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(54) Assembly comprising a device with a planar antenna

(57) The invention concerns an assembly (1) comprising:
- an electrical device having a housing (5). Inside the housing is a planar antenna element (2) connected to a radio circuit. The planar antenna element (2) is connected to a connection member (9) which penetrates the housing (5),
- an electrically conductive structure (6), having an electrically conductive outer surface (7), wherein
- the housing (5) is configured to be mechanically fastened to the electrically conductive structure (6) and the antenna element (2) inside the housing (5) is configured to be situated at least partly in parallel with the outer surface (7) of the electrically conductive structure (6) and to be in electrical connection with the outer surface (7) via the electrically conducting connection member (9) such that the electrically conductive structure (6) forms a radiating part when the antenna element (2) inside the housing (5) is excited by a radio signal.

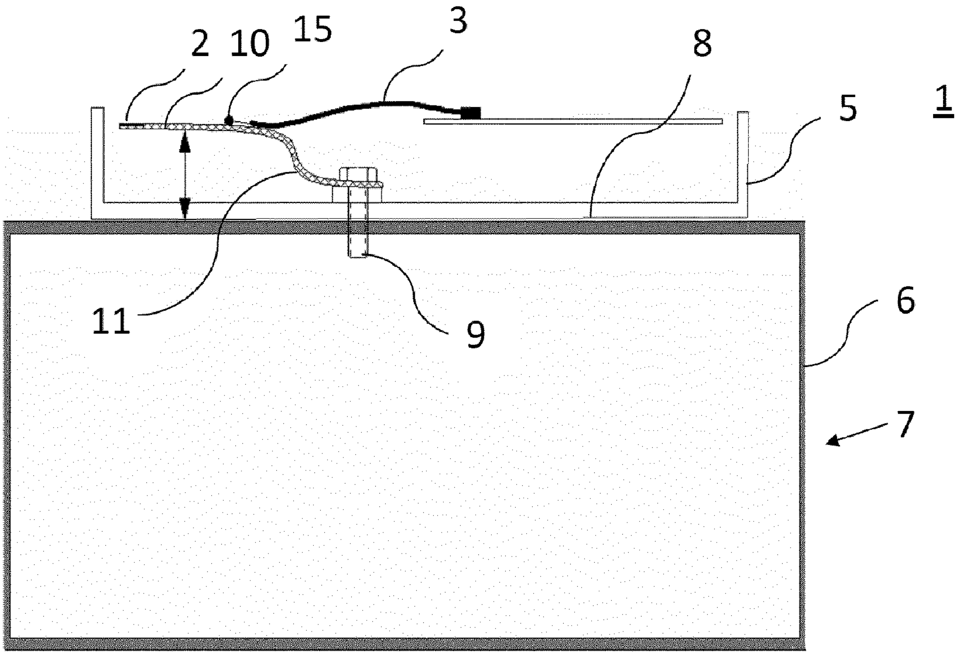

Fig. 3

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Description

Technical field

[0001] This invention relates to an assembly comprising a device with a planar antenna.

Background Art

[0002] With the proliferation of radio technology, many electrical devices are today equipped with a radio interface to enable wireless communication of information from/to such devices.

[0003] For instance, stand-alone devices for measuring some physical parameter can be deployed somewhere in the field and report measurements only via such a radio interface, making them easy to deploy even in places difficult to access.

[0004] Depending on the circumstances, different radio frequencies can be used for the radio interface. When comparatively low frequency bands, such as VHF (Very High Frequency), are used, there is a need for a relatively large antenna due to the long wavelength.

[0005] When using a planar antenna in housings of devices which are small in comparison to the wavelength of the frequency with which they are to operate, there may be a problem with antenna efficiency, since the wavelength of the radio waves to be transmitted is considerably longer than the physical extent of the housing of the device and therefore also the antenna inside that housing.

[0006] Thus, it may happen that a device that otherwise can be made reasonably small will have problems harbouring a larger antenna for a lower frequency band.

[0007] One solution to this problem is to use planar antennas with slits to increase the electrical length of the antenna. In this way, the required frequency may be transmitted since the electrical length of the antenna element can be increased up till the minimum half wavelength while still being able to fit the antenna in a relatively small housing.

[0008] However, such an antenna may never-the-less be quite inefficient in lower frequency bands. A poor efficiency results in higher energy consumption which is generally not desirable and outright detrimental when the device is operated on battery power. Also, a weak radio signal from the antenna lessens the reach of the signal and/or the possible rate of transmission of information.

[0009] A further problem with devices that make use of such a described antenna arises when such devices are connected to some kind of sensor to measure for instance a physical parameter in an electrically conducting, box-like structure. When the antenna directly or indirectly share a common printed circuit board with circuits that are in contact with the sensor and further is operated on a comparatively low frequency, such a sensor can have a negative effect on the antenna efficiency.

Summary of Invention

Technical problem

[0010] It is an object of the present invention to propose a solution for or a reduction of the problems of prior art. A main object is consequently to propose a device with a planar antenna with an improved efficiency.

Solution to Problem

[0011] According to the invention, this is accomplished with an assembly having the features of claim 1.

[0012] The solution to this problem according to the invention is to use an electrically conducting surface of a structure where a housing of the device is mounted, as a part of the radiating structure. In this way - thinking out of the box so to speak - the antenna of the device can be significantly increased in size by employing the outer electrically conductive structure 6 as a part of the antenna.

