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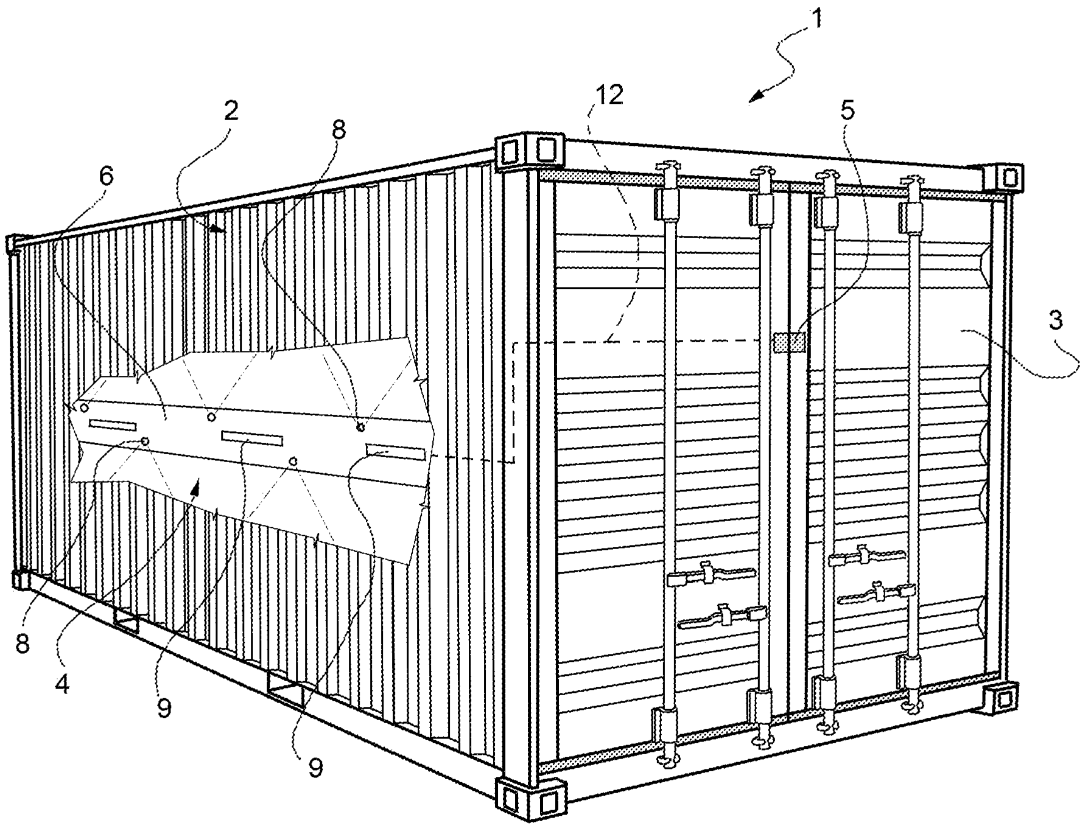
(54) A container anti-intrusion sensor device

(57) A container anti-intrusion sensor device (4) comprising a strip (6) of flexible material, sensors (8; 13; 15; 9) carried by the strip (6) and fastening means (7) for fastening the strip (6) to a wall (2) of a container (1).

FIG. 1



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Description

TECHNICAL FIELD OF 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, via radio, GPS, etc., 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.

[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 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 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 preferred embodiment of the sensor device of the present invention mounted on a container;
- Figure 2 is a front view, on an enlarged scale, of the sensor device in Figure 1;
- Figure 3 shows, in side elevation, the sensor device in Figure 2;
- Figure 4 shows a first variant of the sensor device in Figure 2;
- Figure 5 shows a second variant of the sensor device in Figure 2 mounted on a container;
- Figure 6 shows, in cross-section, a third variant of the device in Figure 2; and
- Figures 7 to 10 are diagrams showing the response of the sensor device in Figure 1 to respectively different external stimuli.

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 made of corrugated sheet metal and closed by a door 3.

[0011] The inner surface of at least one wall 2 of the container 1 is fitted with at least one anti-intrusion sensor device 4 having the function of detecting any tampering or attempted break-ins and sending the associated signals to an electronic control unit 5 (of known type) for data collection, processing and transmission.

[0012] In particular, as shown in Figures 1, 2 and 3, each anti-intrusion sensor device 4 comprises a support strip 6 made of a flexible material, preferably a plastic material such as polyethylene, and fastening means 7, which enable the strip 6 to be fastened to the wall 2 and comprise a layer of magnetic material integral with a face of the strip 6.

[0013] According to other alternative embodiments, the fastening means 7 can have a different shape and/or nature to those of the above-described example. For example, in the embodiment in Figure 6, the fastening means 7 comprise a plurality of magnets, which can be at least partially embedded in the strip 6 and are set apart from each other along the same strip 6, with a pitch equal to the pitch of the corrugations of the wall 2 such that by fixing the anti-intrusion sensor device 4 in a stretched out position transversal to the corrugations of the wall 2, the magnets find themselves in correspondence to the peaks of the corrugations.

