrival effects, echoes and other environmental artefacts of acoustic signals which could otherwise provide a false alarm. This averaging also allows a single ADC to be used which enables greater accuracy (as, for example, the resistor ladder will be identical), such an ADC will be multiplexed between the input channels. The differential of the signal amplitude between the captured signals from the microphones may be in the order of 20dB or more, preferably 10dB or more, most preferably 5dB or more as the threshold to trigger a masking alarm. The lower figure giving a more sensitive alarm and the larger figures a less sensitive alarm but less prone to false alarms ; and

II) differential signal amplitude of a frequency component - the signal amplitude used may be of a given frequency component between the two microphones, such as high frequency that is more likely to be masked, for example if an aperture to the housing is blocked. This is expressed by comparing the first and second conditioned electrical signals. Such a frequency may be in the range 5kHz to 30kHz, preferably in the range 10kHz to 30kHz, more preferably in the range 15kHz to 30kHz. This is higher than frequencies usually analysed for glass break and is utilized for its sensitivity to being attenuated by obstruction of an acoustic path, such as found in masking. The differential of the signal amplitude between the captured signals from the microphones may be in the order of 20dB or more, preferably 10dB or more, most preferably 5dB or more as the threshold to trigger a masking alarm. The lower figure giving a more sensitive alarm and the larger figures a less sensitive alarm but less prone to false alarms but requires frequency selection.

The threshold to trigger a masking alarm of this differential signal amplitude is preferably 5dB or more, preferably 10dB or more, most preferably 20dB all in the frequency range 5kHz to 30kHz as the threshold to trigger a masking alarm this is because the selection of a higher frequency, preferably, in the range 10kHz to 30kHz, more preferably in the range 15kHz to 30kHz range, as higher attenuation from most forms of masking and so allows for reduced sensitivity to trigger an alarm and a lower likelihood of a false alarm. This provides the highest reliability in detecting masking above normal environmental effects.

This differential of the signal amplitude may be averaged over 10ms, preferably over 100ms to avoid time of arrival effects, echoes and other environmental artefacts of acoustic signals which could otherwise provide a false alarm.

Low ambient sound adaptations

[0009] The apparatus may be configured to perform the capture and analysis periodically and compare the first and second conditioned electrical signals and, if:

C) both the signals have no or negligible, absolute, amplitude, (such as less than 10dB, preferably less than 5dB) the apparatus may enter a warning state. In this condition there will be no detected differential as there is limited signal to differentiate. In a warning state the possibility of a silent environment due, not to masking, but to the absence of ambient noise is accommodated. The warning state does not trigger an alarm but continues monitoring for a set period: if during that time there are no sound events that provide more than a negligible amplitude then the masking alarm, optionally differentiated from a masking alarm from A) by being termed a low ambient masking alarm and being output as a separate signal, is triggered.

Alarm triggering

[0010] Triggering a masking alarm comprises one or more of: issuing an audible alarm from the device; sending a signal to a control panel; issuing a visual alarm (such as a flashing light); sending a signal to an emergency response function (such as security personnel) and logging a maintenance request for the device to be checked (such as for blockage of the aperture; microphone masking). The triggering of type A preferably comprises one or more of: sending a signal to a control panel and sending a signal to an emergency response function. This serves to avoid warning a person tampering with the alarm of its status and enabling a greater chance of the person being apprehended. The triggering of type C preferably comprises one or more of: issuing a visual alarm (such as a flashing light) and logging the maintenance request since this can simply be the result of the persistent absence of ambient sound (a quiet night). The visual alarm is preferred as it is likely to trigger video recording equipment to record events and as such presents a preferred combination of equipment in a system.

Calibration

[0011] In a preferred embodiment the acoustic glass-break detector having anti-masking functionality of the present invention has a learning mode. In this mode, for a period of time initiated by an operator the digital signal processor capturing and analyzing the first and second conditioned electrical signals determines a baseline differential of the signals (such as defined in I or II above) and stores these values as providing a no-differential baseline. To illustrate, the first microphone may provide a signal of twice the amplitude in absolute terms of the

second microphone due to installation constraints of the device (or intrinsic electrical characteristics) when normally installed. This is self-evidently not a masked condition and so that differential is recorded as baseline from which differential signal amplitude is determined for the purposes of A), B) and C). Hence, by example a differential calculation for those purposes may be Main/first - Secondary/second - differential, all as an amplitude, such as measured in dB. The differential being positive or negative depending upon the relative baseline signal strengths from the first and second conditioned electrical signals. This installer calibration option is very useful as each installation usually has a significantly different acoustic signature. Optionally the calibration may include an acoustic pulse signal generated by the device and the detection of echoed sound, such as acoustic energy received by the microphones after the pulse has finished. The above calibration preferably supplements any factory generated equalisation of signals but may be used instead and as such simplifies production. The invention as herein described may be factory calibrated to provide negligible signal differential between the microphones, such as by adjusting amplifier gain after production.

