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(71) Applicant: **POLITECNICO DI MILANO** [IT/IT]; Piazza Leonardo da Vinci, 32, 20133 Milano (IT).

(72) Inventors: **CASTELLI DEZZA, Francesco**; Via Kennedy, 2, 20097 San Donato Milanese (MI) (IT). **MAURI, Marco**; Via Cristo Risorto, 8, 20062 Cassano D'Adda (MI) (IT). **TOSCANI, Nicola**; Via Don Minzoni, 69, 26841 Casalpusterlengo (LO) (IT).

(74) Agent: **ZELIOLI, Giovanni**; BOTTI & FERRARI S.p.A., Via Cappellini, 11, 20124 Milano (IT).

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(54) **Title:** SENSOR APPARATUS FOR BODIES IN RELATIVE ROTATION

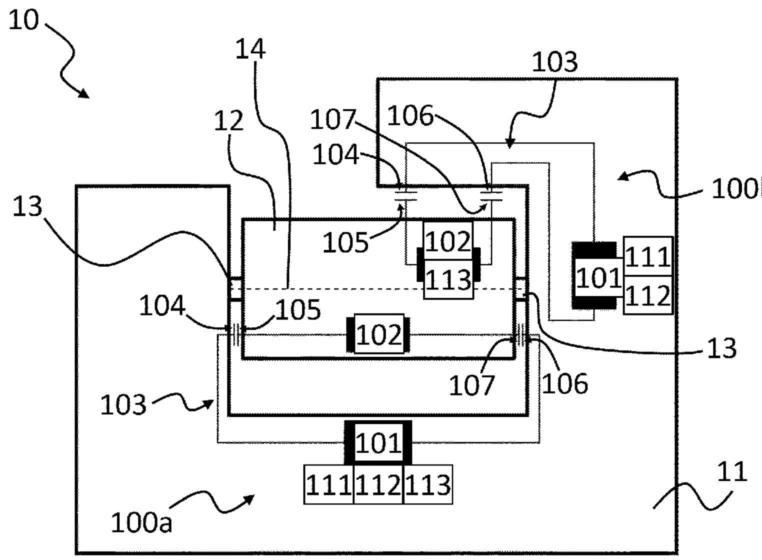

FIG. 1

(57) **Abstract:** Sensor apparatus (100) for a first body (11) and a second body (12) in relative rotation, comprising: a sensor management device (101) arranged on the first body (11); a sensor element (102) arranged on the second body (12); an electrical connection system (103) between the sensor element (102) and the sensor management device (101). The electrical connection system (103) comprises: at least one first plate element (104) constrained to the first body (11) and electrically connected to the sensor management device (101); at least one second plate element (105) constrained to the second body (12) and electrically connected to the sensor element (102). The first plate element (104) and the second plate element (105) are facing each other to provide a capacitive coupling in the electrical connection system (103). The sensor management device (101) comprises at least one power supply (111) configured to electrically power the sensor element (102). The sensor element is powered through the electrical connection system (103).

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Title: Sensor apparatus for bodies in relative rotation

DESCRIPTION

Technical field

The present invention relates to a sensor apparatus for a first body and a second body in relative rotation, with a sensor element and an electrical connection system.

In general, the present invention relates to the transmission of signals for measured or control values, and circuit arrangements for the wireless power supply or the distribution of electrical power.

Prior art

It is known to arrange sensors on parts in relative rotation with respect to the power supply source and/or to the signal processing devices. Said sensors can be of different types, for example: accelerometers, pressure, temperature, electrical voltage or current, environmental quantities, mechanical, chemical sensors, ...

Sensor arrangements for rotating bodies are found both in industrial sectors, for monitoring machinery or processes, and in the traction/propulsion sectors for automotive, railway and aeronautical applications.

Known solutions use sliding contacts for connecting the sensors to the power supply and process control units. Solutions with sliding contacts however implicate difficulties due to the wear of the contacts, the exposure to external elements such as dirt or foreign bodies, which can reduce the reliability of the sensor system.

Document WO03/023731A1 relates to a contact-less data transmission system for rotating machinery which is capable of transferring data from the inside to the outside of the machine, or vice versa. The transmission is performed through two sets of electrical barriers and comprises two sets of brush assemblies which use concentric differential capacitive electrodes without requiring any electrical contact with parts of the machine.

Document EP2642669A1 relates to a system for a contact-less transmission of digital data between two mutually-rotating parts of a machine, comprising a first contact-less data transmitting unit and a second contact-less data transmitting unit, each one of such units being composed of at least one pair of plates for a differential and capacitive signal communication facing and in relative rotation around a rotation axis, each one of such plates being equipped with two pairs of conductive circular paths concentric to such rotation axis.