[0014] According to a further variant (not shown), the fastening means 7 are constituted by a layer, or discrete portions, of an adhesive material which, amongst other things, also allows the strip 6 to be fixed in cases where the wall 2 is made, or finished, with a non-metallic material.

[0015] On the opposite side to the fastening means 7, the strip 6 supports a plurality of sensors comprising optical sensors and vibration sensors having the function, in use, of respectively detecting any light radiation inside the container 1 and any vibration induced on the wall 2 of the container 1, and of transforming this radiation and vibration into respective electrical signals that are sent to the electronic control unit 5.

[0016] In the example in Figures 2 and 3, the optical sensors are constituted by photodiodes 8, which are distributed in groups of two along the entire length of the strip 6 and are equipped with focusing optics able to guarantee a field of view capable of monitoring the space surrounding the strip 6. In a preferred embodiment, the focusing optics are constituted by cylindrical lenses able to ensure the monitoring of all the surface of the wall 2. In other words, by opportunely choosing the number, orientation and distribution of the photodiodes 8, based on the breadth of the surfaces to be monitored and the position where the anti-intrusion sensor device 4 is fastened to the surface itself, the anti-intrusion sensor device 4 is able to detect any light radiation originating from any point of the surface that surrounds the anti-intrusion sensor device 4.

[0017] For example, for a container 1 with an average length of 12m, an anti-intrusion sensor device 4 equipped with six photodiodes 8 with a field of view of approximately 120° each and installed on a side of the wall 2 at a height of 1.3m, namely at approximately half the height of the side, and in a transversal direction to the corrugations of this side, is able to monitor the entire side.

[0018] According to that shown in Figure 2, the vibration sensors comprise plates 9 of a piezoelectric ceramic material solidly glued or directly deposited on the strip 6. The position of the plates 9 on the strip 6 is arbitrary, but preferably the plates 9 are arranged along the strip 6 in alternating positions to the pairs of photodiodes 8 and separated from each other such that when the anti-intrusion sensor device 4 is applied to the wall 2, the plates 9 always find themselves in a position to directly receive any vibrations transmitted by the wall 2. For example, if the anti-intrusion sensor device 4 is prepared for being fixed in a transversal direction to the corrugations of the wall 2 and in stretched out position so as to only adhere to the peaks of the corrugations, the plates 9 will be spaced apart from each other by a distance equal to the pitch of the peaks of the corrugations; instead, if the anti-intrusion sensor device 4 is prepared for being fixed in a transversal direction to the corrugations of the wall 2, but in a folded position so that it adheres both to the peaks and to the troughs of the corrugations of the wall 2, the plates 9 shall be spaced apart from each other by a distance greater than the pitch of the peaks such that, once the anti-intrusion sensor device 4 is applied, the plates 9 find themselves in correspondence to the troughs and the photodiodes 8 find themselves in correspondence to the peaks.

[0019] In the event of an attempted break-in, in which a drill, cutter, grinder or any other type of tool that induces vibration of the wall 2 is used, each plate 9 is able to detect the oscillation that propagates along wall 2 and translate it into an electrical signal proportional to the intensity of oscillation. In addition, the reciprocal positions of the plates 9 on the strip 6 make it possible to characterize the vibration source in:

- displacement, which is proportional to the load induced in the piezoelectric material;
- speed, which is proportional to the time that the oscillation takes to cross the various plates 9;
- frequency, which can be obtained by processing the data on the load induced in the piezoelectric material.

[0020] The electrical signals generated by the optical and vibration sensors, the photodiodes 8 and the plates 9 in the case in point, are transmitted on respective electrically conductive tracks 10, preferably screen-printed on the strip 6 and electrically connected to a connector 11 arranged at one axial end of the anti-intrusion sensor device 4 that, in turn, is electrically connected to the electronic control unit 5 by an electrical cable 12.

[0021] In addition to the tracks 10, the electronics for conditioning and amplifying the electrical signals are also printed on the strip 6.

[0022] Preferably, the electronic control unit 5 comprises a device for detecting the opening of the door 3 and is mounted close to the door 3 (Figure 1) and, normally, outside the container 1.

[0023] The electronic control unit 5 can also be provided with a global positioning device (i.e. GPS), a processor for processing the data, a power management system for managing the powering of the sensors and a device for storing the alarms. Finally, the electronic control unit 5 could be capable of transmitting various types of information, for example, an alarm and an ID signal for the container 1 from which the alarm originated, to a remote monitoring station (for example, via RF radio, satellite, or Wi-Fi).

[0024] The electronic control unit 5 is electrically connected to all of the sensor devices 4 applied to the container 1 and is preferably configured to periodically check the status of the sensor devices 4 and to generate a specific alarm in the case of them being tampered with or malfunctioning.