[0012] This embodiment is particularly effective when: the first and second microphones are in distinctly different audio reception environments. This enables flexibility in installation of the devices without hindering their anti-masking functionality. This embodiment is also particularly effective when: one microphone is at the rear (a wall or ceiling face) of the device housing and the other at an external face of the housing. Alternatively, this embodiment is also particularly effective when: one microphone is disguised, having no visually distinct aperture in the housing. This misleads a person tampering with the device into only masking the other microphone and so enabling the more definite trigger condition A). These ('when') features may preferably be combined.

Self-test functionality

[0013] In a further preferred embodiment (optionally combinable with the first embodiment), the acoustic glass-break detector having anti-masking functionality of the present invention comprises a transducer for producing acoustic energy, preferably inaudible sound (e.g. in 20kHz to 30kHz range), of a frequency and amplitude that the device may detect and upon which a differential may be determined. Specifically: the capture and analysis periodically performed is accompanied by activation of the transducer to provide a sound reference. This avoids dependence upon the vagaries of ambient sound fluctuations in A), and in (optional) C) avoids the negligible environmental sound (quiet night) scenario triggering a false alarm. Alternatively, when in C) the warning state is entered only then is the transducer activated.

[0014] This avoids unnecessary ambient sound being generated. It also enables simple testing to be performed by covering one microphone during installation or main-

tenance and if the transducer is activated then the anti-masking functionality is validated. As mentioned, the transducer sound may be inaudible to the human ear as audible sound could warn a tamperer (such as a person who interferes in a harmful or disruptive manner with the equipment) of their detection which reduces the chances of apprehension. However, inaudible transducer sound necessitates the use of additional equipment on installation and maintenance. So, an audible alarm may be preferred on these other grounds or where the potential for apprehension is unlikely.

Signal analysis

[0015] Preferably the digital signal processor is configured on capturing the first and second conditioned electrical signals to:

- a) determine the amplitude of those signals as a function of time and the frequency components of those signals as a function of time and the amplitude of at least some of the frequency components of those signals as a function of time (such as in I and/or II); and to
- b) analyse the frequency spectrum and amplitude response by digital signal processing, and to signal an alarm if both an amplitude threshold and a statistical band envelope threshold are breached. An example of a statistical band envelope threshold being confidence bands in a regression analysis comparing amplitude as a function of time between first and second conditioned electrical signals. The threshold being, for example a linear regression analysis 'standard error' obtained from an 'ordinary least squares' analysis such as carried out by the DSP. Use of a statistical band envelope provides a more reliable basis for triggering as the effect of data outliers (electrical or acoustic spikes etc.) to give false triggering is minimized.

General features

[0016] In the present invention the acoustic glass-break detector has anti-masking functionality. This functionality is a means to determine if the device has been 'masked': that is if acoustic suppression means have been placed on the detector, such as to muffle sound in an attempt to disable glass-break detection.

[0017] In the present invention the acoustic glass-break detector is preferably a unitary apparatus in which all the features are present in a housing.

[0018] If a housing is used the housing is preferably of a hand-holdable size as in these devices the potential for masking (e.g. complete covering) is greater. In such unitary devices (all the components being within a single housing) the potential for masking is higher and the present invention all the more relevant.

[0019] If a housing is used the microphones are pref-

erably located within the housing and receive acoustic energy from outside the housing primarily through apertures in the housing. The first microphone is preferably on a front face of the housing and the second microphone is preferably on a rear mounting face (e.g. to a wall or ceiling). The apertures are preferably the only (significant) apertures in the housing when mounted (i.e. when screw fixing holes etc. are filled). This gives a greater effect of masking - this may be considered disadvantageous in the art. However, the improved masking detection of the present invention means that a pre-warning of malfeasance is more likely to be found (masking is usually prior to an intended unauthorized intrusion) and so apprehension is more likely to take place due to an alarm being triggered. This is preferably an alarm of the sorts provided above that will not warn the tamperer by providing a signal evident to a person in proximity to the device. The benefit is particularly great in institutional and military use where active security is present, and less so for domestic use.

[0020] The first microphone is preferably an omnidirectional microphone. Both the first and second microphones are preferably identical (i.e. identical in electrical specification). This enables a better comparison of signals between the microphones and minimising the effect on the differentials of the location of a source of acoustic energy relative to the device.

[0021] The conditioning circuitry typically comprises an amplifier to amplify signal intensity and optionally comprises filters so as to selectively remove signal information in particular frequency ranges. The conditioning circuitry is preferably duplicated, with one conditioning circuit for each microphone. The conditioning circuitry typically takes a milliamp level signal from the microphone and converts it into a 0 to 5V signal for analysis by an analog to digital converter, such as an analog to digital converter present as part of a digital signal processor. The digital signal processor takes the first and second conditioned electrical signals and preferably determines the amplitude of those signals as a function of time and as required the frequency components of those signals as a function of time. The processor will preferably determine signal magnitude as a function of time and carry out a fast Fourier transform on each signal to determine the frequency components of that signal and the amplitude of those frequency components. It is not necessary that the apparatus stores the information on an ongoing basis; information may be obtained and analysed in a transitory basis from which derivative measures, such as signal intensity at a given frequency integrated over time may be collated.