[0013] This increases the antenna efficiency due to the larger effective antenna area compared to what can be housed in the device housing.

[0014] The assembly additionally also solves the problem of antenna efficiency in connection with such devices having an antenna and which are also in contact with a sensor, a sensor that is at least partly introduced inside an electrically conducting box.

[0015] According to the invention, the antenna element of the device is galvanically connected to the electrically conducting box to make the electrically conducting box a part of the resulting antenna. The connection of the antenna element to the electrically conducting box effectively short-circuits the sensor radio-wise in relation to the antenna element. Therefore, the printed circuit board is practically not a part of the resulting antenna and thus there is a much lower energy transfer to the sensor from the antenna element without the need for any additional components or measures.

Brief Description of Drawings

[0016] Embodiments exemplifying the invention will now be described, by means of the appended drawings, on which:

Fig. 1 illustrates a device with an antenna according to the prior art,

Fig. 2 illustrates a device with an improved antenna,

Fig. 3 illustrates a sectioned side view of a device with a further improved antenna in the form of an assembly,

Fig. 4 illustrates the device with the further improved antenna in plan view,

Fig. 5 illustrates a sectioned side view of a device with an antenna mounted with a sleeve spacer to an electrically conductive structure,

Fig. 6 illustrates a sectioned side view of a device with an antenna that makes electrical contact with an electrically conductive structure with a compressed spring, and

Fig. 7 illustrates an assembly with a sensor introduced into an electrically conducting box.

Description of Embodiments

[0017] A possible device with a housing 5 enclosing an antenna element 2 that is to be used at a relatively long wavelength compared to the size of the device is illustrated in fig. 1. The housing 5 of the device is, as an example, shown mounted on a box-like structure.

[0018] A solution to the problem of operating an antenna at a frequency implying a wavelength that is comparably long in relation to the size of a housing 5 of a device including the antenna can be seen in fig. 2.

[0019] Here the planar antenna element 2 is made larger by folding twice in the box. In this way, the effective antenna surface becomes larger and therefore the efficiency of the antenna can be improved. Also, since the antenna is larger, the electric length of the antenna can be made longer permitting to send radio waves with a lower frequency/greater wavelength. It should be noted that the device with the housing 5 is depicted without a top cover in fig. 2 for simplicity of interpreting the figure. In reality, when deploying the device, it would also comprise a top cover to make the housing 5 completely enclose the antenna element and other electrical components inside the device to protect them. This is also true for the other figures of this application.

[0020] However, the solution of fig. 2 - while an improvement over the device of fig. 1 - may in some cases also not be completely satisfactory. For instance when there is a need to operate the antenna at a comparably low frequency.

[0021] To improve upon the device of fig. 2, a solution according to fig. 3 is proposed. It is an assembly 1 comprising an electrical device having a housing 5 comprising at least partly an electrically non-conductive material. Inside the housing 5 is located a planar antenna element 2 connected by a transmission line 3 to a radio circuit (not shown in the figure). The planar antenna element (2) further is connected to an electrically conducting connection member (9) which penetrates the housing (5)

[0022] Since there is at least a part of the housing 5 that is made in the non-conductive material, radio waves can be emitted by the antenna element 2 and propagate through the housing 5.

[0023] The assembly can be seen to further comprise an electrically conductive structure 6, having an electrically conductive outer surface 7.

[0024] Further, the housing 5 of the electrical device is configured to be mechanically fastened to the electrically conductive structure 6 and the antenna element 2 inside the housing 5 is configured to be situated at least partly in parallel with the outer surface 7 of the electrically conductive structure 6 and to be in electrical connection with the outer surface 7 via the electrically conducting connection member 9 such that the electrically conductive structure 6 forms a radiating part when the antenna element 2 inside the housing 5 is excited by a radio signal from the radio circuit (not shown).

[0025] This increases the size of the radiating area of the assembly, compared to what is possible to contain in the device housing 5 alone, by employing the outer electrically conductive structure 6 as a radiating part of the antenna. Thereby, the efficiency of the assembly can be improved. It should be noticed that this antenna only has one excitation point and that the antenna element and the electrically conductive structure together forms one antenna. Thus, this assembly is not a system with two separate antennas excited with two different signals.

[0026] When the assembly 1 is to be used to transmit a radio signal, the housing 5 would be fastened to the electrically conductive structure 6 and the antenna element 2 would be situated at least partly in parallel with said outer surface 7 and would be in electrical connection with the outer surface of the electrically conductive structure 6 via the connection member 9, as shown in fig. 3.

[0027] As a variant, the housing of the device could be fastened to the electrically conductive structure 6 with the connection member 9. In this way, both the fastening of the device housing 5 to the electrically conductive structure 6 and the electrical connection of the antenna element 2 to the electrically conductive structure 6 can be effected with one and the same element 9, making the assembly 1 a bit less complicated. This is the case in fig. 3

[0028] The electrically conductive structure could have an electrically conductive outer surface 7 with an area that is larger than an outer surface area 8 of the housing 5, which outer surface area 8 of the housing 5 is the largest outer surface area 8 of said housing 5. That is to say that the electrically conducting structure has an outer surface that is larger than what is possible to contain in the housing 5. The outer surface of the electrically conducting structure is therefore larger than the largest possible surface of an antenna element 2 contained inside the housing 5. This significantly increases the size of the radiating part of the antenna, compared to what is possible to contain in the housing 5 alone, such that a better efficiency is attained compared with what is available when the radiating part is contained in the housing 5. Therefore, in the case of a relatively small housing 5, compared to the resonating wavelength, a comparably large electrically conductive structure can compensate the size of the housing to provide an antenna that never-the-less has an acceptable efficiency.

