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(54) DEVICE FOR REPORTING ALARM PRODUCED BY A PORTABLE GAS DETECTOR

(57) A device for reporting an alarm produced by a portable gas detector to a monitoring station, and a portable gas detector comprising the device. The device comprises: a mechanical framework adapted to attach the device to the portable gas detector; means for sensing vibration; a processor configured to determine whether the alarm is produced, wherein a determination comprises processing a vibration; and a transmitter configured to wirelessly transmit a first signal to the monitoring station, the first signal being indicative of the alarm being produced.

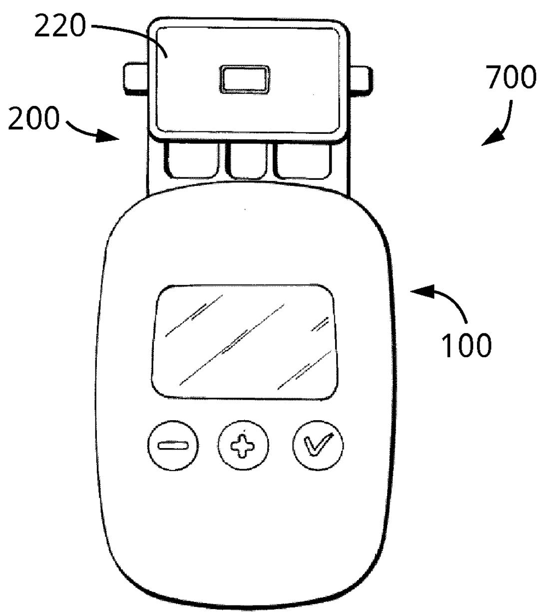

FIG. 7A

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Description

TECHNICAL FIELD

[0001] The present invention relates to the field of alarm reporting, particularly devices for reporting the existence of an active alarm produced by a portable gas detector.

STATE OF THE ART

[0002] The use of gas detectors, that is, devices which produce an alarm when they detect the presence or the absence of a gas, may be important for the safety of people. For example, personnel that must go to or inspect facilities where dangerous or toxic materials and/or substances are present are exposed to hazardous conditions and/or environments. Not only the presence of dangerous materials or substances may affect the health of the personnel, but also the lack of oxygen could result in severe injury or even the loss of human life.

[0003] In these situations, the person that goes to such locations may be conveniently equipped with a device that detects the gas concentration in the premises so that, if it is not a safe environment, the device may produce an alarm indicating so to the person. As the person is warned of such situation, he or she may leave the premises or use equipment that may provide him or her with clean air so as to breath safely, for instance if the content of oxygen in the air is not sufficient the person may decide to use an oxygen mask.

[0004] The gas detectors are carried by the person that is exposed to the hazardous conditions and/or environments and may produce an alarm in the form of vibration and/or sound. It would be convenient, for the person itself and for any personnel involved in the operations or monitoring of the facilities, that the gas detector automatically reported the alarm to a monitoring station that is remote from the person, at least for two reasons: firstly because the person may get injured or lose consciousness while running any task or on his/her way back to a safe location, and secondly because it may assist in taking further preventive actions like, for instance, disabling the flow of gas in gas pipes that may be close to the dangerous location, warning other users of a dangerous condition, etc.

[0005] There are commercially available portable gas detectors that have incorporated therein means for wirelessly communicating the existence of an alarm to a device in a remote location, however such portable gas detectors are generally more expensive than conventional portable gas detectors (not equipped with means for wireless communications) and require replacing already purchased conventional portable gas detectors with these more advanced ones. Further, since the battery of the gas detector must also supply energy to the means for wireless communication, if the battery is not provided with a larger capacity, the gas detector may run out of energy at a faster rate. An example of portable gas detectors with means for wireless communications is the MultiRAE family of gas detectors.

[0006] There have been developments in the prior-art aimed at reporting the alarms produced by an alarm device.

[0007] International patent application publication no. WO2014/098993A1 relates to an apparatus with a controller capable of generating a signal to be transmitted to a remote device when an alarm indication from a sensor is detected. Each of the controller, transmitter and sensor is on-site in a same location. The apparatus described may sense an audible alarm and allegedly may function in any area, however the alarms to be detected are of a domestic nature such as smoke alarms, burglar alarms, or flood alarms.

[0008] US patent application no. US2010/0127865A1 describes a security system capable of detecting alarm sound emitted by off-the-shelf standalone audible devices and notifying of the same to a central office. A device of the system may detect the audible alarm or wirelessly exchange data with wireless devices, and generate and transmit an alarm signal to a remote location using a public switched telephone network. Even though the security system is particularly applicable to buildings, allegedly it may also be used in outdoor areas, or subterranean rooms and passages.

[0009] The patent documents above describe devices for detecting audible alarms and reporting them to a remote location, however the alarms they detect are of a domestic nature, that is, the alarm devices generally have a fixed location.

[0010] Another example of a system and a method for reporting an alarm is international patent application no. WO2016/160799A1. The system is formed by sensors such as remote gas sensors that show the concentration of a gas in a display of a device, and a communications device for communicating data wirelessly to a server. The sensors exchange data with the communications device, for instance data related to the gas concentrations sensed, and the communications device sends the data to the server. The data exchanged between the sensors and the communications device occurs regularly even if no hazardous condition exists.

[0011] In an industrial environment, particularly when an operator is inspecting a potentially hazardous area, the gas detector is portable, namely, it may be carried by the operator so that he or she may be notified of a dangerous situation while moving throughout the facilities. Therefore, it would be desirable to provide a device for reporting an alarm to a remote location (e.g. remote monitoring station or device), where the alarm is produced by a portable gas detector. Further, it would also be desirable that such device could operate with different portable gas detectors without requiring significant customization.

DESCRIPTION OF THE INVENTION

[0012] A first aspect of the invention relates to a device for reporting an alarm produced by a portable gas detector to a monitoring station, the device comprising: a mechanical framework adapted to attach the device to the portable gas detector; means for sensing vibration; a processor configured to determine whether the alarm is produced, wherein a determination of the processor comprises processing a vibration; and a transmitter configured to wirelessly transmit a first signal to the monitoring station, the first signal being indicative of the alarm being produced.

[0013] The mechanical framework of the device may attach to an attachment means of the portable gas detector, thereby attaching the device to the portable gas detector. The attachment means of the portable gas detector may be adapted to attach the portable gas detector to, for example, a belt of the user carrying the portable gas detector; such attachment means, which may be for example a clip mechanism, are commonly provided in commercial portable gas detectors so that the user does not need to hold the portable gas detector and, thus, his or her hands remain free.

[0014] The device is capable of sensing and measuring vibrations that may be generated by the portable gas detector. When the gas detector detects a condition for which it shall produce an alarm (e.g. high concentration of a gas or particles in the environment, low concentration of oxygen in the environment, etc.), the portable gas detector vibrates to alert the user carrying it. Since the user has the portable gas detector close to his or her body (or even in touch with the body), the user can sense the vibrations. As the device is attached to the portable gas detector, the means for sensing vibration provide a signal that varies depending on the magnitude of the vibrations sensed. This signal may be electrical, and the voltage or the current provided may be dependable on the magnitude of the vibrations sensed.

