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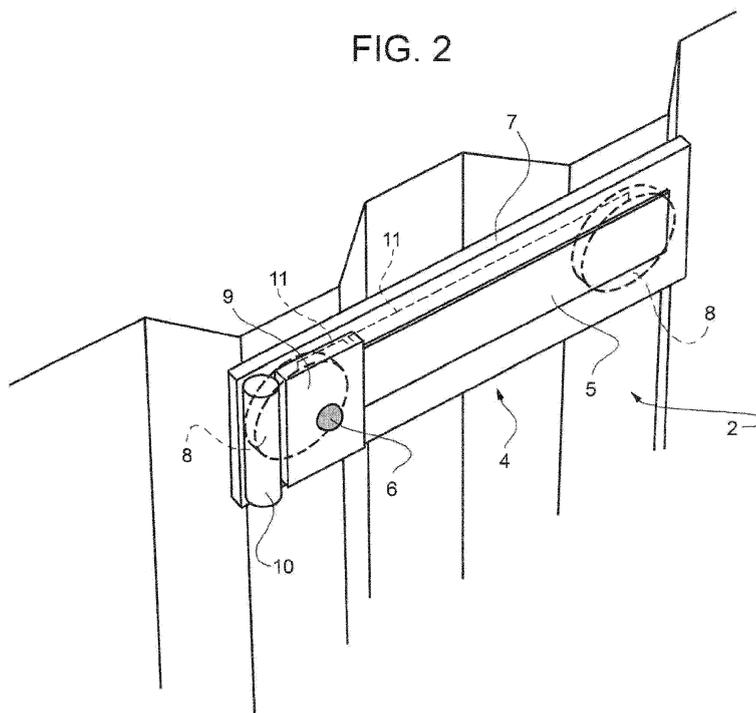
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(54) **A container anti-intrusion sensor device**

(57) A container anti-intrusion sensor device (4), the anti-intrusion sensor device (4) being equipped with a support element (7), fastening means (8) for fastening the support element (7) to a wall (2) of a container (1) in a removable manner, vibration sensor means (5) and light radiation sensor means (6) mounted on the support element (7), an electronic unit (9), which is mounted on

the support element (7) and is electrically connected to said sensor means (5, 6) to receive and process electrical signals from the sensor means (5, 6) for determining the occurrence of a break-in on the container (1) and consequently generating an alarm, and power supply means (10, 5) for the electronic unit (9) mounted on the support element (7).

FIG. 2



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DescriptionTECHNICAL FIELD OF THE INVENTION

[0001] The present invention relates to a container anti-intrusion sensor device.

STATE OF THE ART

[0002] As is known, one of the main problems that container freight companies must face is that of guaranteeing the integrity of the freight, especially when containers are stacked in transit areas, waiting to be loaded onto the means of transport, and are particularly subject to vandalism and/or theft.

[0003] This problem is usually resolved by equipping the containers with key and/or combination-based door-locking devices, preferably equipped with electronic devices able to send an alarm signal, for example, via radio or the telephone network, to an external control unit in the event of the locking device being forced or broken.

[0004] Although effective, this solution nevertheless suffers from the drawback of not permitting the overall integrity of the container to be monitored, as it does not allow the detection, for example, of intrusion or tampering actions made on the sides of the container away from the doors.

[0005] In an attempt to overcome this drawback, the use of monitoring systems based on various types of sensors has been proposed, for example, temperature, humidity, luminosity, acceleration, proximity and smoke sensors, which are preferably installed in combination with each other inside the container to guarantee good reliability, by redundancy, in detecting break-ins or tampering at any point of the container. A monitoring system of this type is described, for example, in US 2006/0181413.

[0006] However, in practice, the above-described solution encounters significant limits, consisting mainly in high costs due to the number of devices to be used, the quantity of data to monitor and the tuning of the algorithms for calculating the alarm thresholds. Furthermore, the application of sensors inside the container normally entails relatively high installation costs that effectively limit the use of these sensors to just new containers and not containers already in circulation.

DESCRIPTION OF THE INVENTION

[0007] The object of the present invention is that of making a container anti-intrusion sensor device, this device being able to eliminate the above-described drawbacks in an efficient and economic manner.

[0008] According to the present invention, a container anti-intrusion sensor device is made according to the attached claims.