[0029] The electrical conductive outer surface 7 could have a physical extent that is equal to or less than ½ wavelengths of a resonating wavelength of the assembly. The restriction on the physical extent of the electrically conducting structure 6, that is that the actual size of the structure does not surpass said length when measured across the conductive surface 7 in any direction, sets an upper boundary of the structure 6 to make sure it does not make the resulting antenna resemble a directive antenna. Thus, in this way a more omnidirectional characteristic of the resulting antenna is retained.

[0030] In order for the electrically conductive outer surface 7 to make a meaningful contribution to the resulting antenna structure, it could be recommended that the surface 7 has a physical extent that is equal to or longer than 0.1 wavelengths of a resonating wavelength of the assembly.

[0031] The antenna element 2 could for instance be formed by a printed circuit board 10. If at least a part of the antenna element 2 is flexible it could be bent 11 in the vicinity of where it connects to the connection member 9, as seen in fig. 3. This is a convenient way of connecting the antenna element 2 to the electrically conducting structure while at the same time keeping the rest of the antenna element 2 at greater distance from the housing wall adjacent to the electrically conducting structure, as shown with the double arrow in fig. 3.

[0032] In fig. 4, a plan view of the assembly 1 with, among others, the electrical device with he planar antenna element 2, the transmission line 3, the housing 5 of the electrical device, the electrically conductive structure 6 and the electrically conducting connection member 9 is visible.

[0033] As an alternative, the antenna element 2 could be rigid and separated by a sleeve 12 from a bottom 13 of the device housing 5 in contact with the electrically conductive structure 6, as illustrated in fig 5. The required distance of the antenna element 2 to the bottom 13 and the electrically conductive structure 6 could then be ensured while at the same time a single connection member 9, for instance a screw 9, could be used to connect it to the electrically conducting structure 6.

[0034] The sleeve 12 may serve as a separating element only or additionally also as an electrically conducting element to connect the antenna element 2 to the electrically conductive structure 6 electrically.

[0035] Instead of a screw and/or a sleeve 12 being the connection member 9, some other object may serve to provide the electrical contact between the antenna element 2 and the electrically conducting structure 6, for instance a spring 9 as seen in fig. 6.

[0036] In the case of fig. 6, the spring does not function to provide a support onto which the antenna element 2 may rest as was the case with the sleeve 12. Instead, the spring is compressed between the antenna element 2 and the bottom 13 of the device housing 5 as seen in fig. 6 where the antenna element 2 is resting on posts 14 and is holding the spring in compressed electrical contact with the electrically conductive structure 6.

[0037] Instead of a screw, sleeve 12 or spring, any other suitable electrical element may of course be used to provide the electrical contact between the antenna element 2 and the electrically conductive structure 6.

[0038] Ordinarily, the radio circuit 4 would be located in the housing 5. However, it is also possible that the radio circuit 4 is located elsewhere and the transmission line 3 would enter the housing 5 through a wall of the same (not shown in any figure).

[0039] When the radio circuit 4 is located in the housing 5, it is also possible to have the antenna element 2 and the radio circuit 4 located on the same printed circuit board. It reduces the count of components of the assembly 1 but may make the antenna more expensive if the PCB of the radio circuit 4 must use a multi layer design, rather than a two sided board that is enough for the antenna itself. A schematic illustration of the antenna element 2 and the radio circuit 4 located on the same printed circuit board is shown schematically in figure 5. A single board can be seen in this sectioned side view.

[0040] It has been found that in some cases it is beneficial if the antenna element 2 is configured to connect to the connection member 9 at a distance of less or equal to 0.1 wavelengths of a resonating wavelength of the assembly from a point 15 where the transmission line 3 connects to the antenna element 2 (see for instance fig. 3). This is due to the fact that the electrical length of the antenna element 2 often is about 0,25 wavelengths. The most distant part of the antenna element, seen from the point 15 where the transmission line connects to the antenna element - the excitation point of the antenna - has a higher electrical field strength and the part closer to the excitation point, has a lower electrical field strength and a higher current density and magnetic field. To get an improvement, it is beneficial to connect connection member 9 at a point closer to the excitation point, so that the current is transferred from the antenna element through the connection 9 to the electrically conductive structure 6 (for instance a metal box). The best connection point for transferring the current from antenna and structure 6 is located within a distance less than 0.1 wavelengths from the excitation point of the antenna.

[0041] In some embodiments, the electrically conductive structure 6, where the housing 5 of the device is fastened, is box-like and the assembly 1 can further comprise an electrically conducting sensor 16 that at least partly is introduced inside the electrically conductive structure 6, see fig. 7. In figure 7, the sensor is denoted by a dashed line, reference numeral 16 is really pointing to the electrical line connecting to the sensor. The sensor can for instance be intended to register a physical parameter that is to be reported via a radio interface enabled by the assembly 1. As such, a sensor is in this context understood to encompass any kind of sensor or measuring transducer that can be used to measure a quantity of some sort and report the measurement to some other entity. It may also encompass an electrical line transmitting a measurement from the sensor. Further, electrically conductive means that some part of the sensor is electrically conductive at some frequency.