[0025] This check is based on the capacity of the piezoelectric material to behave like a sensor or like an actuator according to the type of stimulus it is subjected to; in practice, the check is carried out for each anti-intrusion sensor device 4 by sending and electrical control signal to one of the plates 9 of the anti-intrusion sensor device 4 so as to provoke a vibration by means of the plate 9 itself, which is then detected and transformed into an electrical signal by the other plates 9 of the anti-intrusion sensor device 4. Based on the return signal received, the electronic control unit 5 is able to evaluate the correct positioning of the anti-intrusion sensor device 4 and the correct operation of the all the plates 9.

[0026] The signal sent by the electronic control unit 5 to the "actuator" plate 9 and the return signal received from the "sensor" plates 9 is stored in the electronic control unit 5 at the time of installation and constitutes the ID signal that is periodically sent by the electronic control unit 5 to evaluate the operation of the anti-intrusion sensor device 4.

[0027] Naturally, even in the case where the vibration sensors are not of the piezoelectric type, it is possible to carry out the above-described check by arranging piezoelectric elements along the strip 6 that are electrically connected to the electronic control unit 5 to receive and transmit the electrical control signals.

[0028] According to a variant, and only in the case where the fastening means 7 are of the magnetic type, the correct installation of the sensor devices 4 is checked by electrically connecting the fastening magnetic layer or magnets of each anti-intrusion sensor device 4 to the electronic control unit 5, such that the metal wall 2 becomes part of the electrical circuit of the electronic control unit 5. In this way, a possible detachment of the anti-intrusion sensor device 4 from the wall 2 would cause the circuit to open and would be immediately detectable by the electronic control unit 5, for example via the generation-acquisition-testing of an electrical signal along the circuit.

[0029] According to that shown in Figure 4, the optical sensors, instead of being photodiodes 8, can be defined by optical fibres 13 arranged along the strip 6 such that their visual field is sufficiently wide to monitor everywhere around the anti-intrusion sensor device 4.

[0030] All of the optical fibres 13 arranged along the strip 6 converge to a combiner device 14, which is positioned close to the connector 11 or, in alternative, is integrated into the latter, and has the function of "merging" the bundle of optical fibres 13 into a single optical fibre so that the light radiation collected from the bundle can be detected by a normal optoelectronic receiver unit (not shown) and transformed into a corresponding electrical current signal. The optoelectronic receiver unit can be placed in correspondence to the combiner device 14 and connected to the electronic control unit 5 by means of simple electrical connection, or be placed in correspondence to the electronic control unit 5 and connected to the combiner device 14 by means of an optical fibre.

[0031] With respect to the photodiodes 8, the optical fibres 13 have the advantage of avoiding the application of relatively expensive optoelectronic components, such as the photodiodes 8, to the strip 6, which is preferably of the disposable type and is designed to have a life cycle equal to the period of time that the cargo of a given shipment remains inside the container 1.

[0032] According to that shown in Figure 5, the optical fibres 13 of the previous example can be substituted by a single optical fibre 15, which is arranged in serpentine shape over almost the entire area of the strip 6 and, in use, is traversed by a light signal generated by an optoelectronic transmission unit (not shown) and received and transformed into an electrical signal by an optoelectronic receiver unit (not shown). The optoelectronic transmission and receiver units are each connected to a free end of the optical fibre 15 and can be placed in proximity to the strip 6 and connected to the electronic control unit 5 by means of an electrical connection, or be placed in correspondence to the electronic control unit 5 and connected to the optical fibre 15 on the strip 6 by means of a further segment of optical fibre.

[0033] In this case, as shown in Figure 5, the strip 6 has larger dimensions with respect to those of the strip 6 in the previously described examples and, once fastened to the inner surface of a side of the wall 2, is preferably able to cover most of this surface.

[0034] A possible break-in attempted on the container 1 through the side of the wall 2 equipped with a strip 6 of this type would cause the optical fibre 15 to break, with consequent interruption of the light signal and immediate detection of the anomaly by the optoelectronic receiver unit.

[0035] Obviously, both in the case of the anti-intrusion sensor device 4 with optical fibres 13 (Figure 4) and in the case of the anti-intrusion sensor device 4 with a single optical fibre 15 (Figure 5), the strip 6 is also equipped with vibration sensors, such as piezoelectric plates 9 for example.

[0036] With reference to Figures 7 to 10, the functioning shall now be described, by way of example, of an anti-intrusion sensor device 4 of the type shown in Figures 1 and 2, namely of the type equipped with a plurality of plates 9, which permit detection of an attempted break-in using drills, cutters or grinders independently of luminosity conditions, and photodiodes 8, which permit detection of both light radiation coming from the outside, in the case of daytime break-in, and light radiation due to the use of artificial light or cutting tools such as grinders, oxyacetylene welding or similar.