Document US4242666A relates to a multichannel data acquisition system for measurements on rotating members of operating machinery, having a capacitive coupling link between rotating and stationary members. Electronic circuitry mounted on the rotating member provides a pulse-code modulated signal containing the measured information for transmission through the capacitive coupling link. Power required to operate the rotating circuitry is inductively coupled from a stationary high-frequency source.

Summary of the invention

The object of the present invention is to overcome drawbacks of the prior art.

Further particular object of the present invention is to improve the power supply of a sensor arranged on a part in relative rotation.

Further particular object of the present invention is to allow a better reading of a sensor arranged on a part in relative rotation.

These and other objects are achieved by a sensor apparatus according to the features of the appended claims, which form an integral part of the present description.

An idea underlying the present invention is to provide a sensor apparatus for a first body and a second body in relative rotation. The apparatus comprises a sensor management device arranged on the first body and a sensor element arranged on the second body. An electrical connection system between the sensor element and the sensor management device comprises: at least one first plate element constrained to the first body and electrically connected to the sensor management device; at least one second plate element constrained to the second body and electrically connected to the sensor element. The at least one first plate element and the at least one second plate element are facing each other to provide a capacitive coupling in the electrical connection system. The sensor management device comprises at least one power supply configured to electrically power the sensor element. The sensor element is powered through the electrical connection system.

The sensor apparatus of the present invention provides a capacitive coupling between a first body and a second body in relative rotation, so as to power a sensor element placed on a part of the system in relative rotation with the power supply, and also so as to read and/or process the signal provided by the sensor element.

The first plate element and the second plate element provide surfaces facing each other so as to form a capacitor. In particular, the first plate element and the second plate element are made of electrically conductive materials, preferably of metallic materials.

Advantageously, the sensor apparatus of the present invention allows to improve the power supply of a sensor arranged on a part in relative rotation.

Advantageously, the sensor apparatus of the present invention allows a better reading of a sensor arranged on a part in relative rotation.

Further features and advantages will become more apparent from the detailed description made hereinafter, of non-limiting preferred embodiments of the present invention, and from the dependent claims which outline preferred and particularly advantageous embodiments of the invention.

Brief description of the drawings

The invention is illustrated with reference to the following figures, given by way of a non-limiting example, wherein:

– Figure 1 illustrates a system of bodies in relative rotation, to which embodiments of sensor apparatuses according to the invention are applied.

– Figure 2A outlines a first embodiment of a sensor apparatus according to the present invention.

– Figure 2B outlines a second embodiment of a sensor apparatus according to the present invention.

– Figure 3 exemplifies a first embodiment of the capacitive electrical connection system according to the present invention.

– Figure 4 exemplifies a second embodiment of the capacitive electrical connection system according to the present invention.

– Figure 5 exemplifies a third embodiment of the capacitive electrical connection system according to the present invention.

– Figure 6 exemplifies a sectional view of one half of the electrical connection system of Figure 5.

– Figure 7 exemplifies a fourth embodiment of the capacitive electrical connection system according to the present invention.

– Figure 8 exemplifies a sectional view of one half of the electrical connection system of Figure 7.

– Figure 9 illustrates a variation of Figure 6.

– Figure 10 illustrates a variation of Figure 8.

In the different figures, analogous elements will be identified by analogous reference numbers.

In the same figure, even in the presence of more elements of the same type, sometimes only one will be indicated for clarity of representation, it being understood that the other elements of the same type are also included in the disclosure.

Detailed description

The present invention relates to a sensor apparatus 100, which will be indicated, in the following, sometimes only by the refence 100 and sometimes by the reference 100 followed by a letter in order to distinguish the different embodiments.

Figure 1 illustrates a system 10 of bodies in relative rotation, to which embodiments of sensor apparatuses 100a and 100b are applied.

The system 10 comprises a first body 11 and a second body 12 which are configured for a relative rotation. In this example, the first body 11 comprises rotational supports 13, that is bearings, which are indeed configured to allow the rotation of the second body 12 around the axis 14.

In the present embodiment, two embodiments of the sensor apparatus 100 will be exemplified. They will be described as a unique apparatus, for the sake of brevity, and the differences between the two embodiments will be then highlighted.

The sensor apparatus 100 comprises a sensor management device 101 arranged on the first body 11 and a sensor element 102 arranged on the second body 12. In this sense, the indication "first" body and "second" body is to be understood in a purely indicative and non-hierarchical way:

a body comprises thereon the sensor element (and it will be the “second” body described herein) while the other body comprises thereon the sensor management device (and it will be the “first” body described herein). Practically speaking, if an accelerometer and the related data acquisition control unit are positioned on a railway axle and, for example, the accelerometer will go on the axle and the control unit on the frame, then the axle will be the “second” body and the frame the “first” body. However, various configurations of the sensor apparatus can be provided according to the present invention, with respect to the type of bodies in relative rotation.