[0015] The processor of the device receives the vibrations outputted by the sensing means and processes them. The vibrations may be digitized first with an analog-to-digital converter so that a bit stream of vibration data may be supplied to the processor for its processing; the analog-to-digital converter may be integrated with the processor or may be provided as a separate integrated circuit for example. The bit stream may be directly processed by the processor and/or kept in a memory buffer, in which case a time interval stored as vibration may be processed at once so as to determine whether the portable gas detector is producing an alarm. The processor may determine whether the vibrations sensed belong to an active alarm or not, that is, whether the portable gas detector is producing an alarm. Even if the means for sensing vibration are configured to sense the vibrations of the portable gas detector owing to the attachment of the device to the detector, the means for sensing vibration may detect the movement of the user carrying the detector (irrespective of the alarm being produced by the detector or not) and, thus, provide a signal for the vibrations that include the movement of the user, therefore the vibrations must be processed so as to determine whether in fact there is an active alarm.

[0016] The processor may determine that there is an active alarm by processing the vibration sensed and checking whether it exceeds predetermined thresholds. If the determination of an active alarm is positive, the processor sends an alarm signal (that indicates that there is an active alarm signal produced by the portable gas detector) to a transmitter that, in turn, transmits the signal to a monitoring station that is remote from both the user and the device. The alarm signal sent to the transmitter may be digital or analog; when the alarm signal is digital, first it may be converted into an analog signal by means of a digital-to-analog converter, or the transmitter may be configured to receive a digital signal and process it in order to transmit the signal. The transmitter is configured to transmit the signal wirelessly.

[0017] The device comprises one or more batteries that supply energy, namely power, to the components thereof.

[0018] Accordingly, the device of the invention is capable of reporting the existence of an alarm even if the user and, thus, the portable gas detector move with respect to the remote monitoring station.

[0019] In preferred embodiments of the invention, the means for sensing vibration comprise an accelerometer for sensing the vibration.

[0020] In preferred embodiments of the invention, the device further comprises means for sensing sound, the means for sensing sound comprising a microphone; further, the determination of the processor further comprises processing a sound.

[0021] With the means for sensing sound, the device may perform a double processing in order to determine whether there is an active alarm that shall be reported to a monitoring station. Particularly, the device may sense an alarm produced by the portable gas detector where the alarm comprises both a vibration alarm and a sound alarm; commercially available portable gas detectors may provide both kinds of alarm so that the user may be warned by sensing either the vibration (for instance in the belt, if the detector is attached thereto) or the sound. Therefore, if one of the two alarms is not noticed by the user (e.g. because the vibration is damped by the clothing, or because the environment is noisy or the user is wearing headphones and thus cannot hear the audible alarm), the other one may be.

[0022] Irrespective of the user noticing one alarm or the other, the device may use both to determine whether there is an active alarm, that is, whether the portable gas detector is producing an alarm. The device processes the sensed vibration and sound, determines for each of them whether an alarm is detected, and combines their outputs to determine whether an alarm has been detected. The combination of the outputs is preferably with an

AND logic function, that is, the alarm is only positively detected when both outputs indicate so; else it is determined that there is no alarm, or that if one of the vibration or the sound as processed is indicative of an active alarm, that the alarm is a false positive (and thus no alarm signal is transmitted by the transmitter).

[0023] Reporting an alarm based solely on the vibration may result in reporting false alarms, mainly because the processor is generally configured to positively identify an alarm using thresholds with lower certainty. It is not permissible that an actual alarm would not be reported, therefore the thresholds are lowered so that, if it is unclear that there is an alarm, the alarm is reported anyway. With double detection, even if the thresholds are low, there are less false positives because there is no correlation between the vibration sensed and the sound sensed (i.e. they are separate alarms; the vibration is not produced by the sound, that is, the vibration is not a pressure wave of an audible alarm but a vibration produced by a vibrator of the portable gas detector), so it is less likely that both the vibration and the sound sensed when there is no alarm would go beyond the thresholds set.

[0024] In some of these preferred embodiments, the processor is configured to process the vibration prior to processing the sound. That is, the processor first carries out the determination of whether there is an alarm being produced by means of the vibration sensed. If the determination is positive, that is, if it is considered that there is an active alarm, the processor then carries out the processing of the sound, which may be more energy-consuming than the processing of the vibration as, generally, more data is necessary to properly represent the sensed sound. In contrast, if after processing the vibration the determination is negative, that is, if it is considered that there is no active alarm, the processor does not process the sound in order to save energy. Even if the determination based on the sound were to be positive, the use of an AND logic function would result in a negative determination by the processor anyway.

[0025] Also, in some of these embodiments, the processor is further configured to switch the means for sensing sound between an active mode and a dormant mode depending upon the processing of the vibration. If according to the vibration it is determined that there is no active alarm, the processor may switch the means for sensing sound to a dormant mode so as to save energy. When the determination by processing the vibration is positive, then the processor may switch the means for sensing sound to an active mode so that the alarm determination may be complemented by processing the sound. The processor may instruct the means for sensing sound to switch to a dormant mode after a succession of negative determinations based on the vibration; this succession may be specified in terms of a number of successive negative determinations carried out by the processor (e.g. after 100 negative determinations, after 1000 negative determinations, etc.), and may be set by an operator that configures the device.

[0026] A dormant mode may be one of a switched off mode and a low power-consumption mode (but not completely switched off).

[0027] In some embodiments, the processor is configured to process the sound prior to processing the vibration. That is, the processor first carries out the determination of whether there is an alarm being produced by means of the sound sensed. If the determination is positive, the processor then processes the vibration. The processor may not process the vibration if based on the processed sound it determines that there is not an active alarm; the use of an AND logic function will output a negative determination of the existence of an active alarm.

[0028] In some embodiments of the invention, the device further comprises an accelerometer for sensing a movement of the device. The processor is further configured to switch the means for sensing vibration between an active mode and a sleep mode based on the movement.

[0029] The movement sensed is processed by the processor, which determines whether the device has been still (i.e. has not moved) in a while (e.g. 5 minutes, 10 minutes, etc.). If the determination is positive, that is, if the processor determines that the device has been still for a determined period of time, the processor may switch the means for sensing vibration to a sleep mode in order to save energy. When the processor determines that there is movement again, it may switch the means for sensing vibration to an active mode. The movement as outputted by the accelerometer may be an analog signal that is digitized so that the processor may process it. It is preferable that the period for which the device has to be still before switching the means for sensing vibration to a sleep mode is set to a value of several minutes: the tasks that the user carrying the portable gas detector has to perform may entail standing still for some time. In contrast, a long period of time in which a device has been still may mean that the portable gas detector has been detached from the user (e.g. leaving the portable gas detector on a secure location) and, inadvertently, not switching off the device to save power. The period of time may be specified in terms of a lapse of time (comparing the time when the first determination occurred with the current time) or number of iterations of such determinations, that is, the amount of times that the processor carries out the movement processing.

[0030] In those embodiments of the invention in which the device further comprises means for sensing sound, the processor may also be configured to switch the means for sensing sound between an active mode and a sleep mode based on the movement as well. In this case, both the means for sensing sound and the means for sensing vibration may be switched simultaneously to one of the active and sleep modes.

[0031] In the embodiments in which the means for sensing vibration comprise an accelerometer, the accelerometer for sensing a movement of the device is a different accelerometer than that for sensing the vibration.

[0032] In some embodiments of the invention, the device further comprises a receiver configured to wirelessly receive a second signal comprising a reprogramming instruction, the processor being further configured to reprogram itself with the reprogramming instruction.