BRIEF DESCRIPTION OF DRAWINGS

[0009] The invention shall now be described with reference to the attached drawings, which illustrate some non-limitative embodiments, where:

- Figure 1 shows a container equipped with a plurality of sensor devices of the present invention;
- Figure 2 shows a preferred embodiment of the sensor device of the present invention;
- Figure 3 shows, in side elevation, a variant of the sensor device in Figure 2; and
- Figure 4 is a diagram representing the response of the sensor device in Figure 2 to a vibrational stimulus.

PREFERRED EMBODIMENTS OF THE INVENTION

[0010] In Figure 1, a container of known type is indicated, as a whole, by reference numeral 1 and is defined by a box-shaped body delimited laterally by a wall 2 of corrugated sheet metal and closed by a door 3.

[0011] The container 1 is equipped with a plurality of anti-intrusion sensor devices 4, each one of which is fastened to the inner surface of the wall 2 and, in use, has the function of detecting an attempted break-in through the detection of stress induced on the wall 2 by cutting or perforating tools such as drills, cutters or grinders, and/or light radiation filtering inside the container 1 due to the presence of an opening in the wall 2 or the use of cutting tools such as oxyacetylene flame, blowlamp or grinder.

[0012] As shown in Figure 2, each anti-intrusion sensor device 4 comprises two types of sensor for this purpose: a vibration sensor, in this case a plate 5 of a piezoelectric material, and a light radiation sensor, in this case a photodiode 6.

[0013] The plate 5 and the photodiode 6 are mounted on a support bar 7 suitable for being fastened to the wall 2 in a removable manner by two permanent magnets 8, which are rigidly connected to the bar 7 on the opposite side from the plate 5 and are preferably spaced apart along the bar 7 at a distance equal to the pitch of the corrugations in the wall 2, such that when positioning the bar 7 in a transversal direction to the corrugations, the magnets 8 find themselves in correspondence to the flat peaks of the corrugations and, in consequence, form a stable fastening of the bar 7 to the wall 2.

[0014] Obviously, the use of the piezoelectric plate 5 as a vibration sensor and the photodiode 6 as a light radiation sensor is only of exemplifying significance and other sensors of different shape and/or type could be advantageously used for detecting vibrations and light radiation. For example, an optical fibre could be used in place of the photodiode 6.

[0015] The bar 7 also supports an electronic unit 9, which is electrically connected to the plate 5 and to the photodiode 6 and is powered by a battery 10 that is also

placed on the bar 7.

[0016] The electronic unit 9 is capable of managing, in a manner that shall be described in detail further on, the system's power supply, the storing and processing of data received from the respective plate 5 and the respective photodiode 6, and transmitting, via radio or GSM for example, possible hazard or alarm signals to a control unit (not shown), which could be mounted on the container 1 or be remotely located and positioned, for example, on the means of transport or in a control centre.

[0017] In the case where it is local, namely positioned on the container 1, the control unit (not shown) is preferably mounted on the door 3 and includes a door opening detector. Instead, in the case where the control unit (not shown) is remote, the container 1 is preferably equipped with a door opening detector (not shown) in communication with the control unit.

[0018] The "dialogues" between the electronic unit 9 and the control unit (not shown) are preferably one-way, except for alarm reception verification messages, so as not to permit external devices to access or change the settings of the electronic unit 9 itself.

[0019] In addition, the electronic unit 9 is preferably configured to respond to an identification request ('ping') periodically sent by the control unit. Each identification request is stored by the electronic unit 9 in a non-volatile memory, preferably EEPROM, in which all warning signals and alarms sent to the electronic unit 9 by the respective vibration and light radiation sensors are also stored. The memory can only be cleared at the end of the mission by means of a direct connection to a computer or interrogation device.

[0020] The number and position of the anti-intrusion sensor devices 4 in the container 1 are arbitrary and are chosen, each time, so as to create the most uniform "cover" possible inside the container 1. For example, it is necessary to take into account the amount of cargo and its arrangement in the container 1, as an excessive amount or its positioning against one side of the wall 2 might prevent possible light radiation from filtering inside the container 1 and/or change the mechanical impedance of the side itself, impeding or modifying the propagation of vibrations caused, for example, by a cut or hole made in the sheet metal.

[0021] In the example shown in Figure 1, the container 1 is equipped with four anti-intrusion sensor devices 4 (of which only three are visible) placed at the four upper vertices of the container 1; in this configuration, each anti-intrusion sensor device 4 is delegated to monitoring the two sides of the wall 2 adjacent to it, with the result that the group of anti-intrusion sensor devices 4 is sufficient to monitor all of the inside of the container 1.