[0022] As previously mentioned, an objective of the invention is to provide means for meeting the anti-masking criteria of the relevant standard.

[0023] Practically speaking this means that an acoustic glass-break detector is typically housed in a housing such as a box and an aperture is present in the housing to permit acoustic energy to enter the housing for micro-

phone detection. Hence, in use, a person tampering with the equipment could seek to block the microphone aperture in an attempt to mask the acoustic glass-break detector. If the microphone hole is blocked by glue, foam, plastic skin, gum, etc., this has the consequence that the intruder cuts-off the acoustic path of the detector, and the acoustic glass-break detector will therefore lose detection function and be unable to carry out reliable protection while glass-breaking events could occur in the absence of anti-masking measures. Therefore, it is important to implement an anti-masking functionality for an acoustic glass-break detector to detect, mitigate or preferably obviate the effects of masking.

Directional microphone

[0024] Alternatively, the first microphone of the present invention may be a directional microphone for capturing acoustic energy and converting it into a first electrical signal. A directional microphone is a microphone configured either in itself, or in conjunction with other parts of the apparatus, to detect sound by capturing acoustic energy selectively with respect to direction. The directional microphone may be a conventional microphone element which is physically placed to preferentially detect sound from a particular direction. For example, the microphone may be placed at the end of a sound absorbent walled tube, such as a rubberised tube, the tube pointing in the direction from which directional sound information is to be obtained. However, the directional microphone may preferably be a microphone which is inherently sensitive to sound from one particular direction. When the microphone is directional the calibration in-situ functionality is particularly useful to avoid false alarms.

Interoperability

[0025] In order to solve the problems and requirements mentioned above, the present invention provides one or more of an apparatus, method and system to detect accurately whether a microphone hole is blocked or not, thus, the present invention implements anti-masking function to support the functionality of an acoustic glass-break detector according to EN grades 3&4 described previously.

[0026] A method comprises the method features of the apparatus described. A security system of the present invention comprises the apparatus described in conjunction with further security system features, such as selected from a control panel connected to the detector and video surveillance of the detector, particularly video surveillance triggered by changes in light intensity.

Microphone failover

[0027] In the event that a first microphone, such as one placed at the front face of a device, is determined as being masked, the glass breakage determination can

failover to the signal from the second microphone so as to maintain signal quality for glass-break determination. In this respect the first and second microphone elements (i.e. the electrical transducer component and conditioning circuitry) are preferably to the same specification.

Detailed description

[0028] The present invention is illustrated by means of the following figures, which provide schematic information:

Figure 1 provides a functional block diagram of the present invention;

Figure 2 provides an example of application structure of a glass-break detector;

Figure 3 provides a schematic of the main and secondary acoustic paths to the microphones used in the present invention;

Figure 4 is a block diagram example of the present invention; and

Figure 5 discloses a simplified algorithm processing flow chart of the present invention.

[0029] The present invention is illustrated in figure 1 and comprises the features:

110, a main acoustic transducer module in the form of a first microphone;

120, a secondary acoustic transducer module in the form of a second microphone;

130, a signal condition unit I providing conditioning circuitry;

140, a signal condition unit II providing conditioning circuitry; and

150, a MPU (Master Processing Unit) module 150 comprising a digital signal processor.

DSP is a digital signal processor forming part of the MPU. ADC1 and ADC2 are analog to digital conversion units forming part of the MPU.

The arrow directions represent the signal flow and control.

[0030] The present invention provides two acoustic paths to capture sound: the glass breaking sound is picked up by the main acoustic transducer module 110, processed by the following signal condition unit I 130, finally sent to Master Processing Unit (MPU) module 150 for analog to digital conversion (ADC) and digital signal processing, the signal flow is shown in Fig.1. In Fig. 1, a secondary audio path (120, 140, ADC2) is implemented to support the main audio path. The secondary acoustic path is to primarily capture the ambient sound as audio information. The MPU 150 further comprises a digital signal processor (DSP). For practical purposes a digital signal processor (DSP) in the form of a modern microcontroller will typically provide both MPU and DSP functionality in a single unit. A DSP is a high speed math-capable

signal processor capable of analysis of sound-intensity-derived signals in real time. The DSP is required to perform calculations, such as Fourier transforms, to realistically generate the functionality of the device.

[0031] Fig.2 is, on the right, a schematic of a physical device (shown left) relevant to the present invention. As shown in figure 2, the present invention may be a unitary device in a housing. The housing may comprise the features:

- 210, a main acoustic path (i.e. generally in the outermost face of an installed device) in the form of an aperture;
- 220, a soft rubber tube, such as will make sure the main path is focused on likely glass breaking direction on installation (such as pointing toward a window) and hence to give a degree of directionality to an otherwise omnidirectional microphone;
- 230, an upper cover, for providing an outermost face on installation;
- 240, a printed circuit board (PCB) (this being the location of all the electronic components of the device) for providing a unitary device;
- 250, a lower housing; for providing a rear face on installation; and
- 260, a secondary acoustic path (i.e. generally behind; on rear face) in the form of an aperture.