The sensor apparatus 100 comprises an electrical connection system 103 between the sensor element 102 and the sensor management device 101.

The electrical connection system 103 comprises at least one first plate element 104 constrained to the first body 11 and electrically connected to the sensor management device 101.

The electrical connection system 103 further comprises at least one second plate element 105 constrained to the second body 12 and electrically connected to the sensor element 102.

The at least one first plate element 104 and the at least one second plate element 105 are facing each other in order to provide a capacitive coupling in the electrical connection system 103.

In this regard, it should be noted that the plate elements are outlined herein with circuital equivalents (capacitors) only on a side of the first body and of the second body, but that real plates should be imagined as arranged to at least partially surround said bodies.

In a preferred embodiment, exemplified herein, the plate elements are circular and “closed”, to surround the bodies along 360° of the structure. In other embodiments, said plate element could be not “closed” according to the available spaces and to the specific geometry, as long as they are adapted to be facing each other in order to provide a capacitive coupling.

Preferably, the electrical connection system 103 further comprises a third plate element 106 constrained to the first body 11 and electrically connected to the sensor management device 101.

Preferably, the electrical connection system 103 further comprises a fourth plate element 107 constrained to the second body 12 and electrically connected to the sensor element 102.

The third plate element 105 and the fourth plate element 106 are also facing each other in order to provide a capacitive coupling in the electrical connection system 103.

Preferably, the sensor management device 101 comprises at least one power supply 111 configured to electrically power the sensor element 102, through the electrical connection system 103.

Preferably, the sensor management device 101 further comprises a converter 112, preferably functioning in square wave or with PWM modulation, for intervening on a power supply current provided by the power supply 111.

Preferably, in an embodiment of the sensor apparatus 100a, the sensor management device 101 comprises a processing system 113 for a signal, and the electrical connection system 103 is configured to transfer said signal.

Preferably, in an embodiment of the sensor apparatus 100b, the sensor element 102 comprises a processing system 113 for a signal and the electrical connection system 103 is configured to transfer said signal, in an analogical or digital mode.

A plurality of processing systems could be provided in the sensor management device and/or the sensor element.

In particular, the processing system 113 comprises an A/D converter and/or a digital transmission system and/or a suitable signal conditioning system, selected based on the specific application of the sensor apparatus 100.

Furthermore, the sensor management device 101 is configured to detect, through the electrical connection system 103, a measure of the sensor element 102.

In general, the sensor apparatus 100 is meant for measuring applications i.e., it provides: a sensor element 102 and a sensor management device 101, and possibly a signal processing unit 113 and a power supply 111.

The sensor element 102 and the sensor management device 101 are on a different part of the system 10 (that is respectively the second body 12 and the first body 11), so as to use the electrical connection system 103 to transfer voltage and/or signal.

In the example of the sensor apparatuses 100a and 100b, two possible arrangements of the system functionalities are illustrated. In the apparatus 100a, the processing unit 113 is on the primary side of the sensor management system 101, while, in the apparatus 100b, it is on the secondary side of the sensor element 102. Other possible solutions can be admitted, swapping the functionalities and exchanging primary with secondary, according to the particular considered application. In fact, it would be possible in principle to also have power supply and sensor on the same side and a processing system on the other side.

Figure 2A outlines a first embodiment of a sensor apparatus 100c according to the present invention, and Figure 2B outlines a second embodiment of a sensor apparatus 100d according to the present invention.

In order to achieve the completely contactless configuration of the sensor apparatus 100c, two systems of plates 104, 105 and 106, 107 can be used. The sensor apparatus 100c represents a preferred embodiment.

As described, the contactless transfer can be aimed both to the power supply of a sensor 102 and to the processing of its measure.

As exemplified by the sensor apparatus 100d, only one system of facing plates 104 and 105 would be enough to allow an energy transfer between the two bodies; in this case, a system 201 of brushes, sliding contacts, bearings, etc. could be for example used as return path for the current. The sensor apparatus 100d represents a less preferred embodiment.

As mentioned, the operating principle is based on the capacitive coupling in the electrical connection system 103: two facing surfaces, for example 104 and 105, behave as a capacitor. An energy transfer among parts in relative rotation, that is the first and the second body, occurs inside a system based on the usage of one or more capacitors, as displayed in the corresponding circuits.

The sensor apparatus 100 provides a configuration which is both able to power the sensor 102 and to process the measure thereof.

Each capacitor 104, 105 or 106, 107 is formed by at least one pair of facing surfaces. A surface 104 or 106 is fixed to the structure on which the electric power source is installed and on which the processing of the signal can occur, while the other surface 105 and 107 is integral with the part of the system on which the sensor 102 is installed.