[0022] In particular, it should be underlined that the lens of the photodiode 6 of each anti-intrusion sensor device 4 can be chosen so as to have a more or less broad "field of vision". Preferably, each lens is designed to have a sufficiently broad "field of vision" to cover two or three sides of the wall 2 adjacent to the respective

anti-intrusion sensor device 4; in fact, a photodiode 6 with a very large "field of vision", able to cover all of the wall 2 for example, although being utilizable, would render the contribution of a point event less significant and, in any case, would not be able to monitor sides facing the respective anti-intrusion sensor device 4 due to the cargo's presence.

[0023] From the energy standpoint, the electronic unit 9 is able to guarantee operation of the respective anti-intrusion sensor device 4 for a certain period of time, preferably exceeding three months. Self-power is guaranteed by the presence of the battery 10 and an energy management system that provides for:

- the use of "energy collection" techniques by means of a power generation unit based on external stimuli; and
- the use of "sleep" techniques for keeping the anti-intrusion sensor device 4 in a minimum energy consumption state.

[0024] With regard to "energy collection", the above-mentioned power generation unit is preferably a piezoelectric element, which, in virtue of the characteristic of piezoelectric materials of generating current proportional to the level of deformation they are subjected to, enable any vibrations not indicative of a break-in in course to be exploited for recharging the battery 10. This function of recharging the battery 10 can be performed, in addition or in alternative to the above-mentioned piezoelectric element, by the vibration sensor when this is of the piezoelectric type, as in the case of the plate 5 in the example shown.

[0025] With regard to the utilization of "sleep" techniques, the anti-intrusion sensor device 4 is provided with a low-consumption clock for this purpose, which is programmed to return the circuit to an "awake" state to carry out periodic analysis of the situation.

[0026] Under normal conditions, return to the "awake" state takes place when the minimum alarm threshold is exceeded by the energy supplied by the power-generator units, for example a piezoelectric element for detecting vibrations and a photodiode for detecting light radiation.

[0027] Preferably, the power-generator units delegated to providing "wake-up" energy are defined by the vibration sensor, at least when this is of the piezoelectric type as in the case of the plate 5, and by the light radiation sensor, at least when this is an optoelectronic element as in the case of the photodiode 6.

[0028] In particular, the alarm management is able to provide a warning when a minimum initial energy threshold is exceeded so as to cause return to the "awake" state and, in any case, corresponding to a minimum energy stimulation indicative of a security risk, for example, a prolonged low-energy stimulus such as that of a hole made by a small drill bit.

[0029] Following return to the "awake" state, the system activated itself and starts to make a comparison with

a stored digital signature of intrusive event types and a simultaneous analysis of the event's energy threshold. Exceeding the threshold, by the signal generated by the piezoelectric element for example, indicates the presence of a vibration event of a known minimum entity able to include all types of mechanical opening of the container; however, such an event need not necessarily correspond to a break-in, but perhaps to a meteorological event such as rain or hailstones or some other event. For this reason, after the system is activated from a sleep state, a comparison may be made between the signal and a "digital signature" stored in the device. This signature can have different forms, for example, a spectrum of vibration frequencies, and enable the device to differentiate a cut containing high-frequency components from rain, which mainly has low-frequency components.

[0030] Analysis of the energy threshold can be carried out on certain frequency bands indicating, for example, that the presence of high energy at high frequencies indicates the use of mechanical tools such as drills and so on.

[0031] Both indicators, namely the threshold and the signature, can generate an alarm using a logical 'OR' operation, which is indicated for detecting cuts made using specific tools that generate a reduced energy level but identifiable in form and type. For vibration, an alarm will be generated from a logical operation of the type <"awake" AND ("energy threshold" OR "comparison with stored sample")>; while for light, a logic operation of the type ("awake" AND "energy threshold") will be implemented or, in cases where broad spectrum sensors are used, spectral analysis of the radiation can be performed and the radiation be identified and classified as:

- solar radiation: a 'WARNING' signal is generated, not indicative of a break-in if acquired on its own; situation to be verified with the door opening detector (not shown) placed on the door 3;
- artificial white radiation (artificial lights, torches, etc): a 'WARNING' signal is generated, not indicative of a break-in if acquired on its own; situation to be verified with the door opening detector (not shown) placed on the door 3;
- infrared radiation (living beings, anomalous heating or fire): a 'WARNING' signal is generated;
- red-hot metal emission spectrum: a 'BREAK-IN ALARM' signal is generated;
- sparks: a 'BREAK-N ALARM' signal is generated.