[0033] An operator, located from instance in the monitoring station, may reprogram the processor over-the-air. In this sense, a signal comprising a reprogramming instruction is transmitted to the device. The reprogramming instruction may comprise, for example, adjusting one or more thresholds for the determination of an alarm being produced, adjusting the amount of time that the device must be still in order to enter into a sleep mode, etc.

[0034] In some embodiments of the invention, the transmitter and the receiver of the device are implemented as a transceiver. A transceiver includes circuitry that is common to both the transmitter and the receiver.

[0035] In some embodiments of the invention, the transmitter is configured to wirelessly transmit the first signal to the monitoring station through a remote device, the remote device comprising means for transmitting electromagnetic signals through a cellular network. In these cases, the transmitter may communicate with a remote device such as a mobile phone carried by the user. The mobile phone provides connectivity to a cellular network such as GSM, UMTS, and/or LTE, and thus the transmitter may first wirelessly transmit (e.g. using a wireless communication technology such as BlueTooth, WLAN, ZigBee, tethering, etc.) the signal to the mobile phone, which in turn wirelessly transmits the signal to the monitoring station. Similarly, in the embodiments in which the device comprises a receiver, the receiver may also be configured to wirelessly receive a signal through the remote device.

[0036] In some other embodiments, the transmitter is configured to wirelessly transmit the first signal to the monitoring station through an ad hoc network. The ad hoc network may comprise a plurality of communication devices which transmit and receive data from other devices within the same network; the communication devices may relay data from device to device up to the monitoring station. Similarly, in the embodiments in which the device comprises a receiver, the receiver may also be configured to wirelessly receive a signal through the ad hoc network.

[0037] In some other embodiments, the transmitter is configured to wirelessly transmit the first signal to the monitoring station through a cellular network. In these cases, the transmitter comprises a modem configured to transmit data through a cellular network such as GSM, UMTS, and/or LTE. Similarly, in the embodiments in which the device comprises a receiver, the receiver may also be configured to wirelessly receive a signal through the cellular network.

[0038] In preferred embodiments of the invention, the processor is a microcontroller or is a part thereof (that is, the device comprises a microcontroller that comprises the processor). A microcontroller may be a cost-effective device for integrating the means for sensing of the device and the transmitter with a processor. Generally, a microcontroller has input/output ports for receiving and transmitting data, hence the microcontroller may communicate with the different means for sensing and the transmitter in an effective way.

[0039] In some embodiments of the invention, the determination further comprises:

counting a number (n_A) of times that the vibration exceeds a first determined vibration threshold (A_threshold) during a determined lapse of time (t_A); and

checking that the number (n_A) is greater than or equal to a second determined vibration threshold (CA_lower_threshold) and smaller than or equal to a third determined vibration threshold (CA_upper_threshold).

[0040] In some embodiments of the invention, the determination further comprises:

counting a number (n_S) of times that the sound exceeds a first determined sound threshold (S_threshold) during a determined lapse of time (t_N); and

checking that the number (n_N) is greater than or equal to a second determined sound threshold (CS_lower_threshold) and smaller than or equal to a third determined sound threshold (CS_upper_threshold).

[0041] In this sense, the processor is configured to count the numbers of times the vibration and/or the sound are exceeding the respective thresholds in respective lapses of time and to check whether they are within the ranges delimited by respective lower and upper thresholds.

[0042] Thus, when the number n_A, that is the number of times the vibration exceeds the threshold A_threshold (that is, that the amplitude or magnitude of the vibration is beyond the threshold) during the lapse of time t_A (for example an interval of one second), is within the range delimited by the thresholds CA_lower_threshold and CA_upper_threshold, it is determined that the portable gas detector is producing a vibration alarm. It may be convenient to set an upper threshold since that avoids false positives due to an excessive number of vibrations the device may undergo, for example, due to a machine or vehicle nearby that is producing some vibrations.

[0043] Similarly to the vibration alarm, the processor determines there is an active sound alarm when the number n_S, that is the number of times the sound exceeds the threshold S_threshold (that is, that the amplitude or magnitude of the sound is beyond the threshold) in the lapse of time t_S (for example an interval of three seconds), is within the range delimited by the thresholds

CS_lower_threshold and CS_upper_threshold. The upper threshold may avoid false positives due to a noisy environment.

[0044] Any of the lapses of time t_A and t_S may be regarded as a sequence of analog or digital values of vibration and sound that have been sensed during such lapses of times.

[0045] The parameters n_A, t_A, A_threshold, CA_lower_threshold, CA_upper_threshold, n_S, t_S, S_threshold, CS_lower_threshold, and CS_upper_threshold may be configured by an operator either directly on the device or by transmitting a signal comprising a reprogramming instruction for reprogramming the processor of the device.

[0046] Further, in some embodiments, the vibration and/or the sound to be processed for determining the existence of an active alarm are filtered so as to be characterized for the particular frequencies, patterns, amplitudes, etc. that may feature the vibration and/or sound alarms of each portable gas detector. That is, since each portable gas detector generally produces a different vibration and/or sound alarm, by filtering the sensed vibration and/or sound, the determination carried out by the processor may be more accurate and, thus, the number of false positives may be further reduced. In this sense, the filtering may be performed analogically with electronic circuitry that is adjusted for a particular portable gas detector.

[0047] A second aspect of the invention relates to a portable gas detector comprising: means for measuring gas concentration in an environment; means for producing an alarm in the form of vibration; and a device according to the first aspect of the invention, the device being attached to an attachment means of the portable gas detector.

[0048] In some embodiments, the portable gas detector further comprises means for producing an alarm in the form of sound.

[0049] Similar advantages to those described for the first aspect of the invention may also be applicable to the second aspect of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

[0050] To complete the description and in order to provide for a better understanding of the invention, a set of drawings is provided. Said drawings form an integral part of the description and illustrate embodiments of the invention, which should not be interpreted as restricting the scope of the invention, but just as an example of how the invention can be carried out. The drawings comprise the following figures:

Figures 1A-1B show a portable gas detector capable of producing an alarm.

Figure 2 shows a device for reporting an alarm in accordance with an embodiment of the invention.

Figures 3A-3B partially show the device of Figure 2.

Figure 4 schematically shows several components of the device in accordance with an embodiment of the invention.

Figure 5 shows a flow chart of the operation of the device in accordance with an embodiment of the invention.

Figure 6 shows a flow chart of the operation of the device in accordance with another embodiment of the invention.

Figures 7A-7B show a device in accordance with an embodiment of the invention attached to a portable gas detector.

DESCRIPTION OF A WAY OF CARRYING OUT THE INVENTION

[0051] Figure 1A shows a portable gas detector 100 when seen from the front, and Figure 1 B shows the same portable gas detector 100 when seen from the back. The portable gas detector 100 is provided with means (not illustrated) for sensing the concentration of gas. The portable gas detector 100 is also provided with means (not illustrated) for determining whether the sensed concentration of gas corresponds to a hazardous condition. The way in which the portable gas detector 100 performs the identification of a hazardous condition is not within the scope of the present invention.

[0052] The portable gas detector 100 may include a display 101 through which a user may know the amount of battery left, the concentration of gas detected, and/or other information. For instance, the user may use one or more buttons 102 of the portable gas detector 100 to switch on or off the portable gas detector 100, and the user may know whether the portable gas detector 100 is in fact switched on or off depending on what is indicated in the display 101. In other examples, the portable gas detector 100 may include visual indicators, such as LEDs, that may indicate similar information.