[0037] Under normal conditions and after the container 1 has been closed, the state of the sensor devices 4 consists in an almost null signal from the photodiodes 8 due to the total impossibility of light radiation being able to penetrate inside the container 1 and in an almost null signal from the plates 9 due to the absence of vibration. Signals from the plates 9 are characterized by frequencies below 60 Hz, mainly due to vibrations induced by electrical tools used for breaking in scraping against the walls of the container 1.

[0038] The behaviour of the plates 9 and the photodiodes 8 shall now be described in four cases of attempted break-in and with reference to respective diagrams representing the amplitude of the signals generated by the photodiodes 8 and the plates 9 as a function of time.

a) CASE OF DAYTIME BREAK-IN USING A DRILL/CUTTER/GRINDER - Figure 7

[0039]

A-B period: the attempted break-in begins; the plates 9 detect the vibrations induced on the wall 2 by the break-in tool;

B- period: an opening has now been made into the inside of the container 1; the signal from the photodiodes 8 is continuous and due to external light entering the container 1.

b) CASE OF NIGHTTIME BREAK-IN USING A DRILL/ CUTTER/GRINDER - Figure 8

[0040]

A-B period: the attempted break-in begins; the plates 9 detect the vibrations induced on the wall 2 by the break-in tool;

B- period: an opening has now been made into the inside of the container 1; the signal from the photodiodes 8 is discontinuous and due to artificial light entering the container 1, for example, light coming from a torch to identify things, or from external lighting.

c) CASE OF DAYTIME BREAK-IN USING AN OXY-ACETYLENE FLAME/BLOWLAMP - Figure 9

[0041]

A-B period: the attempted break-in begins; the plates 9 do not generate signals due to the substantial absence of induced vibration on the wall 2 by the break-in tool;

B- period: an opening has now been made into the inside of the container 1; the peak in the signal from the photodiodes is due to the blowlamp/oxyacetylene flame/grinder; afterwards, the signal is continuous and due to external light entering the container 1.

d) CASE OF NIGHTTIME BREAK-IN USING AN OXY-ACETYLENE FLAME/BLOWLAMP - Figure 10

[0042]

A-B period: the attempted break-in begins; the plates 9 do not generate signals due to the substantial absence of induced vibration on the wall 2 by the break-in tool;

B- period: an opening has now been made into the inside of the container 1; the peak in the signal from the photodiodes is due to the blowlamp/oxyacetylene flame/grinder; afterwards, the signal is discontinuous and due to artificial light entering the container 1, for example, light coming from a torch to identify things, or from external lighting.

[0043] With regard to the electronic control unit 5, the alarm activation logic is based on the comparison of the signals produced by the optical sensors, the photodiodes 8 in the case in point, and the vibration sensors, the plates 9 in the case in point, with the respective reference models.

[0044] With regard to the photodiodes 8, the alarm signal is generated with known techniques, based on exceeding a threshold, gradient evaluation, etc., implemented in the electronic control unit 5 for signal processing and conditioning. In particular, in order to improve the signal-noise ratio, in use, each photodiode 8 is in a quiescent state until the threshold value is exceeded, after which the signal values of photodiode 8 are evaluated over time, multiplying them by an opportune time interval (in practice, an integral of the signal is obtained). The resultant value is compared with a previously stored value and if it should exceed this value, an alarm signal is returned.

[0045] With regard to the plates 9, an analogue bandpass filter is implemented in the electronic control unit 5 that is centred on 50Hz (typical frequency when using tools such as drills, grinders, cutters, etc.) with a typical bandwidth of 20Hz-30Hz. The signal filtered in this manner, in the same way as for the photodiodes 8, is only considered when a preset threshold value is exceeded and from that moment on the product of the acquired values and the opportune time interval is calculated. The resultant value is compared with a previously stored value and if it should exceed this value, an alarm signal is returned.

[0046] In connection with that described above, it is possible to deduce that the electronic control unit 5 is configured to selectively assume a sleep state with minimal energy consumption and an awake state in which the electronic control unit 5 is active and able to receive and transmit electrical signals respectively from and to the sensor devices 4 and to generate and transmit any alarm signals.

[0047] In particular, passage from the sleep state to the awake state takes place:

- periodically, when the electronic control unit 5 is activated, for example, by an internal clock, for sending electrical signals to each anti-intrusion sensor device 4 and, based on the response of the anti-intrusion sensor device 4, checking the correct positioning and operation of the respective strip 6 in the above-described manner;
- if an external event occurs, when the piezoelectric plates 9 and/or the photodiodes 8 are stimulated by vibrations and/or light radiation and transmit respective electrical signals to the electronic control unit 5. In this regard, it should be specified that in this case, return to the awake state only takes place when the electrical signals sent to the electronic control unit 5

by the plates 9 and/or the photodiodes 8 exceed a minimum energy threshold.

[0048] The energy management of the system constituted by the electronic control unit 5 and the sensor devices 4 also provides for the energy induced by stimuli not indicative of a break-in in course, and therefore having values below the mentioned minimum threshold, to be "recovered" and used to charge a battery or similar device for powering the electronic control unit 5.