Both the arrangement of the facing surfaces of the plate elements 104, 105, 106, 107 and the operating frequency of the electrical connection system 103 are key factors for dimensioning the capacity of the capacitors. In fact, for measuring applications, the current and voltage value must be limited in the electrical connection system 103.

For this purpose, it is possible to use a converter 112 which adjusts the voltage and/or current to the load. Furthermore, an accurate analysis of the system on which the sensor apparatus 100 is to be installed allows to identify the operating frequencies, in order to avoid interferences or electromagnetic compatibility issues with the neighboring instrumentation. Once voltage and operating frequency are known, in addition to the current absorbed by the load, it is possible to design the capacitor.

By way of example, it should be imagined having to power a sensor at $V_s = 10$ V rms which can absorb $I_s = 5$ mA rms and which has an input resistance equal to $R_{in} = 100\ \Omega$. Furthermore, it should be imagined having to work at f = 30 kHz, so as not to cause any interference with the neighboring instrumentation.

It is possible to calculate the capacity which allows the correct operation of the system by inverting the relationship which allows the calculation of the module of the impedance between the capacitor and R_{in}:

$$C = \sqrt{1/(\omega^2 ((V_s^2)/(I_s^2) - R_{in}^2))} = 2.66 \text{ nF}$$

The sensor apparatus 100 allows an active and reactive power transfer to the sensor element 102 placed on the second body 12.

In some cases, it can be appropriate to re-phase, by introducing inductive elements. The overall inductance can arrive up to the resonance condition, such that the capacitive nature of the energy transfer system is compensated. For this purpose, it is possible to connect the new reactive element in series to the RC branch or in parallel thereto, according to the needs. The first solution implies an increase of the current under the same power supply conditions, while the second one implies a decoupling between source and load.

The series inductance can be determined by imposing the cancellation of the imaginary part of the impedance seen from the power supply terminals of the circuit, that is:

$$L_s = 1/(\omega^2 C) = 10.60 \text{ mH}$$

This solution can be used in the cases in which the source must only power the sensor, without detecting and/or processing the measure.

Considering the example mentioned previously, the dimensioning of the inductor L_p is proposed. In this case:

$$L_p = (R_{in}^2 + 1/(\omega^2 C^2)) C = 10.62 \text{ mH}$$

In this case, the solutions with series resonance contribute to reduce the switching losses.

The selection of the switching frequency also depends on the selection of the technology of the semiconductors.

The converter 112 can be able to dynamically vary the switching frequency in order to be able to follow the resonance conditions when the parameters of the circuit vary (due to variations of the load, of the mechanical characteristics of the capacitive coupler, due to overheating of the parts, ...).

It is possible to use the same system also with more reduced functionalities, that is only to detect the measure and process it, without simultaneously powering the sensor. A possible solution can be to superimpose the signal to the power supply by sufficiently separating them in frequency, or to provide power cycles of the sensor element 102 and detection cycles of the signal.

Figure 3 exemplifies a first embodiment 300 of the plate elements of a capacitive electrical connection system.

In this embodiment 300, the at least one first plate element and the at least one second plate element comprise one or more annulus-shaped plates.

Figure 4 exemplifies a second embodiment 400 of the plate elements of a capacitive electrical connection system.

In this embodiment 400, the at least one first plate element and the at least one second plate element comprise one or more cylinder-shaped concentric plates.

In general, the at least one first plate element and the at least one second plate element define a gap configured to avoid contacts or sliding, so as to provide a capacitive coupling without electrical discharges.

The capacitive coupling is provided by facing at least two conductive surfaces of the plate elements with respect to each other. Depending on the available space, on the power supply conditions and on the needs of the sensor element, it is possible to use (vertically beside) annulus-shaped or (horizontally beside) cylinder-shaped concentric plates, or a combination thereof.

Obviously, (at least) one pair of plate elements form a capacitor.

Each plate element must be fixed to only one respective part of the bodies in relative rotation.

Figure 5 exemplifies a third embodiment 500 of the capacitive electrical connection system according to the present invention, while Figure 6 exemplifies a sectional view of one half thereof, rotatable with respect to the axis 14.

In this embodiment, the at least one first plate element 501 and the at least one second plate element 502 comprise a combination of annulus-shaped plates and cylinder-shaped concentric plates, which are nested with respect to each other in order to minimize the encumbrance.

As visible, the at least one first plate element 501 is constrained in integral rotation exclusively with the first body 11, while the at least one second plate element 502 is constrained in integral rotation exclusively with the second body 12.

Figure 7 exemplifies a fourth embodiment 700 of the capacitive electrical connection system according to the present invention, while Figure 8 exemplifies a sectional view of one half thereof.