[0053] When the portable gas detector 100 determines that there is a hazardous condition, it produces an alarm in the form of vibration. In this sense, the portable gas detector 100 may include a vibration device (not illustrated) that makes the portable gas detector 100 vibrate, thus this vibration is not result of a pressure wave produced by a sound (e.g. an audible alarm); the vibration may in fact generate a pressure wave that inherently produces a sound, but the vibration is not produced from a sound. The user may notice the vibration and, thus, be alerted that a hazardous condition is underway.

[0054] The portable gas detector 100 may further include means for producing an audible alarm, for instance a speaker (not illustrated), which when there is a hazardous condition produces an alarm in the form of sound. The sound may be heard by the user in order to be warned. The audible alarm produces a pressure wave which may also be a vibration, but it is readily apparent that the vibration generally features an intensity that cannot be detected by the user.

[0055] With respect to Figure 1B, it can be observed that the portable gas detector 100 includes attachment means 110, for instance a clip or another mechanism that allows attaching the portable gas detector 100 to the clothing of the user carrying the portable gas detector 100. By way of example, the attachment means 110 may secure the portable gas detector 100 to a belt of the user so that the hands of the user remain free for any device which he or she may need to operate.

[0056] Figure 2 shows a device 200 in accordance with an embodiment of the invention. The device includes a mechanical framework 210 adapted to attach the device 200 to a portable gas detector. For example, with respect to the portable gas detector 100 of Figures 1A-1B, the mechanical framework 210 of the device 200 is adapted to attach to the attachment means 110 of the portable gas detector 100 so as to secure the device 200 to the portable gas detector 100.

[0057] The device 200 further includes a unit 220. The unit 220, which is also illustrated in Figure 3B, houses several components that make the device 200 operable; these components are described below with respect to Figure 4. The unit 220 is attached to the mechanical framework 210 with screws 215 (only one is shown, and it is illustrated with phantom lines because it is not visible from the perspective of Figure 2).

[0058] Figure 3A shows the mechanical framework 210 also illustrated in Figure 2. The mechanical framework 210 features an opening 211 that may adjust to the attachment means of a portable gas detector. The opening 211 may be modified by bending or removing some flaps 212 and, therefore, adapt the device 200 to be attachable to different portable gas detectors, the attachment means of which may differ from model to model. A region 213 is provided in the mechanical framework 210 for hosting the unit 220. The mechanical framework 210 is provided with holes 214 for receiving screws 215 that attach the unit 220 to the mechanical framework 210.

[0059] The mechanical framework 210 may be made up of, for example, a metallic material, such as aluminum, or a plastic material.

[0060] Figure 4 shows in a block diagram several components included in a unit 400 of a device in accordance with an embodiment of the invention. The unit 400 comprises one or more batteries 401 for powering the electronics and the components within the unit 400. It further comprises means 421 for sensing vibration, means 422 for sensing sound, means 423 for sensing a movement of the device (e.g. an accelerometer), a microcontroller 410, a transmitter 440, a receiver 441, and a visual indicator 430 (e.g. one or more LEDs). The microcontroller 410 comprises a processor 411.

[0061] Each of the means 421 for sensing vibration (e.g. an accelerometer) and the means 422 for sensing sound (e.g. a microphone) transmits its sensed magnitudes to the processor 411, except when one or both of the means 421, 422 are in a sleep mode so as to drain less energy from the battery 401.

[0062] The processor 411 determines whether the portable gas detector is producing an alarm by processing the vibrations and sounds as sensed by the means 421, 422.

[0063] Preferably, the processor 411 first determines whether a vibration alarm is active, that is, it first processes the sensed vibrations to determine whether the portable gas detector is producing an alarm in the form of vibration. If the processing results in positively determining that a vibration alarm is under way, the processor 411 determines whether the portable gas detector is producing a sound alarm by processing the sensed sounds. If this determination is also positive, that is, if it is determined that there is an active sound alarm, the processor 411 generates an alarm signal that is to be transmitted by the transmitter 440 to a remote monitoring station. In contrast, if the processor 411 determines that there is no vibration alarm currently active, and that this has been the case for several iterations in a row, the processor 411 may switch the means 422 for sensing sound to a dormant mode so as to save energy; when the determination is positive, namely, a vibration alarm is considered to be active, the processor 411 switches the means 422 for sensing sound to an active mode (if the means 422 for sensing sound were in a dormant mode) again for determining whether there is an active sound alarm as well.

[0064] By means of the receiver 441 the device may be reprogrammed. Particularly, the device may receive signals comprising instructions for reprogramming the processor 411, for instance variables such as vibration and/or sound thresholds that shall be exceeded by the sensed vibrations and/or sounds so as to determine that there is an active alarm, number of iterations in which it is determined that the device has not moved so as to enter into a sleep mode, etc.

[0065] Despite the transmitter 440 and the receiver 441 are identified as separate devices, they may as well be integrated as a transceiver.

[0066] The visual indicator 430 may indicate that the device is switched on, that there is a hazardous condition, the status of the battery, etc. The processor 411 may adjust the visual indicator 430 based on the data it processes.

[0067] The microcontroller 410 may be provided with input/output ports for transmitting and receiving electrical signals to/from the different components within the unit 400.

[0068] In another embodiment (not illustrated), a unit of the device does not include means for sensing sound; the processor then determines whether an alarm is active by processing the vibration sensed by the means for sensing vibration.

[0069] Figure 5 shows a flow chart that illustrates the operation of a device in accordance with an embodiment of the invention.

[0070] Once the device is switched on, that is, when it is started 500, it is checked 501 whether the device is still (i.e. not moving). The movement is sensed by the means for sensing a movement of the device. If the processor determines that the device is still, depending on the duration for which it has been still (duration in time or in number of iterations of such determination being made by the processor), the device may enter into a sleep mode 502. The sleep mode 502 is instructed by the processor to one or both means 421, 422 to save energy. It is readily apparent that for determining that there has been no movement it must be taken into account that the signal corresponding to the sensed movement may have noise therein, therefore it may look like that there is some motion when in fact there is not.

[0071] When the device is in a sleep mode 502 (that is, the means for sensing are in a sleep mode), and after sensing 503 the movement it is determined that there is no motion, the device remains in the sleep mode 502, whereas if there is motion, the device is switched to an active mode (that is, the means for sensing are in an active mode) and senses 504 the vibration (with the means for sensing vibration). The processor determines 505 whether there is an alarm based upon the sensed vibration: when no alarm is detected, the device may idle 510 for some time (for example, 5 seconds, 9 seconds, 20 seconds, etc.) until it starts the operation from the beginning; and when the alarm is positively detected, the device senses 506 the sound and processes it so as to determine 507 whether there is also a sound alarm. If the processor determines that there is no sound alarm, the device idles 510 before starting the whole operation again, whereas if a sound alarm is identified, an alarm signal is generated and transmitted 508 to a monitoring station so as to report the existence of an alarm being produced by the portable gas detector. After the alarm is transmitted 508, the device idles 510 for some time before starting the whole operation again.

[0072] When the device is in an active mode, it may, for instance and without limitation, sense vibrations during one second, determine if there is a vibration alarm, sense sounds during three seconds, determine if there is a sound alarm, transmit an alarm to a remote monitoring station if the processor has determined that both the vibration alarm and the sound alarm are active, and then idle for nine seconds before starting again.

[0073] Figure 6 shows the operation of a device in accordance with another embodiment of the invention.