[0032] In Fig 2 the ref# 260 points to a tube and ref# 250 looks more like a path, c.f. path 210. Is "path" the same as "hole in housing", or does it mean the route the sound follows?

[0033] The first microphone 110 is preferably placed in proximity to an internal end of the tube 220. The second microphone is preferably placed in proximity to the secondary acoustic path 260, such as through an aperture in the main face of the lower housing. The housing preferably comprises mounting lugs (not shown: handles or projections used as a hold or support) to offset the housing from a support surface to which it may be attached on installation. This enables acoustic energy from the environment to reach the microphone whilst making it less accessible for masking.

[0034] The purpose of the secondary acoustic path is to allow entry of acoustic energy, preferably in the form of sound surrounding the detector (omnidirectional, but predominantly laterally through 360° in this example) such as through the gap between the lower housing and a support surface. It has been found in practice that the difference in amplitude of the sound signals between main and secondary acoustic paths is normally the same and stable. Therefore, the acoustic glass breakage detector of the present invention can compare the signal amplitude difference from two paths via the MPU/DSP to make a determination, when these two conditions are met, to give:

- 1) a signal amplitude difference value that is above

a threshold value and

- 2) the difference holding time exceeding a time threshold value, i.e. that condition 1) remains after a given time, the holding time threshold value, so that a masking alarm condition should be triggered.

[0035] The main and secondary acoustic paths for sound energy, whether ambient or for glass breakage are shown in Fig.3:

- ① Main acoustic path toward the upper cover for glass breaking detection and ambient sound capture;
- ② Secondary acoustic path for ambient, omnidirectional sound capture, and as shown here with a predominant path behind the device and the surface upon which it is mounted, i.e. directionally.

For the acoustic glass-break detector under normal environment conditions, the two acoustic paths will capture a stable, same sound signal amplitude and frequency spectrum. The MPU/DSP is configured to compare the signals from the two paths. To the extent this may differ calibration and averaging over time (e.g. 10ms as described above) can be used to overcome this, such as in a space having particularly sound adsorbent surfaces (calibration) or sound reflecting surfaces (averaging) or with a complex mix of the two the combination is particularly advantageous.

[0036] If the main acoustic path hole is masked, i.e. blocked, then the main acoustic path to the first microphone is cut off, and the MPU is configured to determine the amplitude difference of sound signal between main (first) acoustic path and secondary acoustic path.

[0037] If the difference value is over the amplitude threshold value, then the MPU optionally starts a timer., Once the holding time exceeds a time threshold value, here 500ms, the MPU can redetermine if the amplitude difference of sound signal between main acoustic path and secondary acoustic path remains over the amplitude threshold value, and if so generate a fault signal or anti-masking signal whilst the condition persists. However, once triggered by an anti-masking signal the masking alarm may latch on until the device is reset. This avoids a tamperer realizing a fault has been triggered and removing the masking so as to avoid an alarm - the key information of a potential future intrusion being recorded.

[0038] In the event that an intruder/tamperer uses a foamed box to cover the overall detector, then the MPU can detect that the sound signal amplitude values derived from acoustic energy in the main and secondary acoustic paths have changed at the same time. In this event, the same as above, once the holding time exceeds a time threshold value, the MPU is configured to generate a fault signal or anti-masking signal in time, i.e. trigger a masking alarm.

[0039] These illustrated devices Pass EN grade3 and grade4 as described above.

[0040] The method and system for acoustic glass breakage detection of the present invention integrates anti-mask functionality, and a platform example based on the present invention is shown in Fig.4. Specifically, Figure 4 shows a block diagram example of the present invention.

[0041] The method of the invention compares the amplitude of sound signal difference from a 'main', i.e. first microphone and a secondary microphone. The function of the main microphone is not only to detect sound from breaking glass but also to detect the ambient sound. The secondary microphone is used for capturing ambient sound, then the MPU is used to compare the two signals from the first and the secondary microphones.

[0042] If masking has not occurred, then the amplitude of the sound signals from both main and secondary microphones will be stable, and the MPU can compare and optionally record the differential signal values over time. However, once an intruder blocks the main microphone hole, the main microphone path is cut off. At the same time the signal amplitude from the main microphone changes, thus, the MPU can calculate that the amplitude difference between main and secondary microphones is changed and can action an alarm accordingly. In addition, the microphone which is not masked may then be used (switched i.e. used by the DSP) as the main audio signal source for determining a glass breakage event. This is not only to maintain sensitivity but the masking may be frequency selective and thus avoid the normal parameters of a glass breakage algorithm being met. (??)

[0043] If the difference value is over the amplitude threshold value, then the MPU can start the timer. Once the holding time exceeds the time threshold value, the MPU can judge the main microphone to be working abnormally and then generate a fault signal or an anti-mask signal as long as the hole is blocked.