[0049] In the case where the vibration sensors are not of the piezoelectric type, like the plates 9, and the light radiation sensors are not optoelectronic units, like the photodiodes 8, the task of providing the "wake-up" energy is performed by current generation units, for example, by piezoelectric units specially arranged on each strip 6.

[0050] Alternatively, this task can also be performed by a piezoelectric vibrational energy recovery system placed inside the electronic control unit 5. The system is formed by one or more piezoelectric units that, by deforming under the effect of the oscillations to which the container 1 is subjected during shipping, generate energy that is stored in a battery or similar device for powering the electronic control unit 5.

[0051] In conclusion of what has been explained above, it should be underline that the use of the anti-intrusion sensor device 4 enables numerous advantages to be obtained, such as, for example, the great ease of installation, application to any type of container, low cost and minimal interference with the cargo inside the container and with loading and unloading operations.

[0052] In addition, the reduced thickness and high flexibility of the strip 6 makes it possible to roll up a series of sensor devices 4, one attached to the other or on a single continuous support strip, so as to form a compact roll, from which the individual sensor devices 4 can be unrolled and removed when they are installed.

[0053] Lastly, it should be specified that in the case where the containers are 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), the anti-intrusion sensor device (4) comprising a strip (6) of flexible material, sensors (8; 13; 15; 9) carried by the strip (6) and fastening means (7) to fasten the strip (6) to a wall (2) of a container (1).

2. The container anti-intrusion sensor device according to claim 1, wherein the sensors (8; 13; 15; 9) comprise at least one optical sensor (8; 13; 15) and at least one vibration sensor (9).

3. The container anti-intrusion sensor device according to claim 2, wherein the vibration sensor (9) is a piezoelectric sensor.

4. The container anti-intrusion sensor device according to claim 2 or 3 and comprising a plurality of vibration sensors (9) spaced apart along the strip (6).

5. The container anti-intrusion sensor device according to claim 2, wherein the optical sensor (8; 13; 15) comprises a photodiode (8) or an optical fibre (13; 15).

6. The container anti-intrusion sensor device according to claim 5 and comprising a plurality of optical sensors (8; 13) arranged along the strip (6) such that their visual field covers the space surrounding the strip (6).

7. The container anti-intrusion sensor device according to claim 5, wherein the optical fibre (15) is arranged in a serpentine shape on the strip (6) and is connected to an optoelectronic light transmission unit and to an optoelectronic light receiver unit.

8. The container anti-intrusion sensor device according to any of the preceding claims, wherein the fastening means (7) are magnetic fastening means.

9. A container anti-intrusion system comprising at least one container anti-intrusion sensor device (4) according to one of the preceding claims and an electronic control unit (5) configured to be connected to the sensor device (4) and to:

   - receive electrical signals from the anti-intrusion sensor device (4), and
   - process said electrical signals to determine the occurrence of a break-in.

10. The container anti-intrusion system according to claim 9, wherein the electronic control unit (5) is configured to periodically check the correct installation and operation of the container anti-intrusion sensor devices (4).

11. Use of an anti-intrusion sensor device (4) according to one of the preceding claims on a container (1) to detect the occurrence of a break-in on said container (1).