In this embodiment, the at least one first plate element 701 and the at least one second plate element 702 comprise a combination of annulus-shaped plates and cylinder-shaped concentric plates, which are nested with respect to each other in order to minimize the encumbrance.

As visible, the at least one first plate element 701 is constrained in integral rotation exclusively with the first body 11, while the at least one second plate element 702 is constrained in integral rotation exclusively with the second body 2.

Particularly considering the embodiments of the capacitors 500 and 700, the following general considerations can be made.

Considering a target capacity value for each capacitor, it can be appropriate to connect more than two facing surfaces in parallel, since the dimensions for only one pair of conductors could be unattainable or for structural reasons connected to the manufacturing of the surfaces (for example too long plates which could lead to contact and/or breaking due to flexing during the rotation).

In other words, it could be appropriate to increase the number of facing surfaces of the plate elements, in order to provide enough capacitive coupling which allows functionality for the specific system.

For example, a series of plate elements could be provided, in number of two or more, which are coaxial and connected in parallel with respect to each other on each of the bodies in relative rotation. This configuration has the advantage of improving the capacitive coupling with the same radial encumbrance of the system.

The limit of number of surfaces for the plate elements is given by the space availability in the structure on which the sensor apparatus is to be installed.

In case of need, it would be anyway possible to divide the whole capacity among two or more capacitors by connecting them in parallel.

Suitable configurations with supports for fixing of the plate elements to the two moving parts can be evaluated.

If the bodies 11 and 12 are made of conductive materials, a suitable non-conductive material (not shown in the Figures) should be provided to the interface between the bodies 11 and 12 and the plate element 501, 502 and 701, 702, so as to guarantee the effectiveness of the capacitive coupling inside the electrical connection system 103.

It is appropriate to provide a small air gap between the two systems of facing surfaces in order to avoid scraping during the movements of the system. For the installation, it is advisable to provide each part in two halves and suitably displace them during the installation.

Referring to the example already discussed, an internal cylinder with radius of 100 mm should be considered. For the sake of simplicity, the configuration with vertically arranged surfaces should be considered. It is supposed to consider that the thickness of the plates and the distance between them is equal to 1 mm. It should be remembered that it is always possible to determine the capacity of a capacitors as:

$$C = \varepsilon S / d$$

wherein ε is the dielectric permittivity of the means between the plates. For the sake of simplicity, it should be considered air as dielectric (so $\varepsilon = \varepsilon_0$). It is possible to determine the surface of each conductor according to the number of facing conductors n:

$$S_n = C d / (n \varepsilon_0)$$

Considering the numerical results reported above, the following surfaces 0.300, 0.150, 0.100, 0.075 and 0.060 m2 are determined for 1, 2, 3, 4 and 5 pairs of facing surfaces, respectively. Considering the configuration with 5 pairs, a height of the capacitor is obtained which is equal to:

$$h = S_5 / (2 \pi r) = 95.61 \text{ mm}$$

with r representing the radius of the internal cylinder. The analyses made with software to the finished elements confirm that a structure analogous to example 500 or 700 and suitably intuitively modified so as to obtain 5 facing surfaces, is such as to have a capacity equal to 2.79 nF, indeed according to the target capacity value of 2.66 nF.

In case of installations of two or more capacitors in the system, it is possible to arrange each device one above the other along the axis both for the solution with horizontal surfaces and the one with vertical surfaces. It is possible to envisage the possible insertion of shields which allow the decoupling between different capacitors or a suitable spacing along the cylinder.

In cases in which it is not possible to increase the number of plates, it can be appropriate to provide dielectric fluid (for example dielectric oil) between the plates, provided that it does not introduce too high viscous frictions. For this purpose, it is appropriate to enclose each capacitor in a hermetic case in order to avoid dielectric dispersions inside the system.

Figure 9 illustrates a variation 500b of Figure 6 and Figure 10 illustrates a variation 700b of Figure 8.

In the embodiments 500b and 700b, the at least one first plate element 501 or 701 and/or the at least one second plate element 502 or 702 comprise beveled edges.

Said bevels included in the manufacturing of the facing surfaces are advantageously configured to avoid excessive electric field accumulation at the edges.

Industrial applicability

The sensor apparatus of the present invention finds advantageous application where the arrangement of sensors (accelerometers, pressure, temperature, electrical voltage or current, environmental quantities, mechanical, chemical sensors, ...) is provided on parts in relative rotation with respect to the power supply source and/or to the processing devices of the signals.

The applications could be both in industrial sectors, for example for monitoring machinery or processes, and in the traction/propulsion sector such as the automotive, railway and aeronautical sector.

Considering the description given above, the skilled person can provide further modifications and variations, in order to satisfy contingent and specific needs.

For example, the sensor apparatus and in particular the corresponding plate elements can be adapted from a mechanical point of view based on the available spaces and working conditions.