[0074] The operation, which is illustrated with a flow chart, is similar to the operation illustrated in Figure 5. The only difference with the operation of the embodiment of Figure 5 is that, for determining whether there is an active alarm, sound is first measured 506 and processed for determining 507 if there is an audible alarm. If there is, the device then measures 504 and processes vibration so as to determine 505 whether there is a vibration alarm also present. If it is determined 505 that there is a vibration alarm as well, the device may transmit 508 an alarm to a remote monitoring station.

[0075] Figures 7A-7B show an apparatus 700 comprising the portable gas detector 100 having the device 200 attached to it. Figure 7A shows the apparatus 700 when seen from the front, whereas Figure 7B shows the same when seen from the back.

[0076] In this exemplary embodiment, the unit 220 of the device 200 is on the upper part of the portable gas detector 100, but it is clear that it could be positioned anywhere else relative to the portable gas detector 100. In some cases, the means for sounding an audible alarm of the portable gas detector 100 are located on the upper part, thus the sound sensing of the device 200 may be more accurate than if the unit 220 is located on the bottom of the portable gas detector 100.

[0077] The unit 220 may be in direct physical contact with the portable gas detector 100 or there may be some space between the two, preferably not more than 5cm (centimeters), and more preferably less than 3cm, 1 cm, 5mm (millimeters), 3mm, or 1 mm, for a more accurate sound sensing of possible audible alarms. Since the unit 220 is attached to the mechanical framework 210 of the device 200, and the mechanical framework 210 is in direct physical contact with the portable gas detector 100, the unit 220 senses the vibrations through the mechanical framework 210 (i.e. the means for sensing vibration sense the vibrations through the mechanical framework 210).

[0078] When the device 200 is attached to the portable gas detector 100 by means of the mechanical framework 210, the attachment means 110 of the portable gas detector 100 are not obstructed thus the attachment means 110 may still be used for attaching the portable gas detector 100 to the clothing of a user, for example the belt. In any case, it is clear that the mechanical framework 210 of the device 200 may also be provided with means for attaching to the clothing of the user so that, in the event that the attachment means 110 break or are obstructed for some reason, the apparatus 700 may be carried by the user.

[0079] It is readily apparent that the mechanical framework 210 may feature different geometries that may be adapted to attach the device 200 to the portable gas detector 100. These geometries are generally conditioned by one or both of the attachment means 110 of the portable gas detector 100 and the housing of the portable gas detector 100 itself. In some cases, the mechanical framework 210 may be provided with flaps, slots, and/or other mechanical elements that ease mechanically attaching the device 200 to the portable gas detector 100; in some examples, these flaps, slots, and/or mechanical elements may be bended, removed, and/or reassembled such that a same mechanical framework 210 is operable with portable gas detectors 100 featuring different housings and attachment means 110.

[0080] In this text, the term "comprises" and its derivations (such as "comprising", etc.) should not be understood in an excluding sense, that is, these terms should not be interpreted as excluding the possibility that what is described and defined may include further elements, steps, etc.

[0081] The invention is obviously not limited to the specific embodiment(s) described herein, but also encompasses any variations that may be considered by any person skilled in the art (for example, as regards the choice of materials, dimensions, components, configuration, etc.), within the general scope of the invention as defined in the claims.

Claims

1. A device (200) for reporting an alarm produced by a portable gas detector (100) to a monitoring station, the device (200) comprising:

   a mechanical framework (210) adapted to attach the device (200) to the portable gas detector (100);
   means (421) for sensing vibration;
   a processor (411) configured to determine whether the alarm is produced, wherein a determination comprises processing a vibration; and
   a transmitter (440) configured to wirelessly transmit a first signal to the monitoring station, the first signal being indicative of the alarm being produced.

2. The device (200) of claim 1, wherein the means (421) for sensing vibration comprise an accelerometer.

3. The device (200) of any of claims 1-2, further comprising a receiver (441) configured to wirelessly receive a second signal comprising a reprogramming instruction; and wherein the processor (411) is further configured to reprogram itself with the reprogramming instruction.

4. The device (200) of any of claims 1-3, wherein the transmitter (440) is configured to wirelessly transmit the first signal to the monitoring station through a remote device, the remote device comprising means for transmitting electromagnetic signals through a cellular network.

5. The device (200) of any of claims 1-4, further comprising means (422) for sensing sound, the means (422) for sensing sound comprising a microphone; and wherein the determination further comprises processing a sound.

6. The device (200) of claim 5, wherein the processor (411) is configured to process the vibration prior to processing the sound.

7. The device (200) of claim 5, wherein the processor (411) is configured to process the sound prior to processing the vibration.

8. The device (200) of any of claims 5-7, further comprising an accelerometer for sensing a movement of the device (200); and wherein the processor (411) is further configured to switch the means (421) for sensing vibration and the means (422) for sensing sound between an active mode and a sleep mode based on the movement.

9. The device (200) of any of claims 1-4, further comprising an accelerometer for sensing a movement of the device (200); and wherein the processor (411) is further configured to switch the means (421) for sensing vibration between an active mode and a sleep mode based on the movement.

10. The device (200) of any of claims 5-8, wherein the determination further comprises:

    counting a number S of times that the sound exceeds a first determined sound threshold during a determined lapse of time t_S; and
    checking that the number S is greater than or equal to a second determined sound threshold and smaller than or equal to a third determined sound threshold.

11. The device (200) of any of claims 1-10, wherein the determination further comprises:

    counting a number A of times that the vibration exceeds a first determined vibration threshold during a determined lapse of time t_A; and
    checking that the number A is greater than or equal to a second determined vibration threshold and smaller than or equal to a third determined vibration threshold.

12. The device (200) of any of claims 1-11, further comprising a microcontroller (410), the microcontroller (410) comprising the processor (411).

13. The device (200) of any of claims 1-12, wherein the vibration is not a pressure wave of an audible alarm.

14. A portable gas detector (100) comprising:

    means for measuring gas concentration in an environment;
    means for producing an alarm in the form of vibration; and
    a device (200) of any of claims 1-13 attached to the portable gas detector (100).