A further example is shown in FIG.4 which develops the invention disclosed in Figure 1 and includes the features of Figure 1. Figure 4 includes:

- 410a main (optionally directional) microphone module,
- 420 a signal process module 420,
- 430 a secondary (preferably omnidirectional) microphone module,
- 440 a signal process module, and
- 450 a MPU (Master Processing Unit) module 450.

[0044] The arrow directions represent the signal flow and control. The signal process unit provides amplification and conditioning so as to provide a signal suitable for reception by the analogue to digital converters (such as a signal in the range 0 to 5 V or 0 to 3.3v) and optionally also buffers the output. BPF represents a band pass filter, this may be used to condition the electrical signals, for example by selecting frequency bands as hereinbefore described. The signal is then fed into the DSP for further conditioning and analysis as previously mentioned. Also

shown in figure 4 is a separate schematic as part of the MPU providing system control logic, a glass-break characteristic library and a threshold judgement function. These features may be part of the MPU or if the DSP in the MPU sure a processor then essentially in the same device. The system control logic provides features such as time delays, sampling frequency and alarm reporting. The glass break characteristic library is used to provide signatures of glass breakage against which the DSP may compare incoming signals, this provides the underlying acoustic class-break detection function. This functionality is assumed to be present throughout this disclosure. The MPU/DSP as a threshold judgement function to carry out the functions of the present invention and also to detect glass breakage. the threshold judgement functionality evaluates whether a glass-break event has occurred and triggers an alarm if required to provide the acoustic class-break detection function.

[0045] Figure 5 shows a schematic of a method of the present invention in which the apparatus of the present invention is utilised and illustrates the function of a holding time threshold value. The function of the holding time threshold value is to repeat the determination if the signals (as defined above) have a differential greater than a threshold and only trigger a masking alarm if the situation is maintained. This has the advantage that transient acoustic effects, such as echoes, do not inadvertently create an alarm condition. The holding time is monitored using a timer of the MPU that is incremented until the predetermined time threshold has been reached (or the differential is below the differential threshold). The holding time threshold value is typically in the order of 1ms to 10s, however, 10ms to 1000ms is typically sufficient in most environments.

[0046] The present invention as described herein provides detailed functionality for anti-masking and is in combination with functionality to provide acoustic glass-break detection and preferably utilises the same hardware, microphones, signal conditioning, digital signal processing unit, MPU system control logic criteria for determining whether audio signals represent a glass break characteristic, threshold judgement functionality to determine if a sufficiently good match is provided between the audio signals and a glass break characteristic and alarm reporting features, option including an acoustic transponder to provide acoustic output.

[0047] As used herein audio relates to signals, recording and processing of signals derived from acoustic energy. The absolute measure of dB (as L_p) is as conventionally determined for acoustics using the ratio of p_{rms}/p_{ref} , where p_{rms} is the root mean square of the measured sound pressure in pascals and p_{ref} is the standard reference sound pressure of 20 micropascals in air. For example: $L_p = 20 \log_{10}(p_{rms}/p_{ref})$ dB. The absolute measure of is dB is as conventionally determined for electrical signals as dBm. Where a differential is concerned dB express the ratio of one value of a physical property to another.

Claims

1. An acoustic glass-break detector having anti-masking functionality comprising:

i) a first and a second microphone, wherein the first microphone is configured for capturing acoustic energy and converting it into a first electrical signal, wherein the second microphone is an omnidirectional microphone configured for capturing acoustic energy and converting it into a second electrical signal; the acoustic glass-break detector further comprising;

ii) conditioning circuitry configured to convert the first and second electrical signals into first and second conditioned electrical signals in a form suitable to be captured by an analog to digital converter; and

ii) a digital signal processor for capturing and analyzing the first and second conditioned electrical signals;

wherein the digital signal processor is configured to thereby:

capture the first and second conditioned electrical signals;

characterized in that the acoustic glass-break detector is configured to perform the capture periodically, perform analysis of the captured signals, including comparing the signals and if:

A) the signals have a differential greater than a threshold, to trigger a masking alarm;

B) the signals have a differential less than or equal to a threshold, to continue operation.

2. The acoustic glass-break detector of claim 1 wherein on comparing the signals if:

C) both the signals have no or negligible amplitude, to enter a warning state.

3. The acoustic glass-break detector of claim 1 or claim 2 wherein subsequent to determining that a differential is greater than a threshold, holding time is entered into, at the end of which, if the capturing and analyzing having been repeated the differential remains greater than the threshold then triggering a masking alarm then occurs.

4. The acoustic glass-break detector of claim 2 or 3 wherein subsequent to determining a warning state, holding time is entered into, at the end of which, if the capturing and analyzing having been repeated the signals remain at no or negligible amplitude then a masking alarm is triggered.

5. The acoustic glass-break detector of any preceding claim wherein the first microphone is on an outer side of the acoustic glass-break detector and the second microphone is on a mounting side of the acoustic glass-break detector for mounting on a support surface.

6. The acoustic glass-break detector of claim 5, wherein the mounting side of the acoustic break glass detector comprises lugs to offset the acoustic glass-break detector from a surface on which it is mounted.