For example, the sensor apparatus and in particular the corresponding sensor management devices 101 and the electrical connection system 103 can be adapted from an electrical and signal processing point of view based on the specifics of the whole system and of the sensor element 102.

The embodiments described herein are therefore to be intended as illustrative and non-limiting examples of the invention.

CLAIMS

1. Sensor apparatus (100) for a first body (11) and a second body (12) in relative rotation, comprising:

a sensor management device (101) arranged on said first body (11);

a sensor element (102) arranged on said second body (12);

an electrical connection system (103) between said sensor element (102) and said sensor management device (101), comprising:

- at least one first plate element (104) constrained to said first body (11) and electrically connected to said sensor management device (101);

- at least one second plate element (105) constrained to said second body (12) and electrically connected to said sensor element (102);

wherein said at least one first plate element (104) and said at least one second plate element (105) are facing each other to provide a capacitive coupling in said electrical connection system (103);

wherein said sensor management device (101) comprises at least one power supply (111) configured to electrically power said sensor element (102),

and wherein said sensor element is powered through said electrical connection system (103).

2. Sensor apparatus according to claim 1, wherein said sensor management device (101) further comprises a converter (112), preferably functioning in square wave or with PWM modulation, for intervening on a power supply current provided said by at least one power supply (111).

3. Sensor apparatus according to claim 1 or 2, wherein said sensor management device (101) and/or said sensor element (102) comprises a processing system (113) for a signal, wherein said electrical connection

system (103) is further configured to transfer said signal.

4. Sensor apparatus according to claim 3, wherein said processing system (113) comprises an A/D converter and/or a digital transmission system and/or a signal conditioning system.

5. Sensor apparatus according to any one of claims 1 to 4, wherein said sensor management device (101) is further configured to detect a measure of said sensor element (102).

6. Sensor apparatus according to any one of claims 1 to 5, wherein said at least one first plate element (104) and said at least one second plate element (105) comprise: A. one or more annulus-shaped plates (300); B. one or more cylinder-shaped concentric plates (400); combinations of A. and B (500, 700).

7. Sensor apparatus according to claim 6, wherein said at least one first plate element (104) and said at least one second plate element (105) define a gap configured to avoid contacts or sliding and to provide a capacitive coupling without electrical discharges.

8. Sensor apparatus according to claim 6 or 7, wherein said at least one first plate element (104) and/or said at least one second plate element (105) comprise beveled edges (500b, 700b) configured to mitigate electrical field accumulation.

9. Sensor apparatus according to any one of claims 1 to 8, wherein said electrical connection system (103) further comprises:

- a third plate element (106) constrained to said first body (11) and electrically connected to said sensor management device (101);

- a fourth plate element (107) constrained to said second body (12) and electrically connected to said sensor element (102);

wherein said third plate element (106) and said fourth plate element (107) are facing each other to provide a capacitive coupling in said electrical connection system (103).

10. Sensor apparatus according to any one of claims 1 to 9, wherein said at least one first plate element (104) is constrained in integral rotation exclusively with said first body (11), and wherein said at least one second plate element (105) is constrained in integral rotation exclusively with said second body (12).

11. Sensor apparatus according to any one of claims 1 to 10, wherein said first body (11) comprises rotational supports (13) configured to allow the rotation (14) of said second body (12).