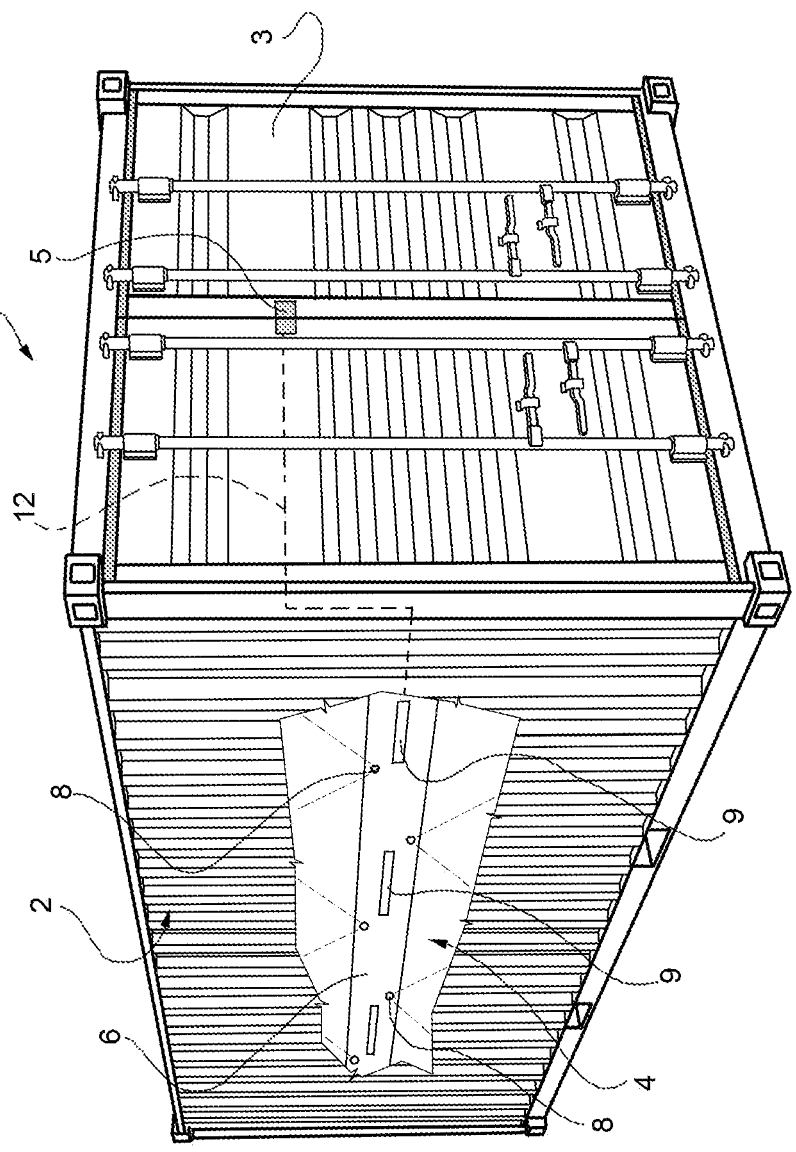


FIG. 1

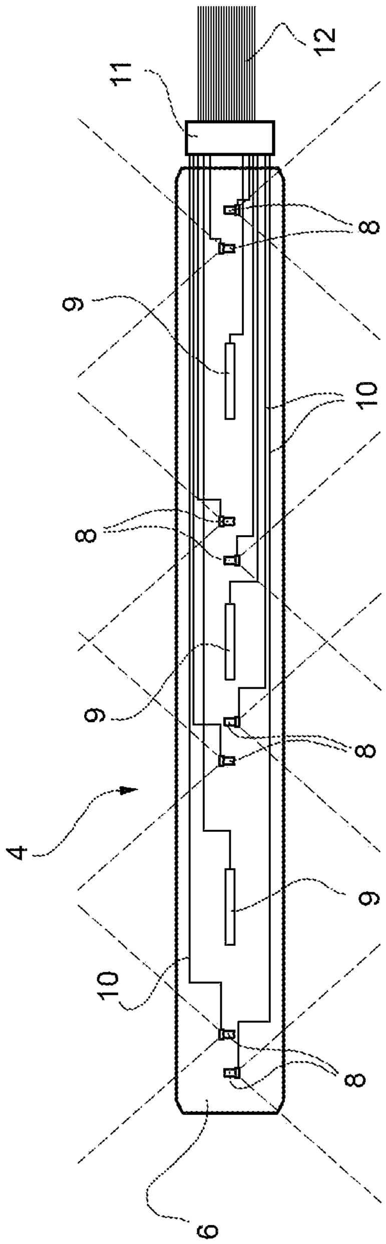


FIG. 2

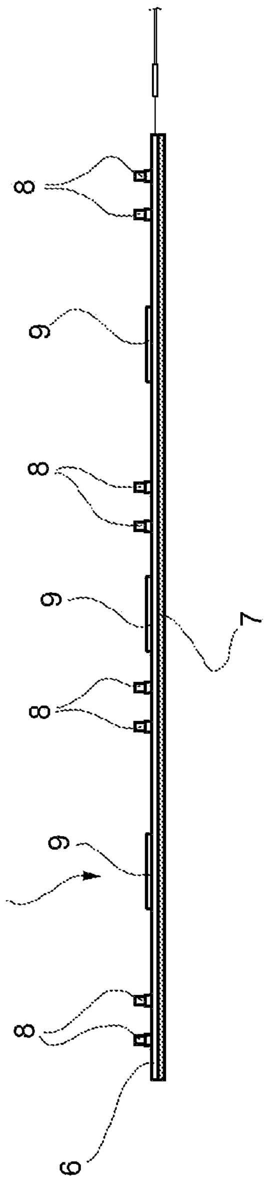
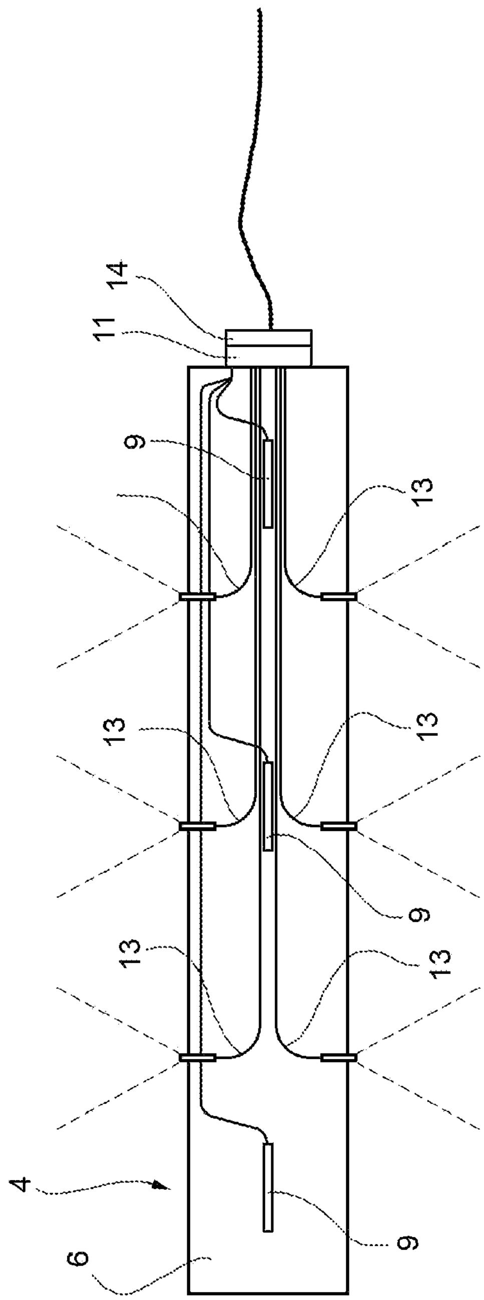