15. The portable gas detector (100) of claim 14, further comprising means for producing an alarm in the form of sound.

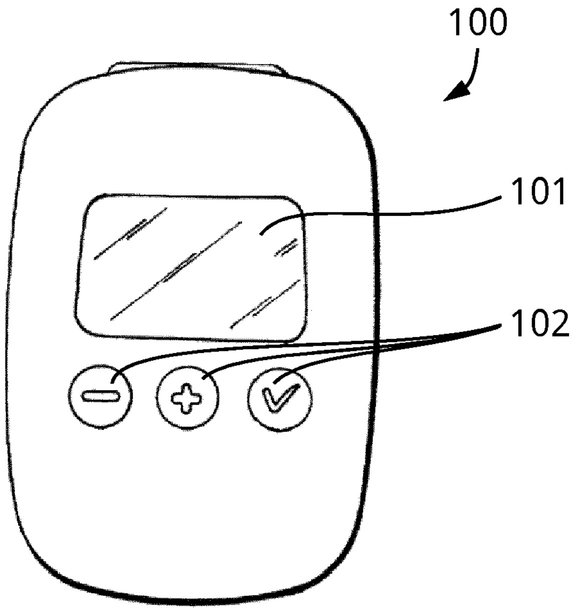

FIG. 1A

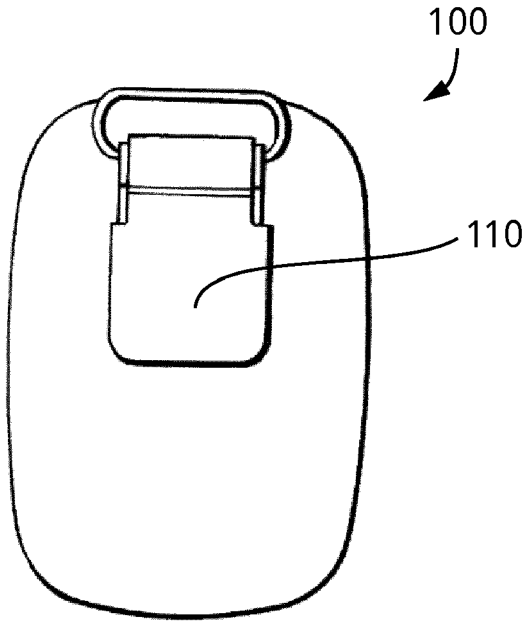

FIG. 1B

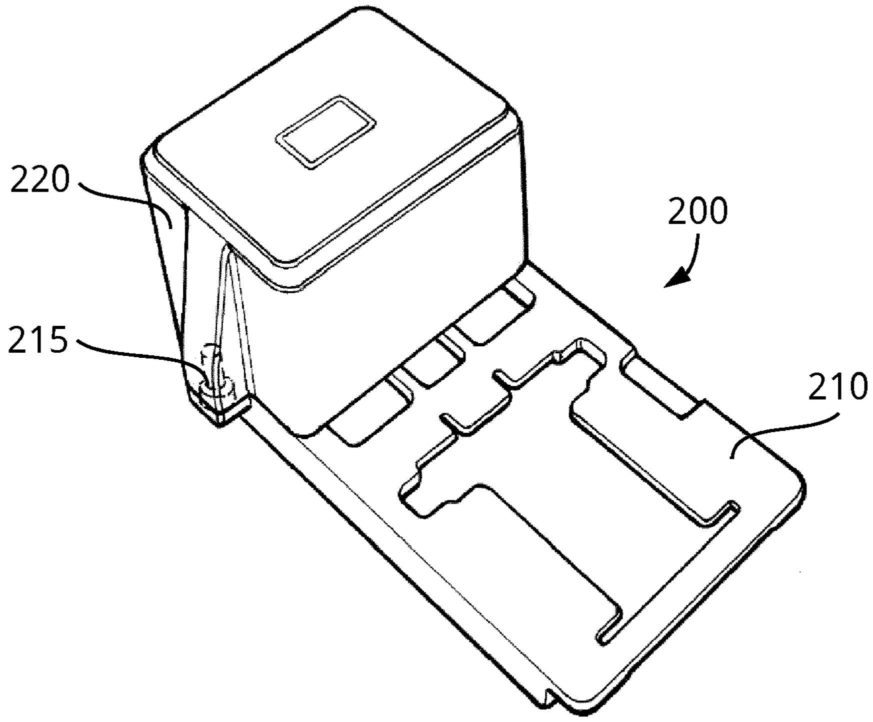

FIG. 2

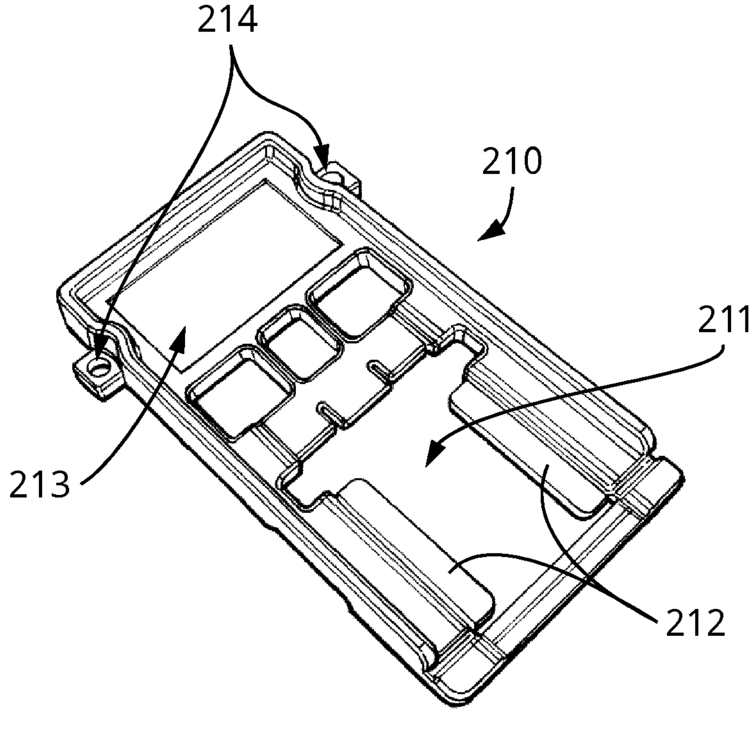

FIG. 3A

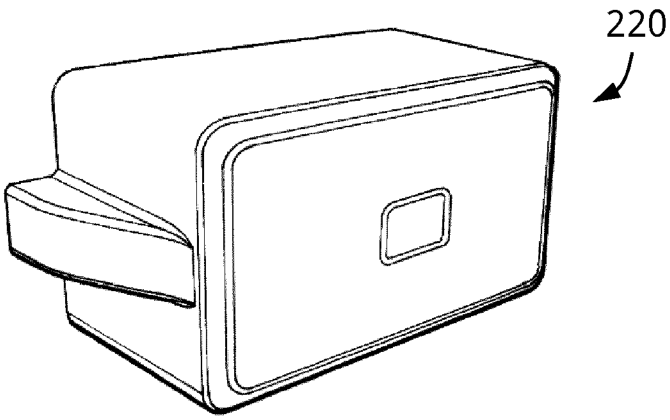
220

FIG. 3B

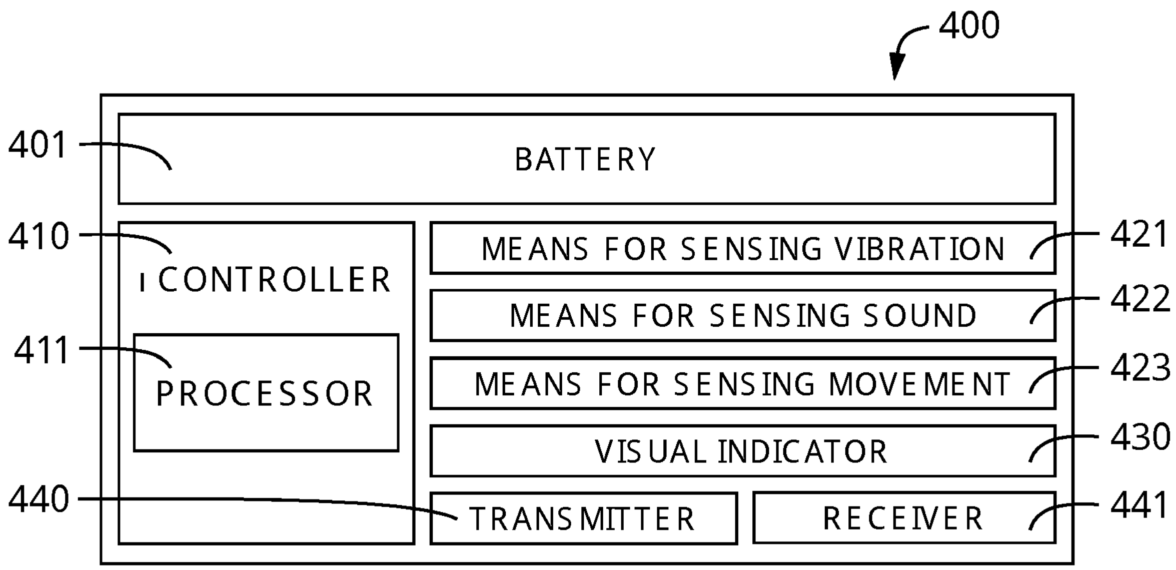
400
401
BATTERY
410
CONTROLLER
411
PROCESSOR
MEANS FOR SENSING VIBRATION
421
MEANS FOR SENSING SOUND
422
MEANS FOR SENSING MOVEMENT
423
VISUAL INDICATOR
430
440
TRANSMITTER
RECEIVER
441