[0042] The sensor would be in connection with a printed circuit board, in order to report any measurements. The printed circuit board, to which measurements from the sensor would be communicated, would also be in connection with the radio circuit, in order to enable the measurements to be communicated wirelessly via the antenna element 2. It is not necessarily so that the radio circuit must be hosted on the PCB where the measurements from the sensor 16 are collected, but they must be in some kind of contact in order for such measurements to ultimately be communicated via the antenna element 2.

[0043] In such an embodiment, with an antenna element 2 in connection with a sensor that is at least partly introduced into a hollow, box-like, electrically conductive structure 6, there might be a problem with the efficiency of the antenna.

[0044] The reason for this inefficiency has been realised by the present applicant to be that the sensor may funnel some of the radio energy to the inside of the electrically conductive box where it is effectively dissipated as heat.

[0045] Having this insight, a possible solution would be to apply an electric filter to the sensor and situate such a filter before the entrance point to the electrically conductive box to filter out the frequencies of the antenna. This would lessen the amount of antenna energy transferred into the box and increase antenna gain. A drawback with that solution is that it requires filter components, adding to the cost and complexity of such a design.

[0046] It turns out that this further problem can be circumvented by the design of an assembly 1 according to this invention. The heart of the solution is that the antenna element 2 is galvanically connected to the electrically conducting box. Without this connection to the electrically conducting box, the sensor effectively becomes a part of the radiating antenna. Having the antenna element directly connected to the electrically conductive box kind of short circuits the sensor in the sense that it does not any longer electrically form part of the antenna.

[0047] Thus, there is no longer any need for a filter and the antenna efficiency is improved since the radio energy is properly radiated in the way it was intended and not through the sensor.

[0048] The assembly 1 according to the invention could for instance be used in the VHF (Very High Frequency) band, making it a VHF antenna. For example the 169 MHz frequency band could be used in some countries for different applications.

[0049] Such an application would be to use the assembly 1 according to the invention to communicate gas flow measurements, for instance by public utilities measuring consumption of coal gas. In such a case, the electrically conductive structure 6 could be a gas flow meter chamber to which the device housing 5 with the antenna element 2 would be attached to complete the assembly 1.

[0050] The electrically conductive structure 6, what ever form it takes, can be made of metal such as aluminium or steel. However, other, electrically conductive materials are also possible and there is really only a need for the surface of the electrically conductive structure 6 to be electrically conductive. Thus, a design with a non-conductive material, coated with an electrically conductive coating is also possible. Such a coating could be metallic or even an electrically conductive synthetic material.

<u>Reference Signs List</u>

[0051]

1. Assembly
2. Planar antenna element
3. Transmission line
4. Radio circuit
5. Housing
6. Electrically conductive structure
7. Electrically conductive outer surface of the electrically conductive structure
8. Outer surface area of the housing
9. Electrically conducting connection member
10. Printed circuit board
11. Bending
12. Sleeve
13. Bottom of the housing
14. Post
15. Point where the transmission line connects to the antenna electrically
16. Line connecting to electrically conducting sensor

Claims

1. Assembly (1) comprising:

- an electrical device having a housing (5) comprising at least partly an electrically non-conductive material, wherein inside the housing is located a planar antenna element (2) connected by a transmission line (3) to a radio circuit (4), wherein the planar antenna element (2) further is connected to an electrically conducting connection member (9) which penetrates the housing (5),
- an electrically conductive structure (6) having an electrically conductive outer surface (7), wherein
- the housing (5) of the electrical device is configured to be mechanically fastened to the electrically conductive structure (6) and the antenna element (2) inside the housing (5) is configured to be situated at least partly in parallel with the outer surface (7) of the electrically conductive structure (6) and to be in electrical connection with the outer surface (7) via the electrically con-

ducting connection member (9) such that the electrically conductive structure (6) forms a radiating part when the antenna element (2) inside the housing (5) is excited by a radio signal from the radio circuit (4).

2. Assembly (1) according to claim 1, wherein the housing (5) is fastened to the electrically conductive structure (6) and the antenna element (2) is situated at least partly in parallel with said outer surface (7) and is in electrical connection with the outer surface of the electrically conductive structure (6) via the connection member (9).

3. Assembly (1) according to claim 2, wherein the housing is fastened to the electrically conductive structure (6) with the connection member (9).

4. Assembly (1) according to any of claims 1-3, wherein the electrically conducting structure has an electrically conductive outer surface (7) with an area that is larger than an outer surface area (8) of the device housing (5), which outer surface area (8) of the device housing (5) is the largest outer surface area (8) of said device housing (5).

5. Assembly (1) according to any of claims 1-4, wherein the electrically conductive outer surface (7) has a physical extent that is equal to or less than ½ wavelengths of a resonating wavelength of the assembly.

6. Assembly (1) according to any of claims 1-5, wherein the electrically conductive outer surface (7) has a physical extent that is equal to or larger than 0.1 wavelengths of a resonating wavelength of the assembly.