FIG. 3

FIG. 4



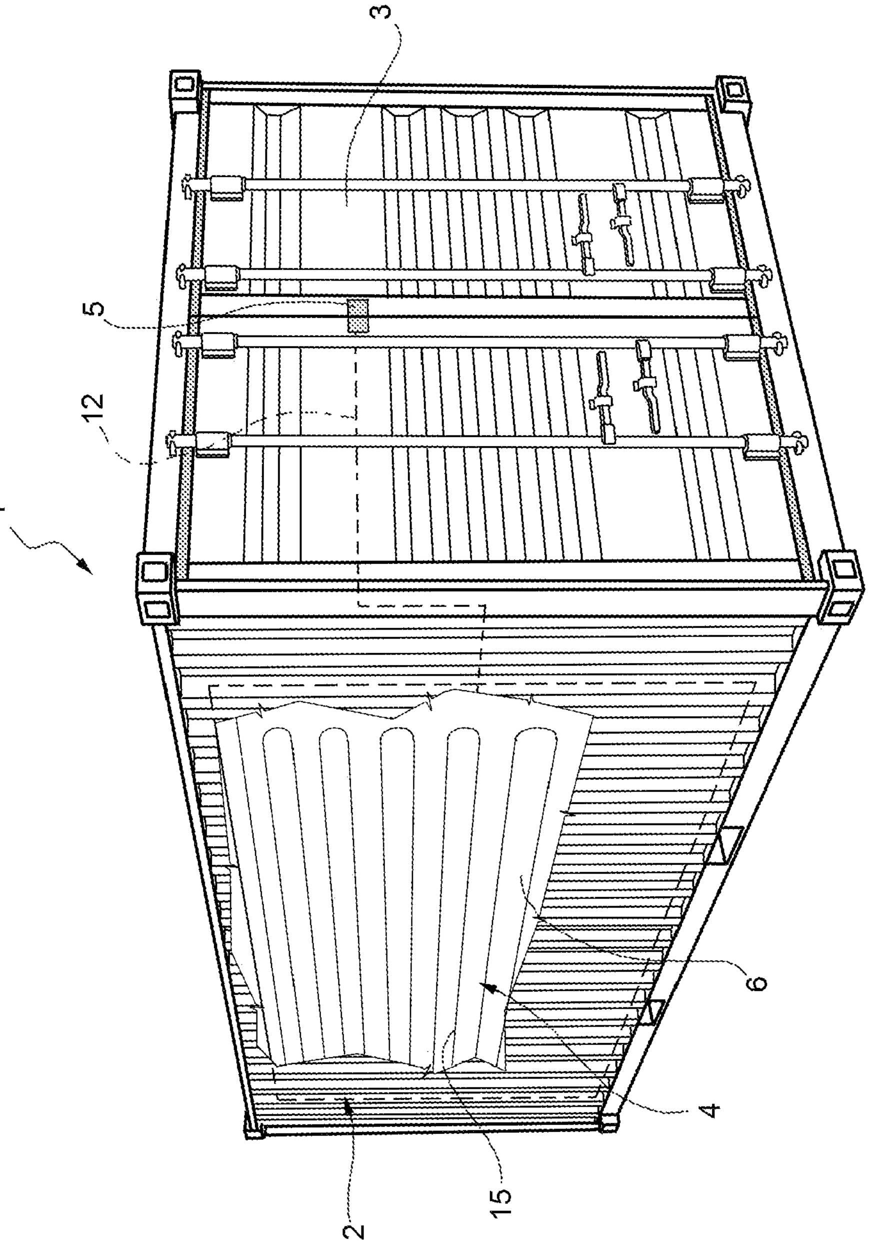


FIG. 5

FIG. 6

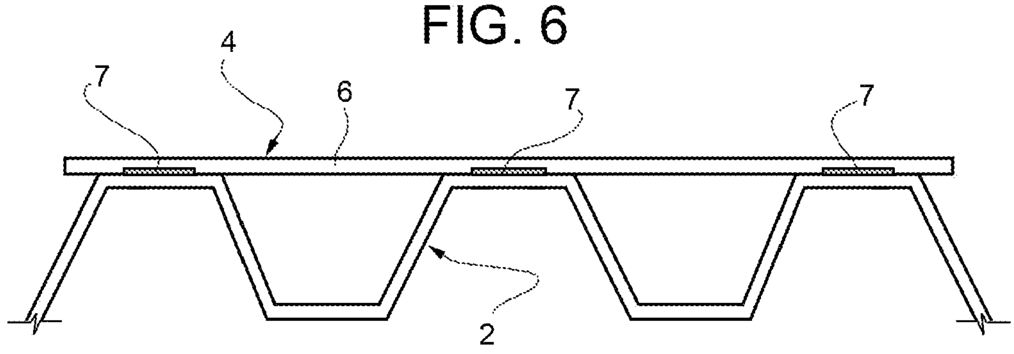


FIG. 7

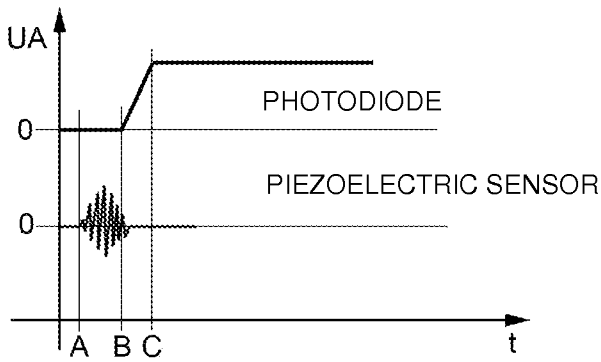


FIG. 8

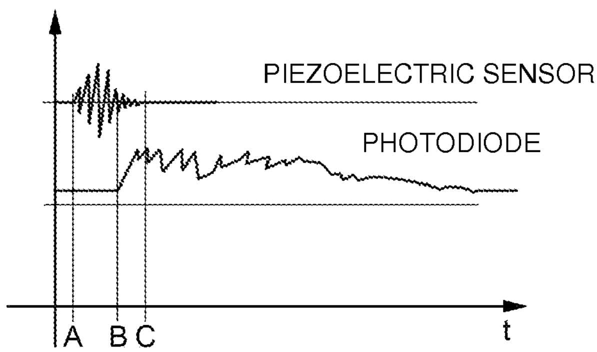
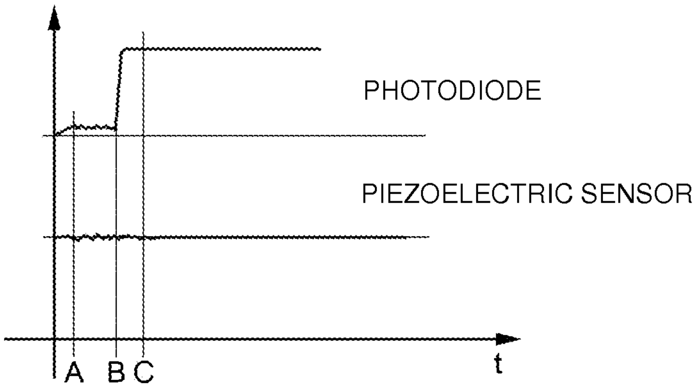


FIG. 9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PIEZOELECTRIC SENSOR
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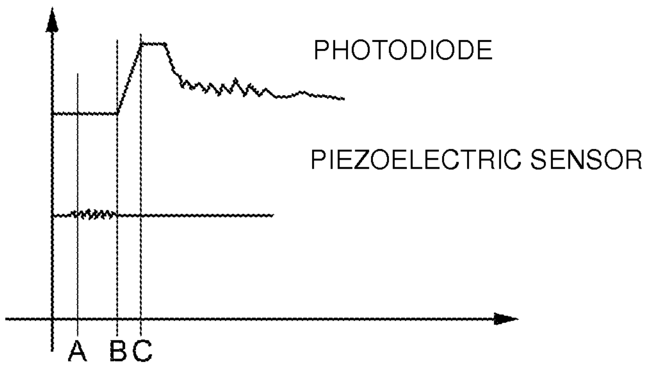
FIG. 10


PHOTODIODE
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A
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EUROPEAN SEARCH REPORT

Application Number
EP 11 42 5079

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
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A	US 5 068 643 A (YASHINA KAZUO [JP]) 26 November 1991 (1991-11-26) * abstract * -----	1,11	

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	30 August 2011	La Gioia, Cosimo

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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