[0032] The identification of a certain type of radiation is provided as a further descriptive item of data of the alarm or generates a 'WARNING' level if the situation indicates an anomaly, but not a full alarm. An alarm is generated in cases classified as 'BREAK-N ALARM'.

[0033] Instead, the temporal analysis of the type of the light signal can allow sparks, due to the use of drills or grinder or similar tools, to be identified.

[0034] The electronic unit 9 is also able to control the

state of the respective anti-intrusion sensor device 4 and to generate a specific alarm in cases of tampering or situations of malfunction in general.

[0035] To this end, as shown in Figure 2, the electronic unit 9 is provided with two electrical contacts 11, which are connected to the magnets 8 and enable the electronic unit 9 to take a reading of the system's electrical characteristics and, in particular, to detect the detachment of the magnets 8 from the metal wall 2 of the container 1. In fact, by means of the electrical contacts 11, the container 1 becomes part of the electrical circuit of the electronic unit 9 and the possible opening of this circuit would cause an energy signal sufficient to trigger return to the "awake" state and a subsequent alarm. If necessary, the electronic unit 9 can perform thorough analysis following this "wake-up" to confirm the detachment, for example, via the generation-acquisition-testing of a known signal through the circuit defined by the contacts-magnets-wall.

[0036] As shown in Figure 3, another solution for testing the continuity of the anti-intrusion sensor device 4 with the wall 2 is obtained by using a bar 7 of ferroelectric material and placing a winding 12 between the two magnets 8 that is electrically connected to the electronic unit 9. The magnetic circuit that is generated in this way between the bar 7, the magnets 8 and the wall 2 is operationally insensitive to the possible presence of paint on the wall 2 itself. The application of a voltage step to the winding 12 generates a current transient easily measurable from the characteristic time of the magnetic circuit and proportional to the impedance of the magnetic circuit itself. Any detachment of the anti-intrusion sensor device 4 from the wall 2 would cause a significant variation in the impedance of the magnetic circuit and would therefore be immediately detectable via the generation-acquisition-testing of an electrical signal through the winding 12.

[0037] The functioning of the anti-intrusion sensor device 4 shall now be described with reference to Figure 4, which graphically illustrates the response of the anti-intrusion sensor device 4 in the case of a vibration event.

[0038] In particular, it is possible to identify three zones in the graph in Figure 4:

- Zone A: zone beneath the "awake" threshold; the circuit can use the energy of the signals to power the system, and neither alarms nor warnings are generated.
- Zone B: zone above the "awake" threshold; the circuit starts more thorough analysis. The signal is rectified and, on one hand, integrated by means of a filter (HW or SW) corresponding to a mobile average proportional to the energy released by the vibration, while on the other, a clean copy of the signal is analyzed and a comparison made with stored data for the signal (via space-time trace or frequency spectrums). An alarm is generated if the comparison is positive.
- Zone C: zone above the "ALARM" threshold; the rec-