FIG. 4

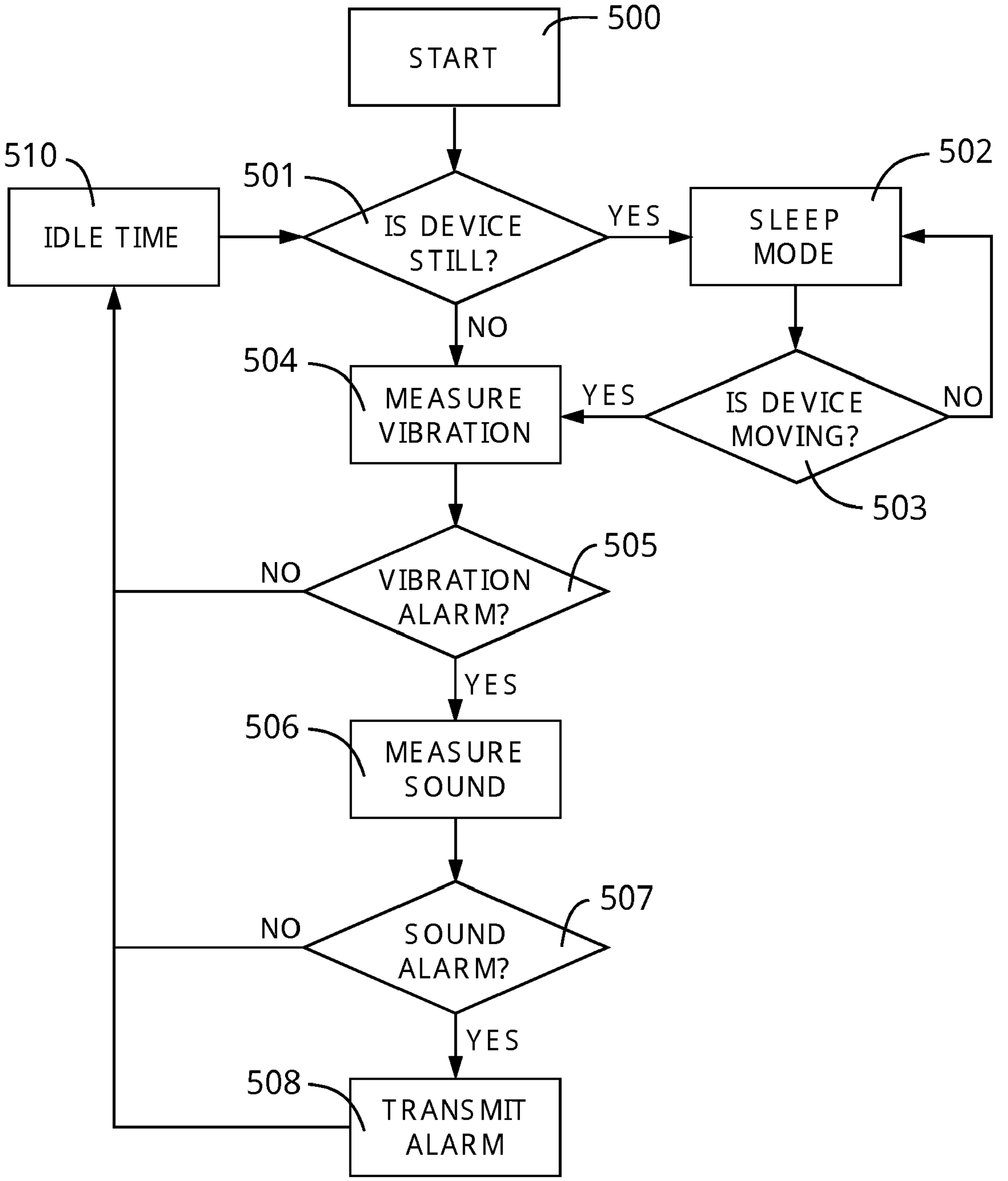
START
500
510
IDLE TIME
501
IS DEVICE STILL?
YES
502
SLEEP MODE
NO
504
MEASURE VIBRATION
YES
IS DEVICE MOVING?
NO
503
NO
VIBRATION ALARM?
505
YES
506
MEASURE SOUND
NO
SOUND ALARM?
507
YES
508
TRANSMIT ALARM

FIG. 5

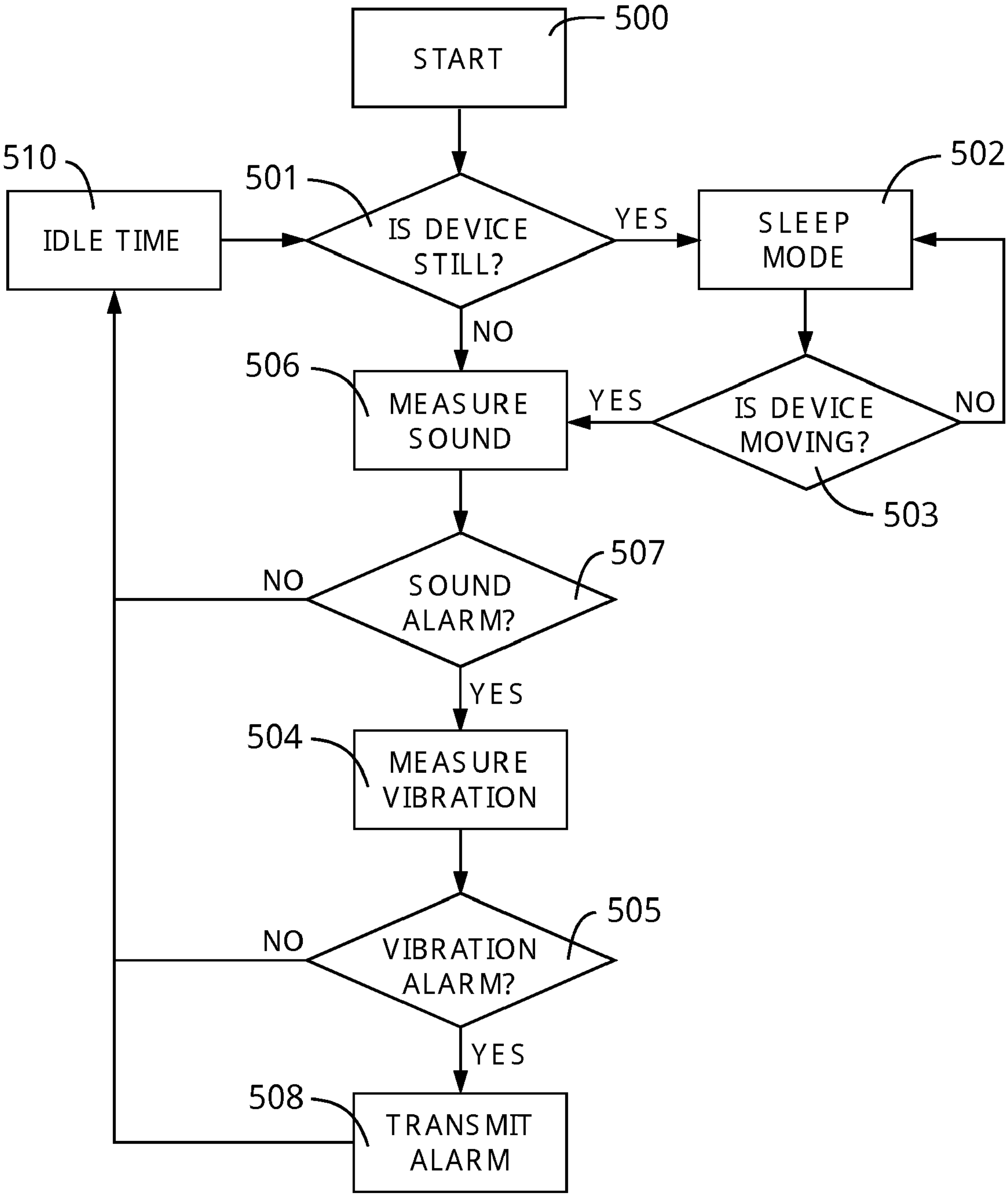
START
500
510
IDLE TIME
501
IS DEVICE STILL?
YES
SLEEP MODE
502
NO
506
MEASURE SOUND
YES
IS DEVICE MOVING?
NO
503
NO
SOUND ALARM?
507
YES
504
MEASURE VIBRATION
NO
VIBRATION ALARM?
505
YES
508
TRANSMIT ALARM