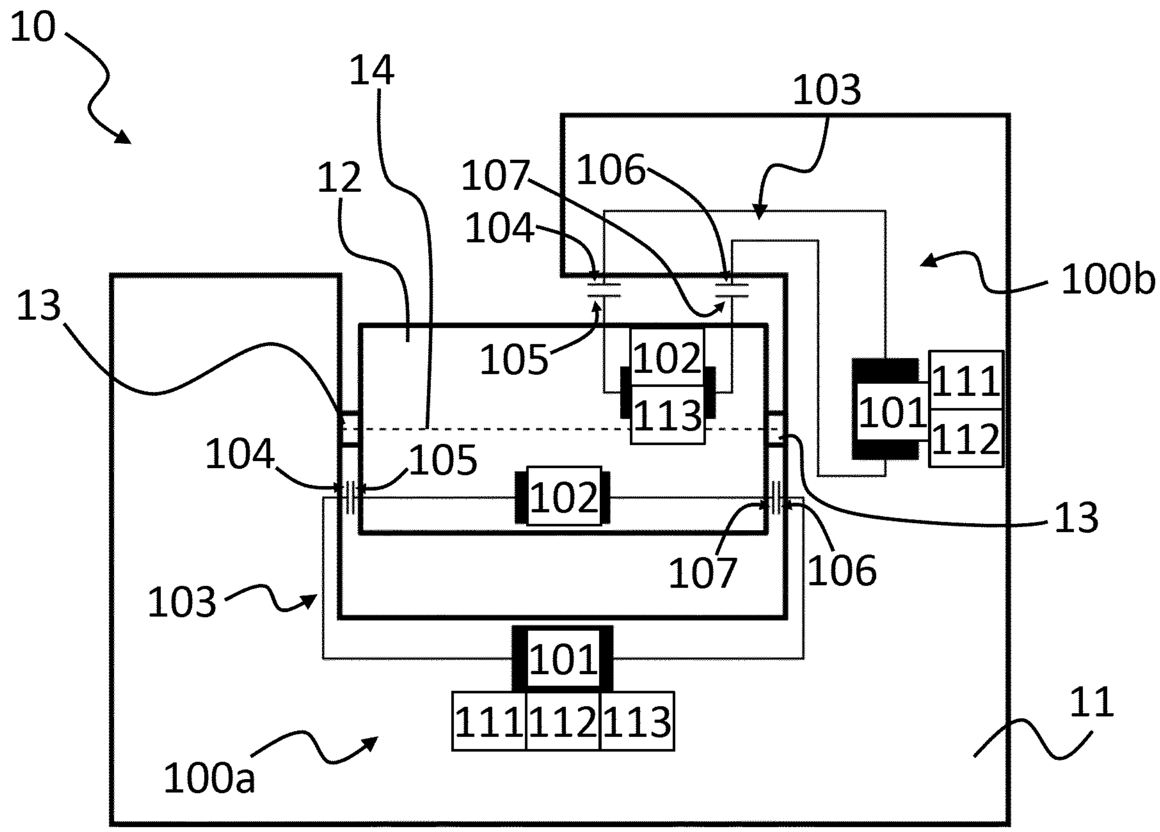

FIG. 1

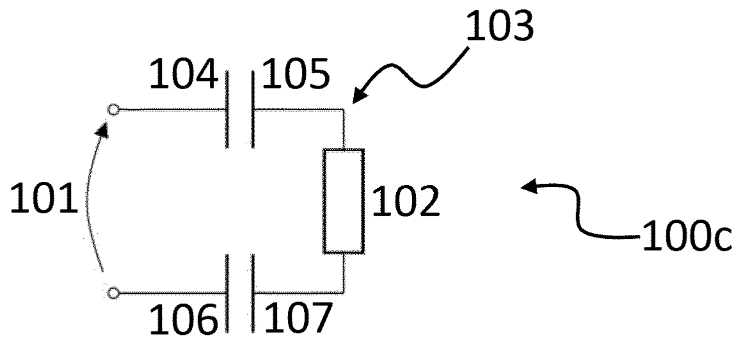

FIG. 2A

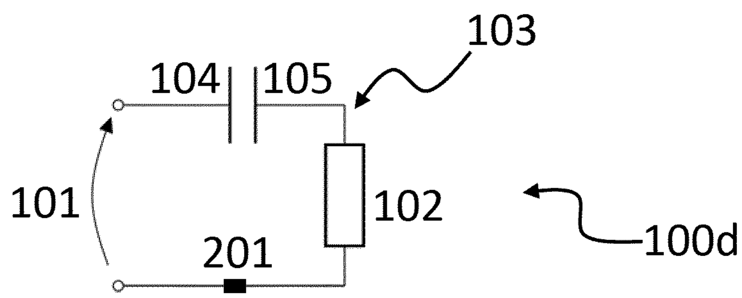