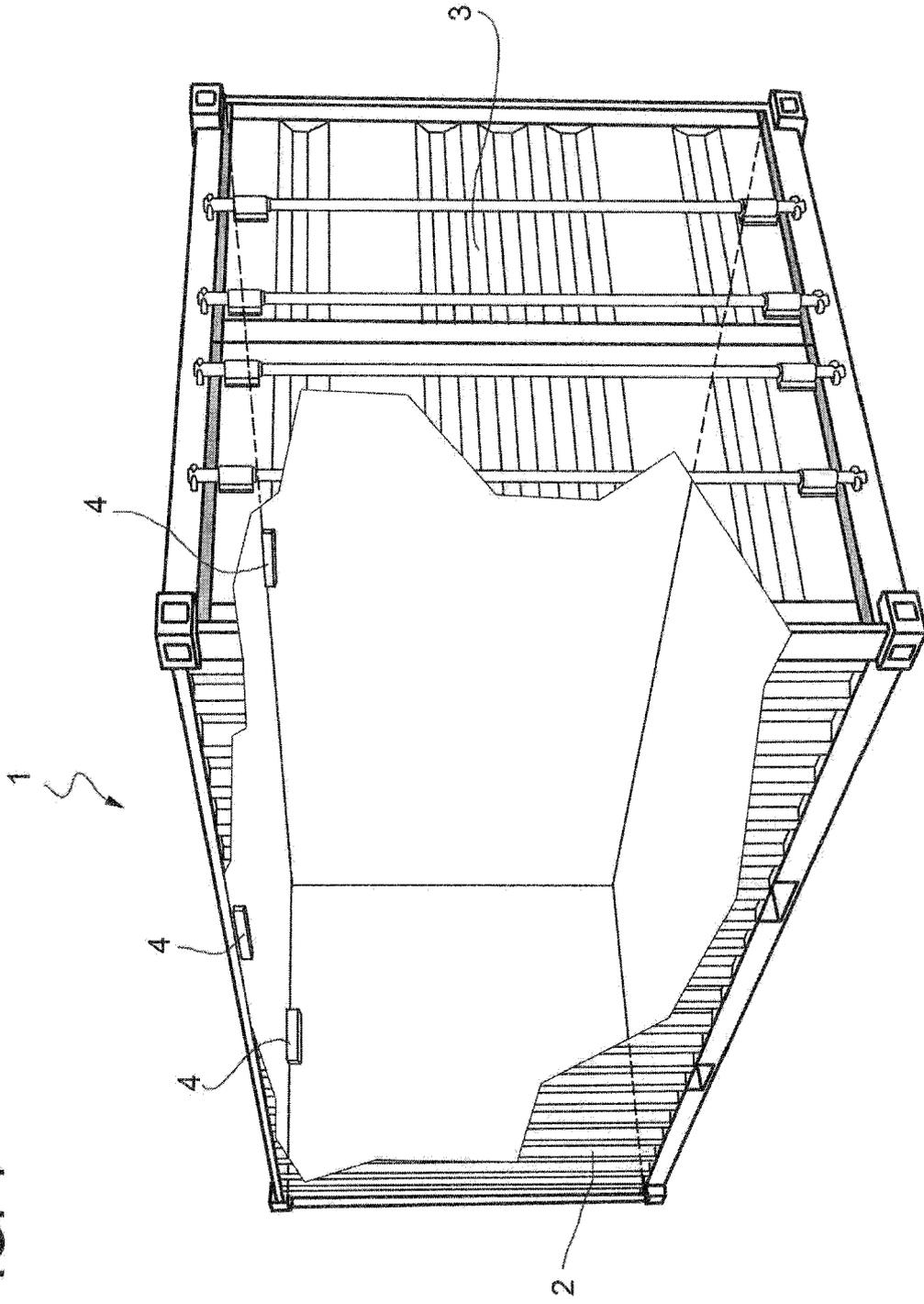
tified and integrated value of the signal (considered as an integral over a predefined interval, e.g. 5 seconds) is such as to indicate a continuative action, such as cutting sheet metal with an unknown tool and is compared with a second threshold (alarm threshold). An alarm is generated if the threshold is exceeded.

[0039] In concluding the description, it should be specified that in the case where the container is of the refrigerated type for transporting perishable goods, the anti-intrusion sensor device 4 can be integrated with other sensors for monitoring, for example, the temperature, humidity, oxygen percentage, etc., in order to guarantee the continuity of suitable conditions for the conservation and preservation of the transported goods during transportation.