7. The acoustic glass-break detector of any preceding claim in which the first and second microphones are the same and the conditioning circuitry on each microphone are the same.

8. The acoustic glass-break detector of any preceding claim in which on a masking alarm condition the acoustic glass-break detector fails over to use the microphone not masked, having the higher signal amplitude, for the determination of a glass breakage condition.

9. The acoustic glass-break detector of any preceding claim in which a calibration mode is available in which ambient acoustic energy levels are captured by the detector and set as a baseline, deviation from which is taken as the basis for calculating the differential between the first and second conditioned electrical signals for the purposes of A) and/or B).

10. The acoustic glass-break detector of any preceding claim in which the differential between the first and second conditioned electrical signals is determined based upon that portion of these signals in the frequency range 5kHz to 30kHz.

11. An acoustic glass-break detector system comprising the detector of claim 1 in conjunction with an alarm panel to which the alarm signal is fed.

12. The system of claim 11 further comprising a video surveillance equipment configured to be triggered by a change in light intensity from the masking alarm as presented by the detector as a visual alarm.

13. The system of claim 12 in which triggering the video surveillance equipment comprises beginning video acquisition of images including or directed to include the detector.

14. The system of claim 13 in which triggering the video surveillance equipment further comprises prompting an operator to view the video images.

15. A method of operating an acoustic glass-break detector comprising providing the detector of claim 1,

or as defined in any dependent claim thereof, and
operating the detector as so configured.

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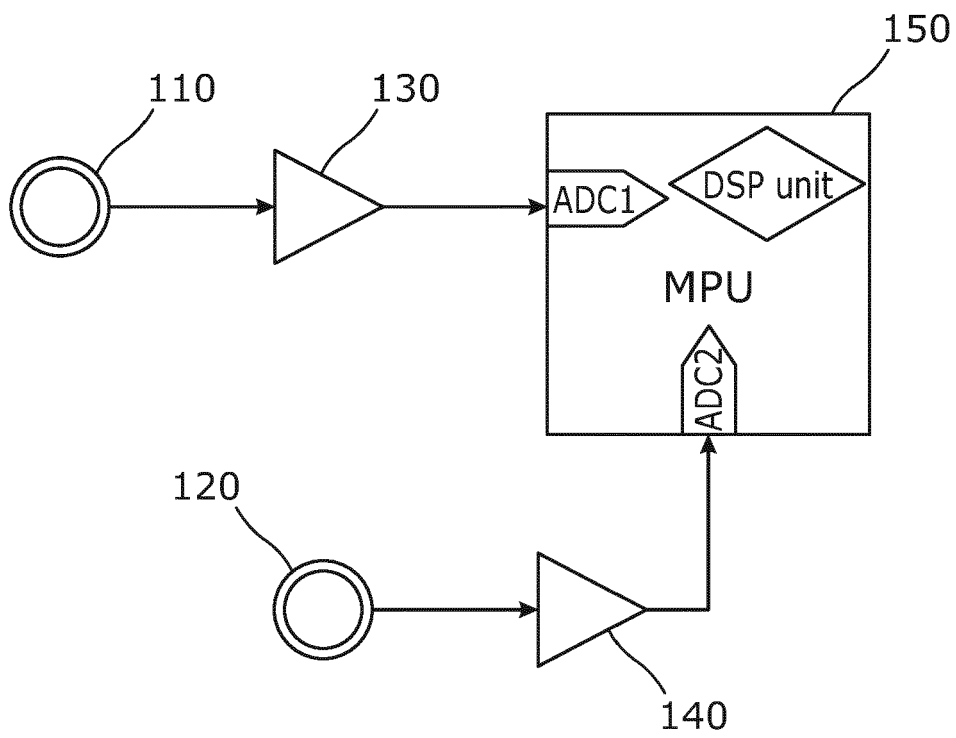