7. Assembly (1) according to any of claims 1-6, wherein the antenna element (2) comprises a printed circuit board (10).

8. Assembly (1) according to any of claims 1-7, wherein at least a part of the antenna element (2) is flexible and is bent (11) in the vicinity of where it connects to the connection member (9).

9. Assembly (1) according to any of claims 1-7, wherein the antenna element (2) is rigid and separated by a sleeve (12) from a bottom (13) of the device housing (5) in contact with the electrically conductive structure (6).

10. Assembly (1) according to any of claims 1-9, wherein the radio circuit (4) is located in the device housing (5).

11. Assembly (1) according to claim 10, wherein the antenna element (2) and the radio circuit (4) are located on the same printed circuit board.

12. Assembly (1) according to any of claims 1-11, wherein the antenna element (2) is configured to connect to the connection member (9) at a distance of less or equal to 0.1 wavelength of a resonating wavelength of the assembly from a point (15) where the transmission line (3) connects to the antenna element (2).

13. Assembly (1) according to any of claims 1-12, wherein the electrically conductive structure (6) is box-like and the assembly (1) further comprises an electrically conducting sensor, at least partly introduced inside the electrically conductive structure (6) and is in connection with a printed circuit board, which printed circuit board is also in connection with the radio circuit (4).

14. Assembly (1) according to any of claims 1-13, wherein the antenna is a VHF antenna.

15. Assembly (1) according to any of claims 1-14, wherein the electrically conductive structure (6) is a gas flow meter chamber.