Claims

1. A container anti-intrusion sensor device (4) for a container (1), the anti-intrusion sensor device (4) comprising a support element (7), fastening means (8) to fasten the support element (7) to a wall (2) of a container (1) in a removable manner, vibration sensor means (5) and light radiation sensor means (6) mounted on the support element (7) and an electronic unit (9), which is mounted on the support element (7) and is electrically connected to said sensor means (5, 6) to receive and process electrical signals from the sensor means (5, 6) for determining the occurrence of a break-in on the container (1) and consequently generating an alarm, the anti-intrusion sensor device (4) also comprising an electric power supply means (10, 5) for the electronic unit (9), said power supply means (10, 5) being mounted on the support element (7).
2. The container anti-intrusion sensor device according to claim 1, wherein the vibration sensor means (5) comprise a piezoelectric element (5).
3. The container anti-intrusion sensor device according to claim 1 or 2, wherein the light radiation sensor means (6) comprise a photodiode (6).
4. The container anti-intrusion sensor device according to one of preceding claims, wherein the power supply means (10, 5) comprise a rechargeable battery (10).
5. The container anti-intrusion sensor device according to claim 4, wherein the power supply means (10, 5) also comprise electric power generators sensitive to mechanical stress.
6. The container anti-intrusion sensor device according to claim 5, wherein said electric power generators comprise said vibration sensor means (5).
7. The container anti-intrusion sensor device according to one of preceding claims, wherein the electronic unit (9) is configured to assume a "sleep" state of minimum energy consumption and to evolve into an "awake" state when break-in occurs or periodically to carry out analysis of the operating state of the anti-intrusion sensor device (4).
8. The container anti-intrusion sensor device according to any of the preceding claims, wherein the fastening means (8) (7) comprise magnets (8).
9. The container anti-intrusion sensor device according to claim 8, wherein the electronic unit (9) is electrically connected to said magnets (8) to define, in use, an electrical circuit with the magnets (8) themselves and the wall (2) of the container (1), the electronic unit (9) being configured to test the operating state of the anti-intrusion sensor device (4) via the generation-acquisition-testing of an electrical signal through said electrical circuit.
10. The container anti-intrusion sensor device according to claim 8, wherein the support element (7) comprises a bar (7) of ferroelectric material and is provided with a winding (12) electrically connected to the electronic unit (9) so as to create, in use, a magnetic circuit between the bar (7), the magnets (8) and the wall (2) of the container (1); the electronic unit (9) being configured to test the operating state of the anti-intrusion sensor device (4) via the generation-acquisition-testing of an electrical signal through the winding (12).
11. A container anti-intrusion system comprising at least one container anti-intrusion sensor device (4) according to one of preceding claims and a control unit configured to receive signals from the container anti-intrusion sensor device (4) and to periodically test the correct installation and functioning of the anti-intrusion sensor device (4) itself.
12. A container comprising at least one anti-intrusion sensor device (4) according to one of the preceding claims.
13. Use of a container anti-intrusion sensor device (4) according to one of the preceding claims in a container (1) to detect the occurrence of a break-in on said container.