FIG. 6

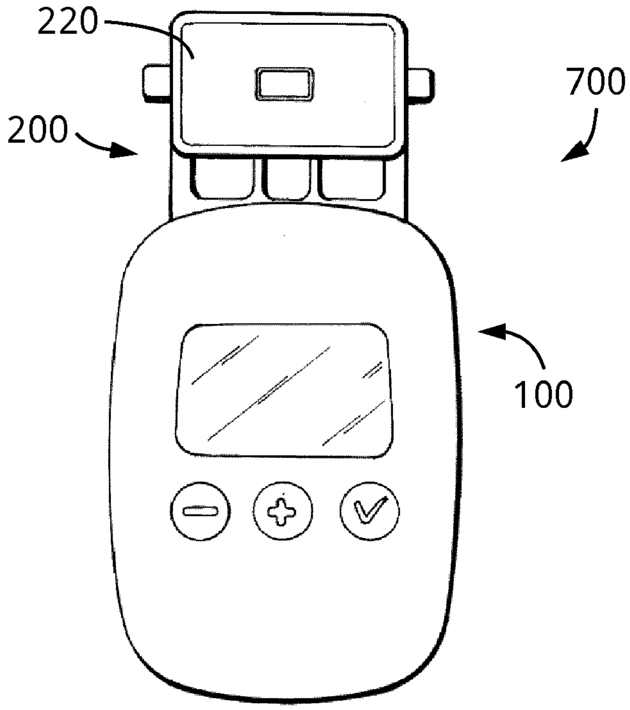

FIG. 7A

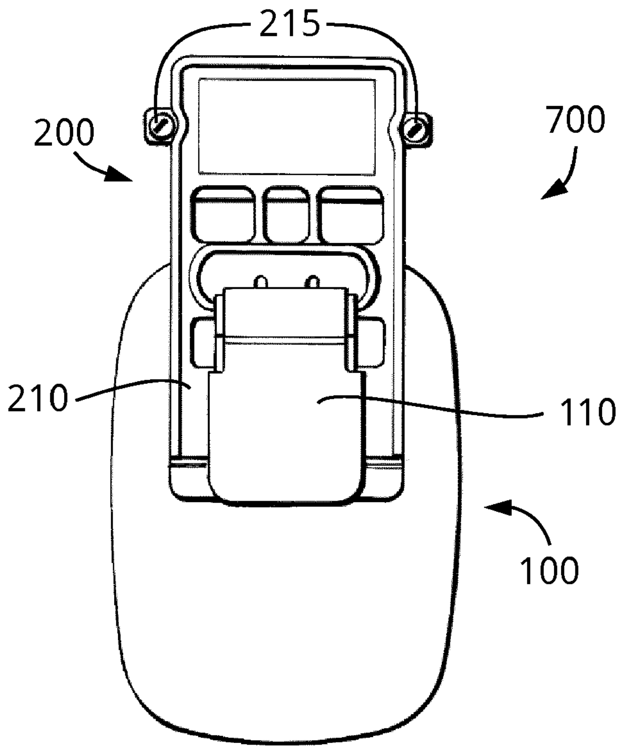

FIG. 7B

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EUROPEAN SEARCH REPORT

Application Number
EP 17 38 2017

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y A	WO 2004/032078 A2 (COMBUSTION SCI & ENG INC [US]) 15 April 2004 (2004-04-15) * figure 8 * * claims 1,11,12 *	1,5-7, 10-13 2,4,14, 15 3,8,9	INV. G08B1/08 G08B21/14
Y	JP H08 315277 A (NIPPON DENKI IDO TSUSHIN KK) 29 November 1996 (1996-11-29) * abstract * * paragraph [0015] *	2	
Y	KR 2010 0132698 A (ITHEALTH CO LTD [KR]) 20 December 2010 (2010-12-20) * abstract * * paragraph [0033] *	14,15	
Y	US 2004/145465 A1 (STULTS LARRY W [US] ET AL) 29 July 2004 (2004-07-29) * abstract * * paragraph [0026] *	4	

TECHNICAL FIELDS SEARCHED (IPC)

G08B

The present search report has been drawn up for all claims

2

Place of search	Date of completion of the search	Examiner
Munich	20 July 2017	Coffa, Andrew

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20-07-2017

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 2004032078 A2	15-04-2004	AT 369598 T	15-08-2007
		AU 2003282904 A1	23-04-2004
		BR 0315050 A	16-08-2005
		CA 2501140 A1	15-04-2004
		DE 60315482 T2	30-04-2008
		DK 1547041 T3	10-12-2007
		EP 1547041 A2	29-06-2005
		ES 2291707 T3	01-03-2008
		HK 1080593 A1	30-01-2007
		IL 167827 A	20-07-2009
		JP 4279255 B2	17-06-2009
		JP 2006502483 A	19-01-2006
		MX PA05003527 A	22-07-2005
		NO 331226 B1	07-11-2011
		NZ 539363 A	28-04-2006
		US 2004145467 A1	29-07-2004
		WO 2004032078 A2	15-04-2004
		ZA 200503069 B	29-11-2006
JP H08315277 A	29-11-1996	NONE	
KR 20100132698 A	20-12-2010	NONE	
US 2004145465 A1	29-07-2004	AT 381084 T	15-12-2007
		CA 2511519 A1	12-08-2004
		CN 1739123 A	22-02-2006
		DE 602004010615 T2	11-12-2008
		EP 1584078 A2	12-10-2005
		US 2004145465 A1	29-07-2004
		US 2007052537 A1	08-03-2007
		WO 2004068429 A2	12-08-2004

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- WO 2014098993 A1 **[0007]**
- US 20100127865 A1 **[0008]**
- WO 2016160799 A1 **[0010]**