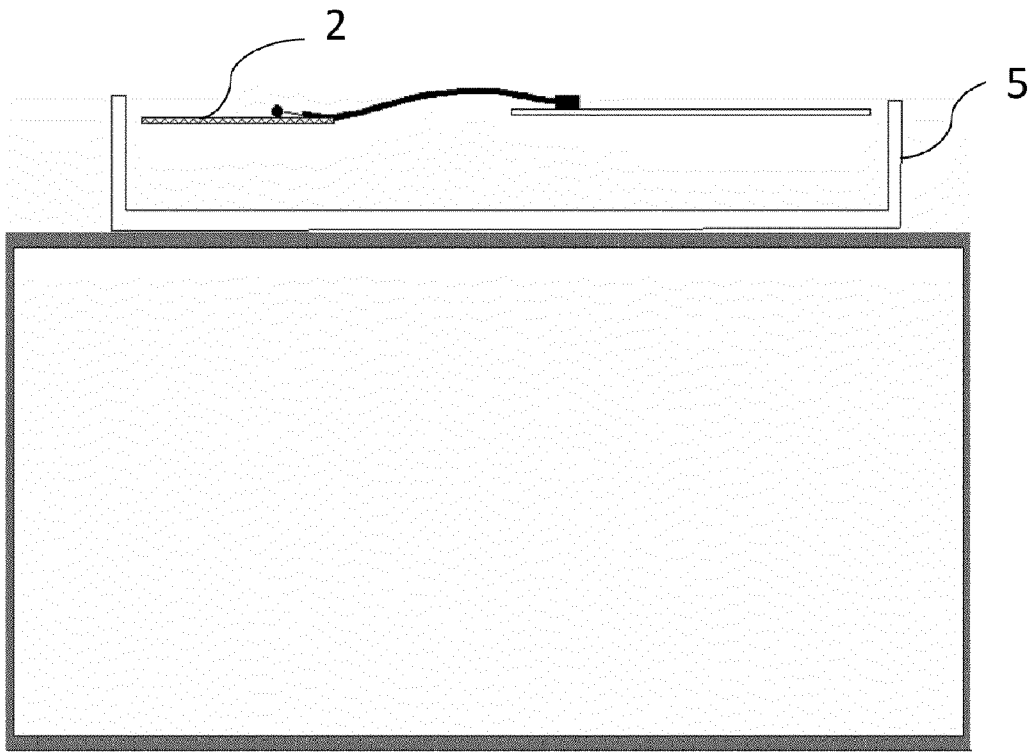

Fig. 1

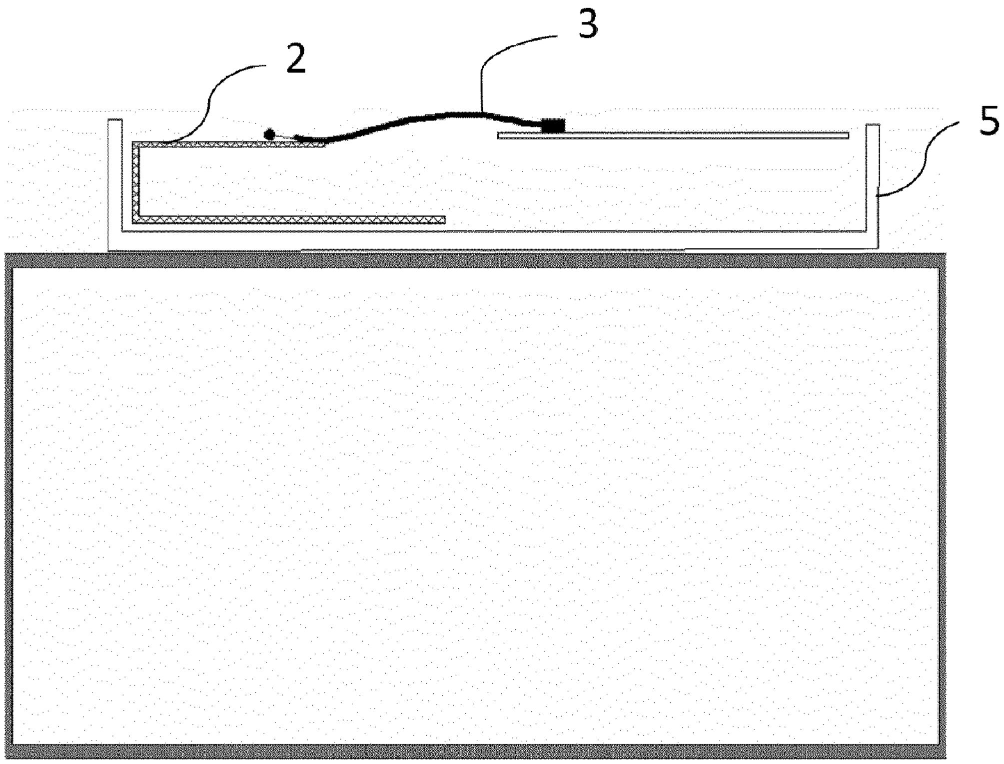

Fig. 2

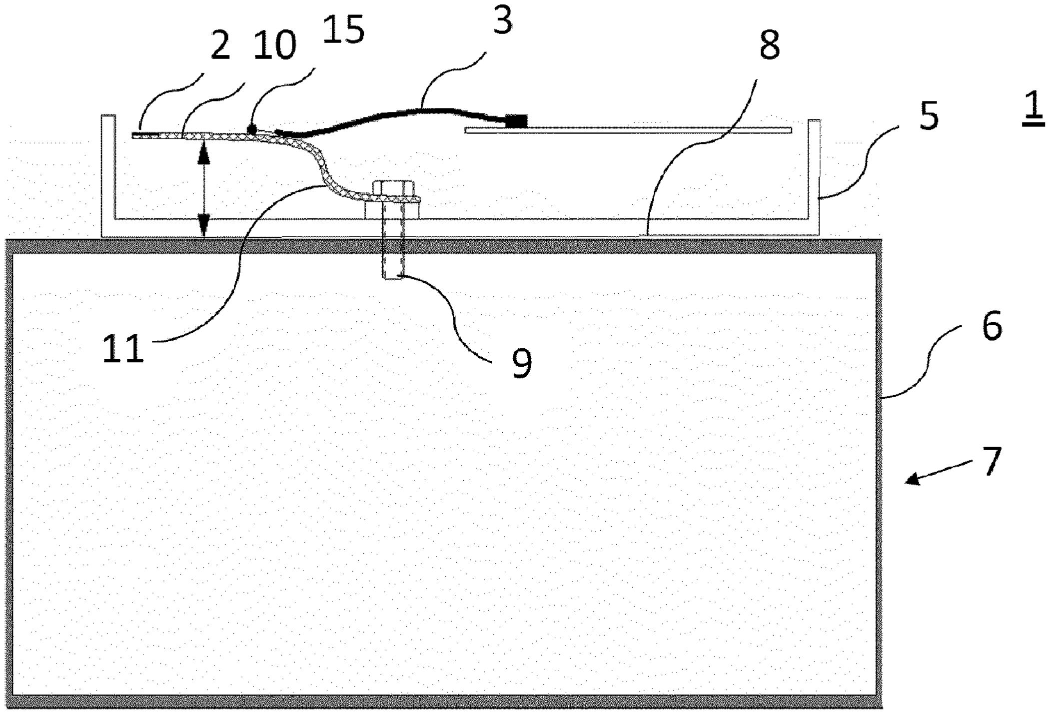

Fig. 3

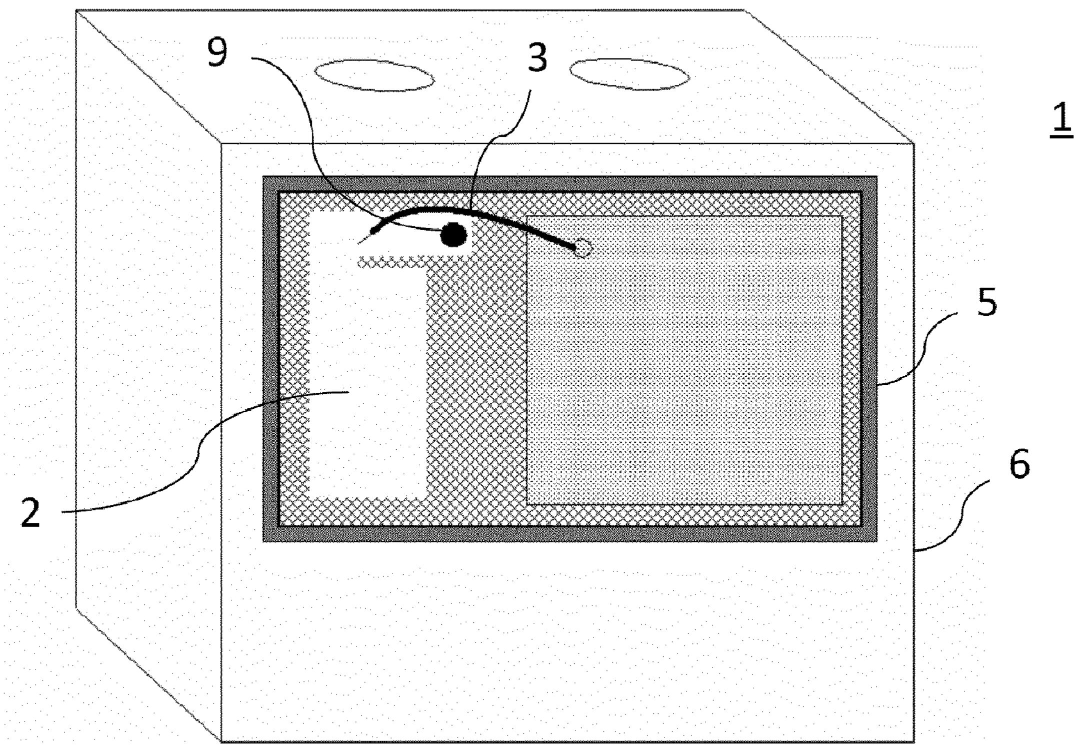

Fig. 4

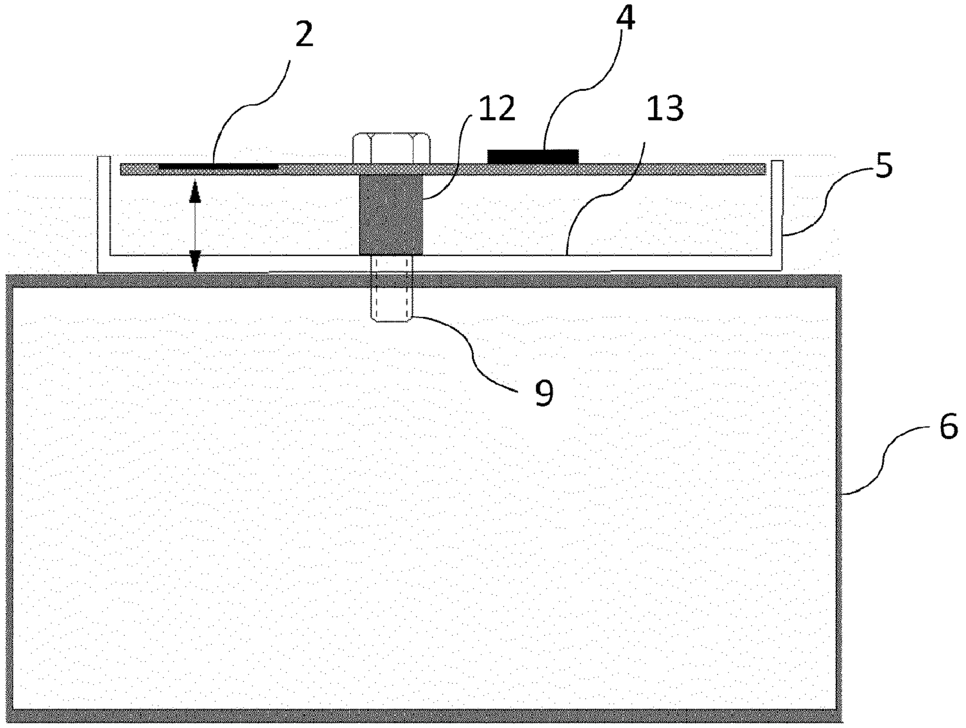

Fig. 5

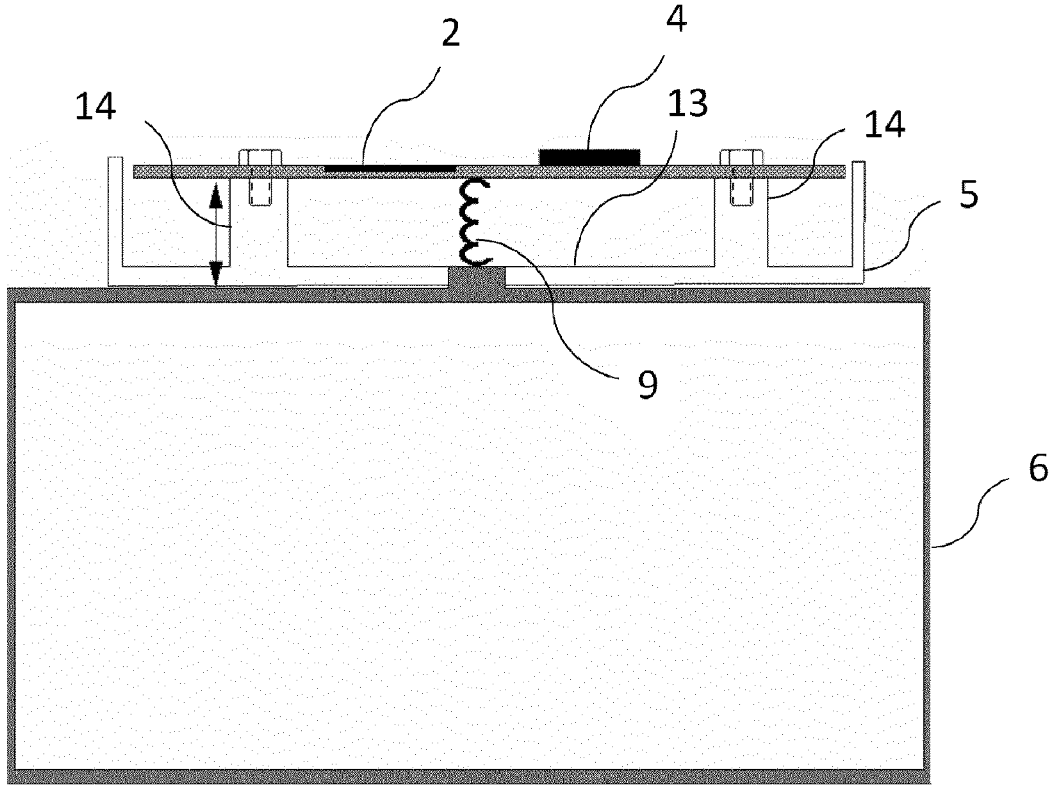

Fig. 6

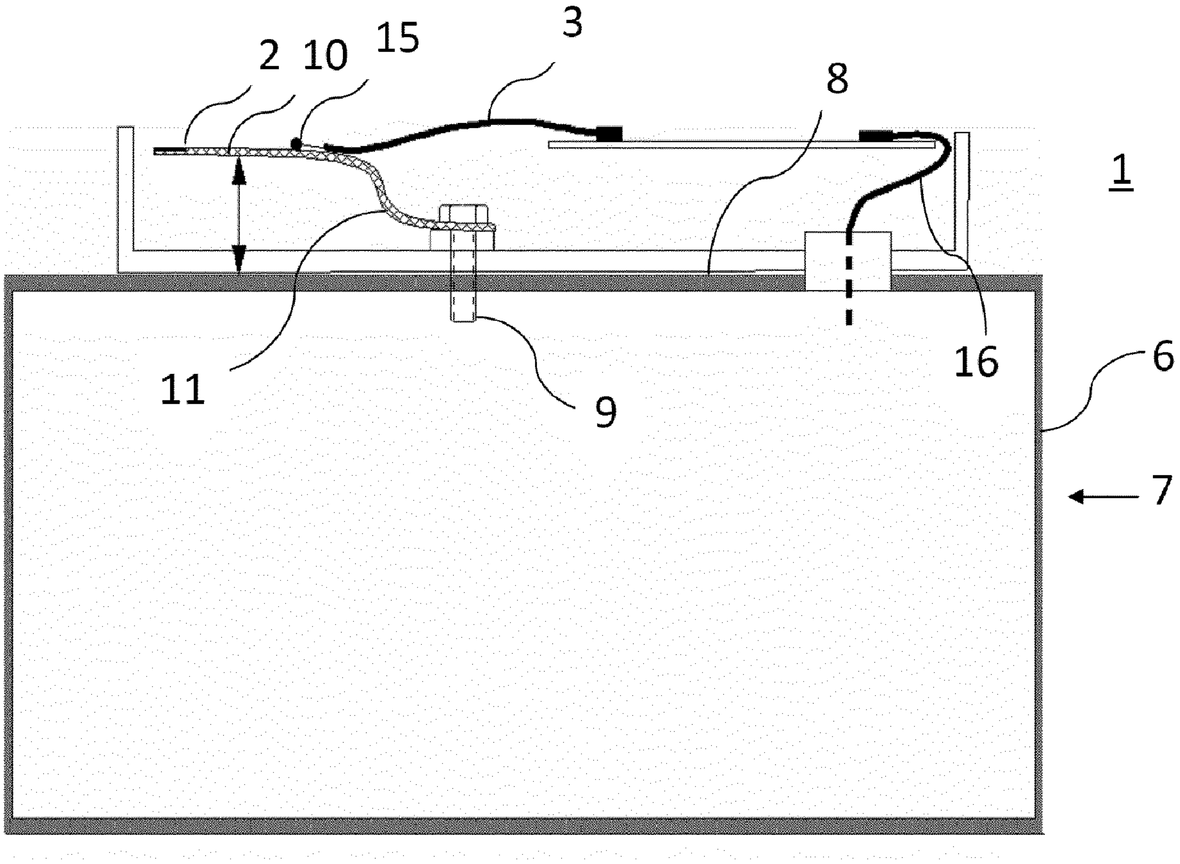

Fig. 7

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EUROPEAN SEARCH REPORT

Application Number
EP 12 18 2491

DOCUMENTS CONSIDERED TO BE RELEVANT

	Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
1	X	US 6 731 920 B1 (IWAI HIROSHI [JP] ET AL) 4 May 2004 (2004-05-04) * abstract; figures 1-2 * * column 8, line 60 - column 9, line 46 * -----	1-15	INV. H01Q1/24 H01Q1/44
1	A	US 2006/017626 A1 (KANNAN ANAND [US] ET AL) 26 January 2006 (2006-01-26) * abstract; figures 1-6 * * page 4, paragraph 35 - page 5, paragraph 48 * -----	1-13	
1	A	US 2011/254741 A1 (ISHIMIYA KATSUNORI [JP]) 20 October 2011 (2011-10-20) * abstract; figure 5 * * page 3, paragraph 50 * * page 4, paragraph 67-70 * -----	1-15	
1	A	FR 2 888 068 A1 (JULLIAN AGNES [FR]) 5 January 2007 (2007-01-05) * abstract * * page 2, line 16 - page 3, line 5 * -----	15	TECHNICAL FIELDS SEARCHED (IPC) H01Q

2 The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
Munich	22 May 2013	Cordeiro, J

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