Figure 1

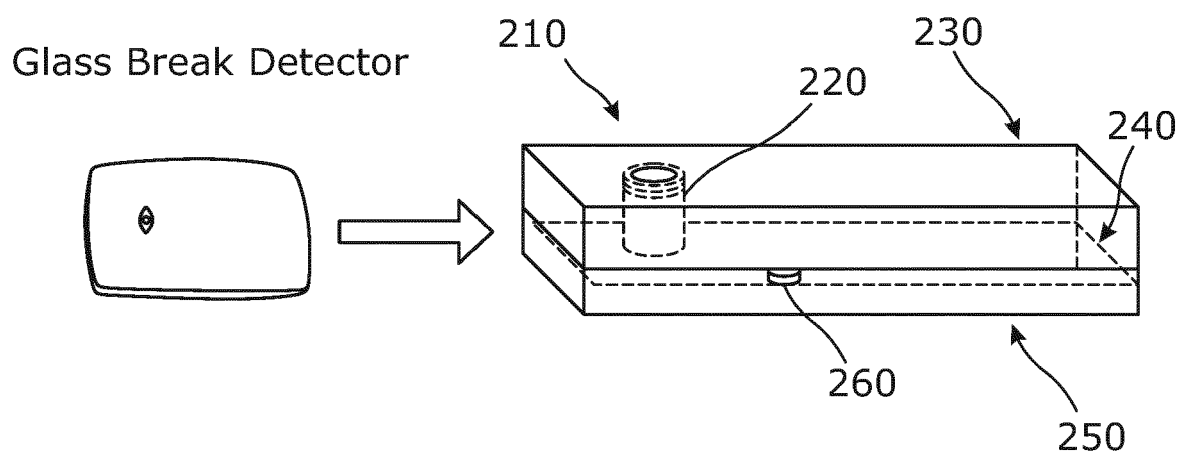


Figure 2

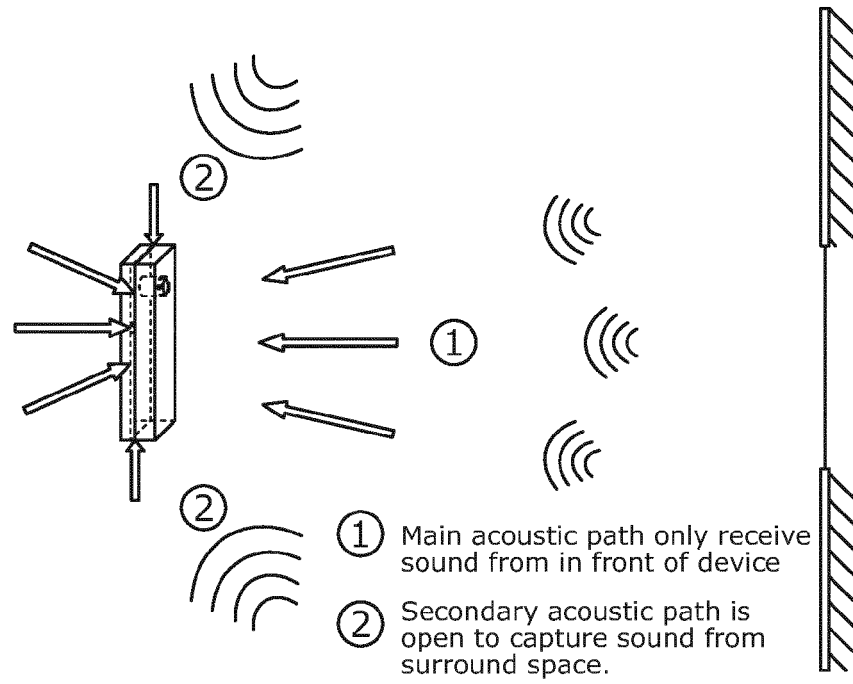


Figure 3

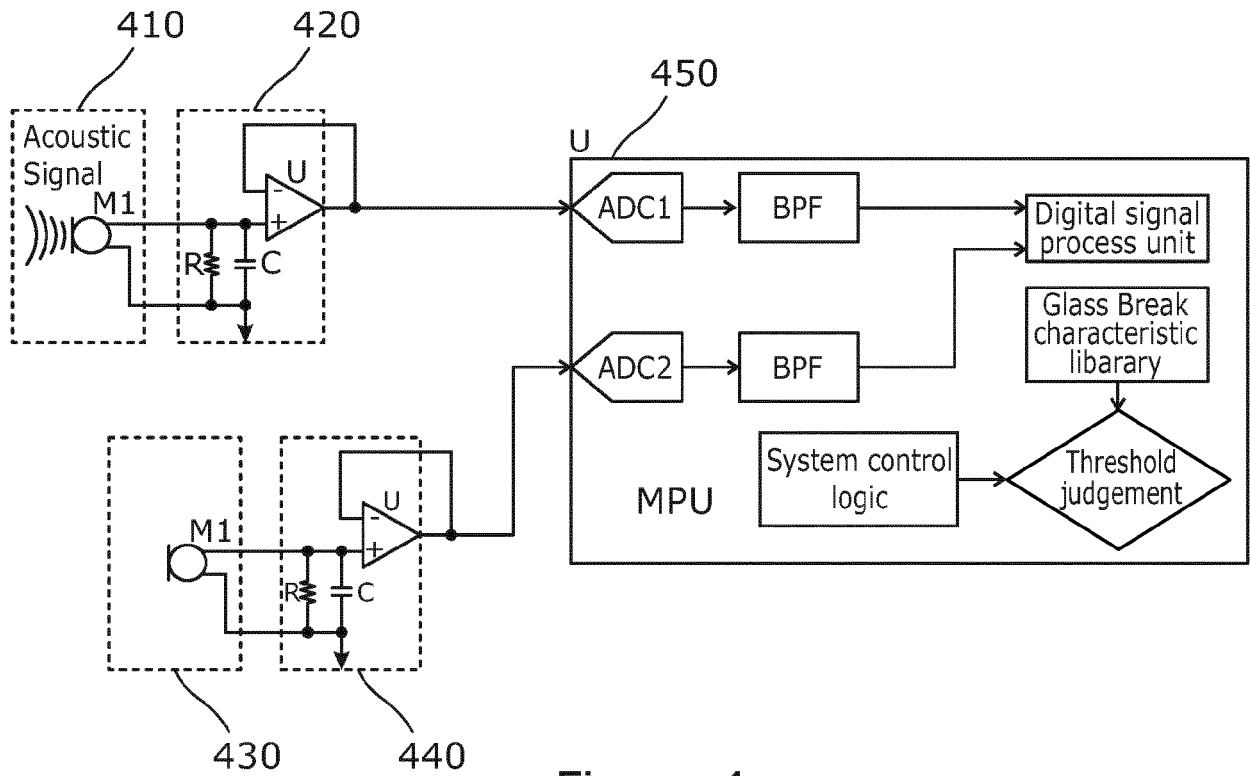


Figure 4

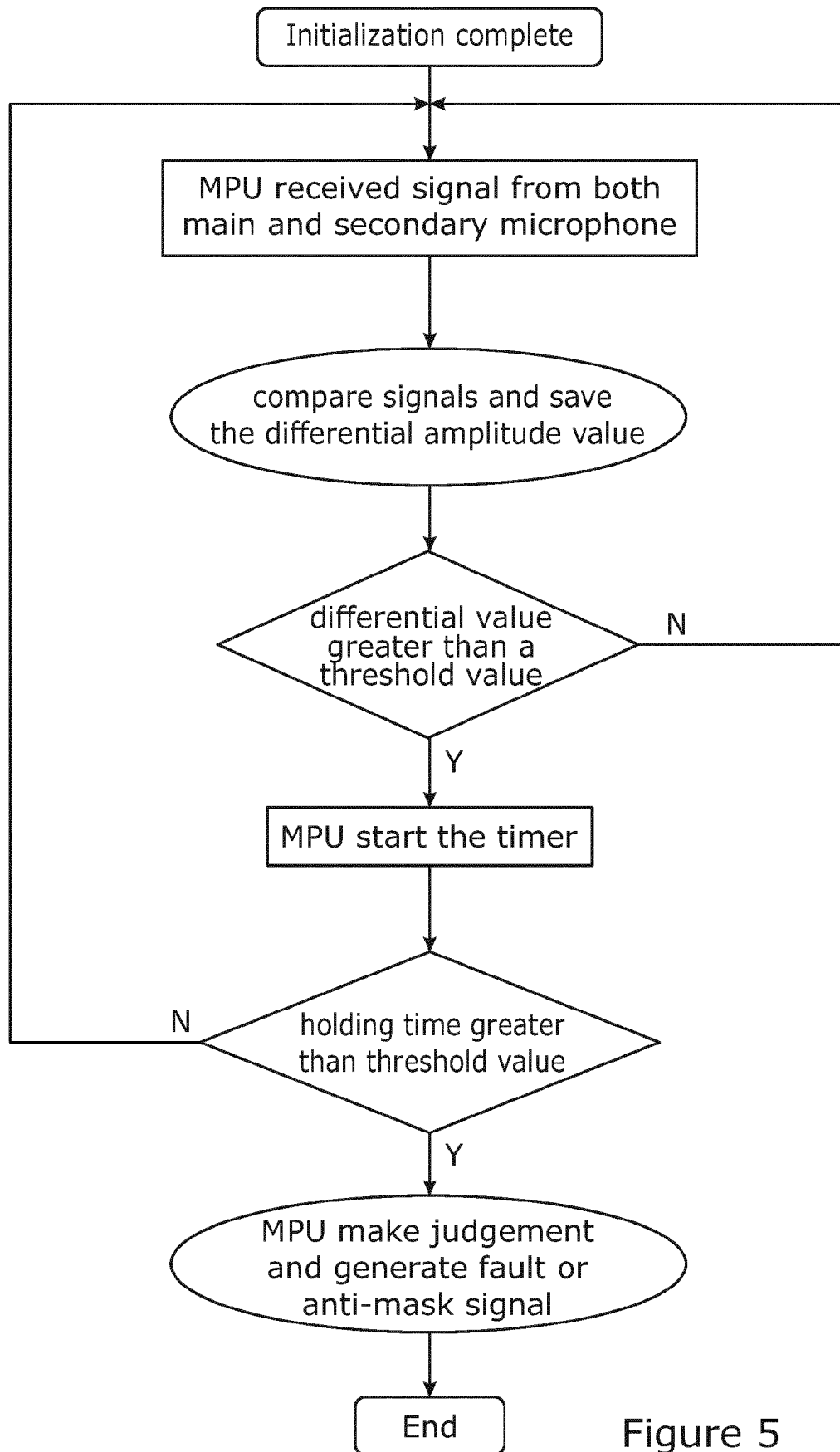


Figure 5



EUROPEAN SEARCH REPORT

Application Number
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			G08B
The present search report has been drawn up for all claims			
Place of search Munich		Date of completion of the search 29 May 2018	Examiner Meister, Mark
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29-05-2018

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