FIG. 1



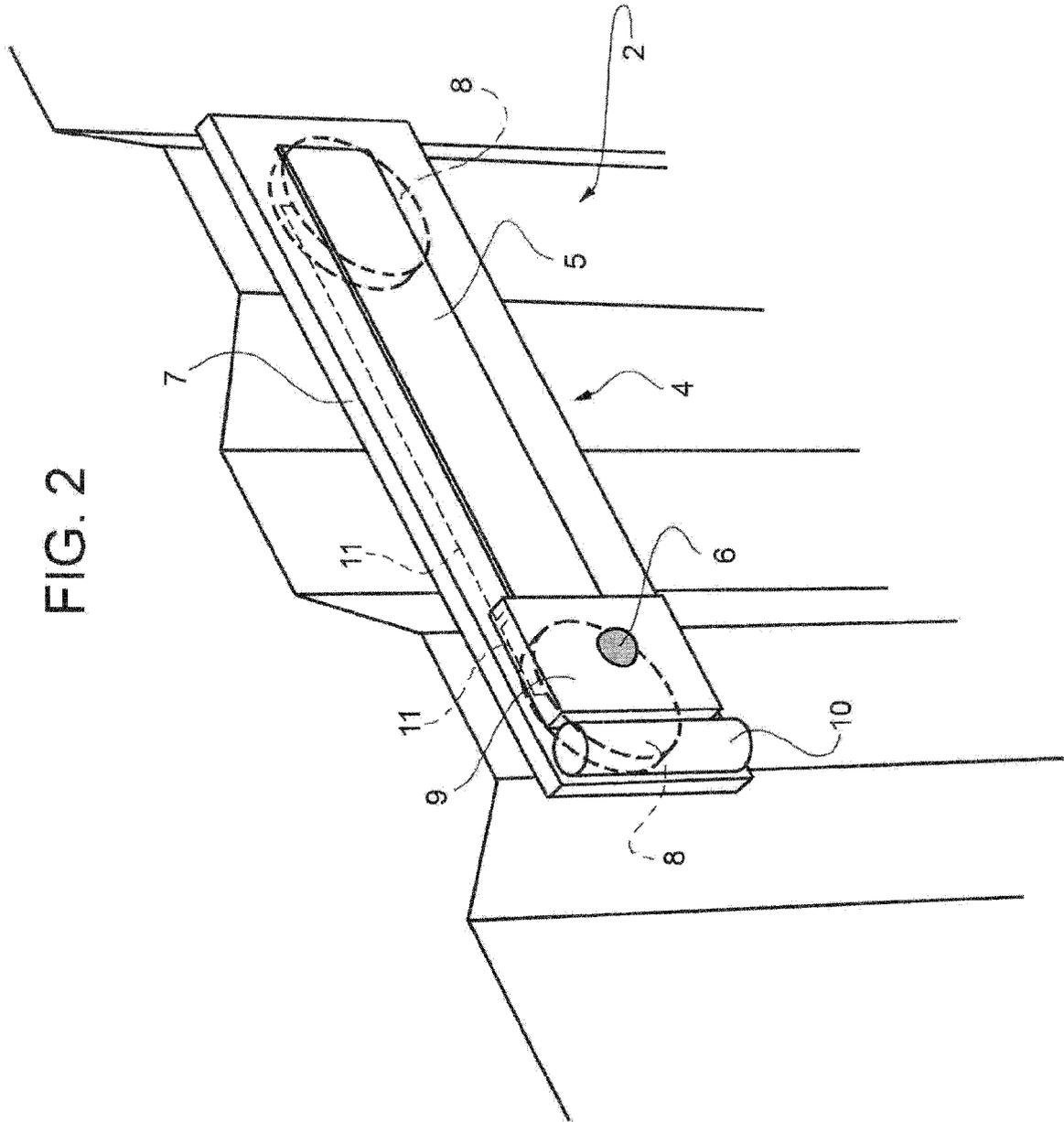


FIG. 3

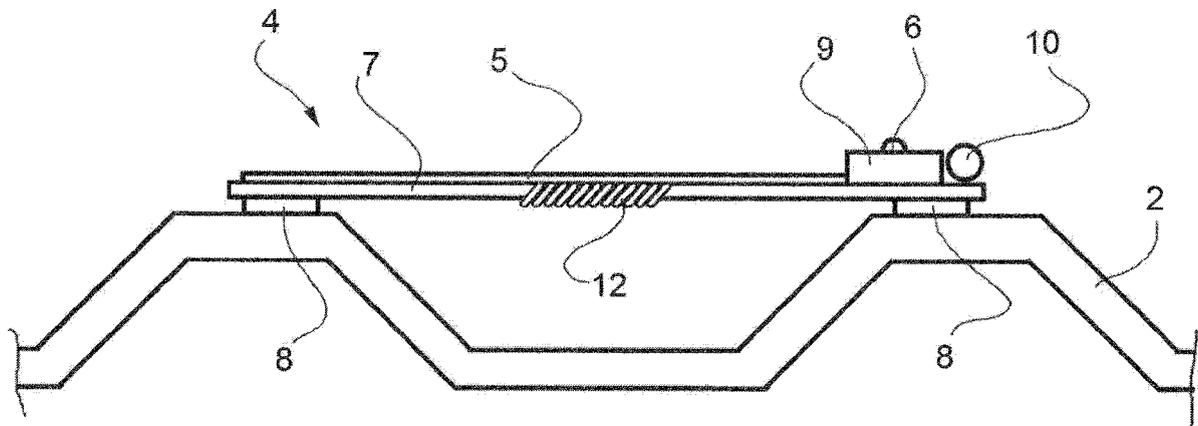
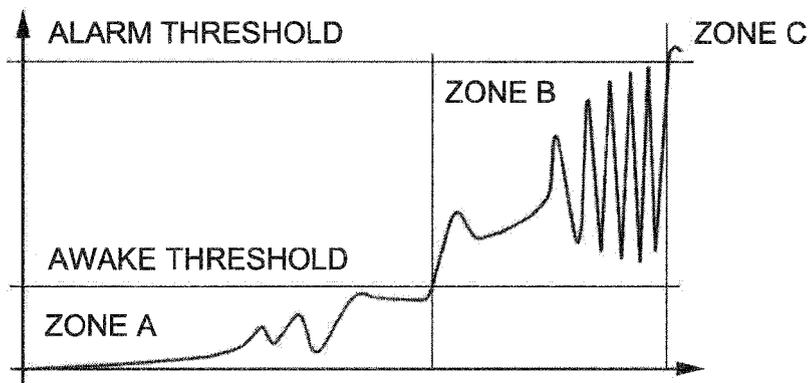


FIG. 4





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Application Number
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Place of search Munich		Date of completion of the search 31 August 2011	Examiner La Gioia, Cosimo
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**ANNEX TO THE EUROPEAN SEARCH REPORT
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