FIG. 2B

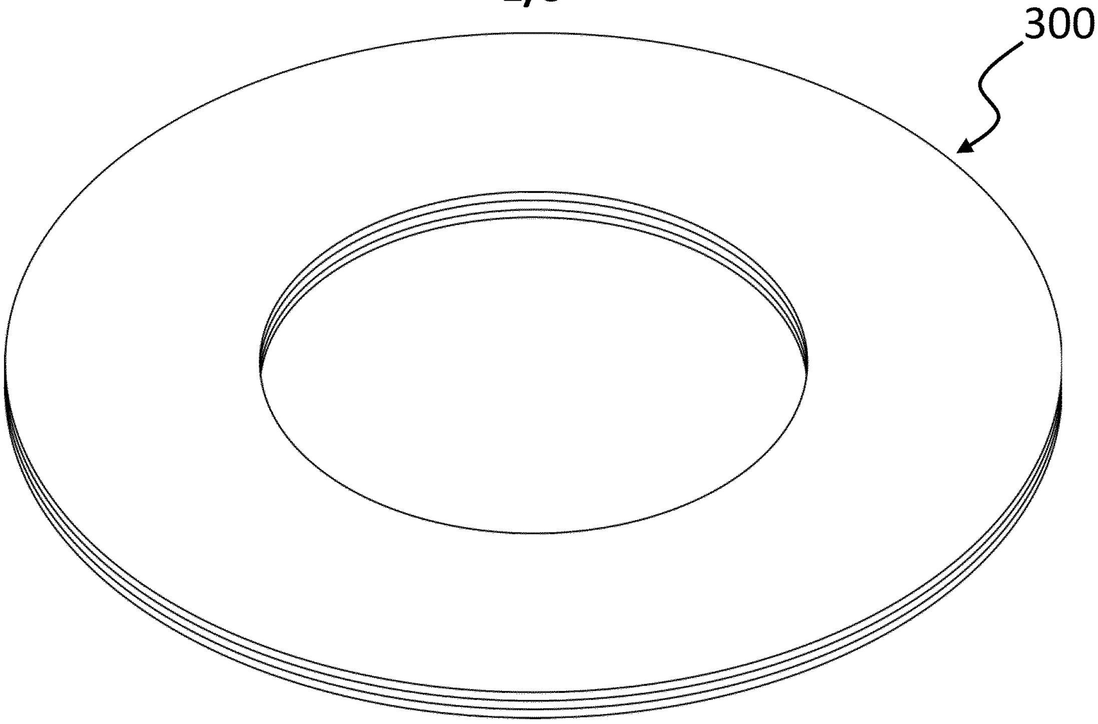

FIG. 3

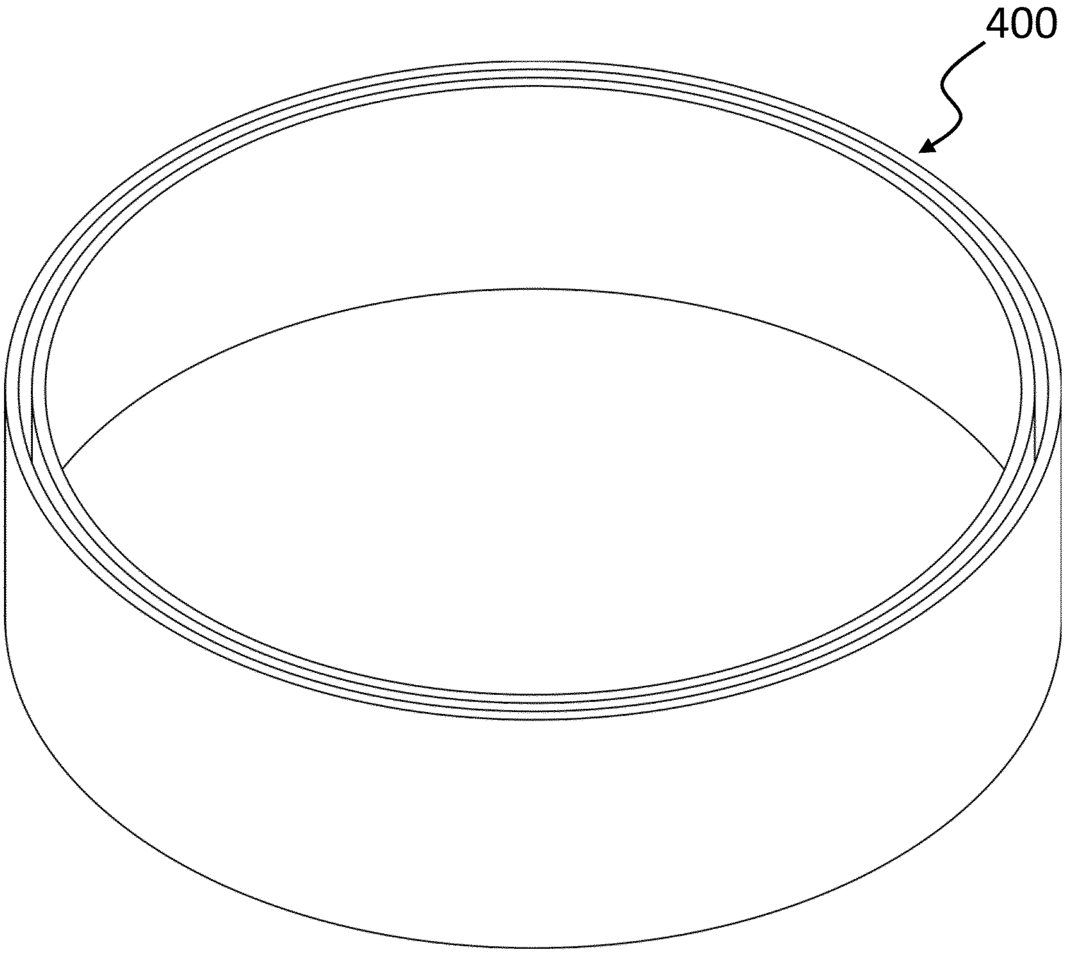

FIG. 4

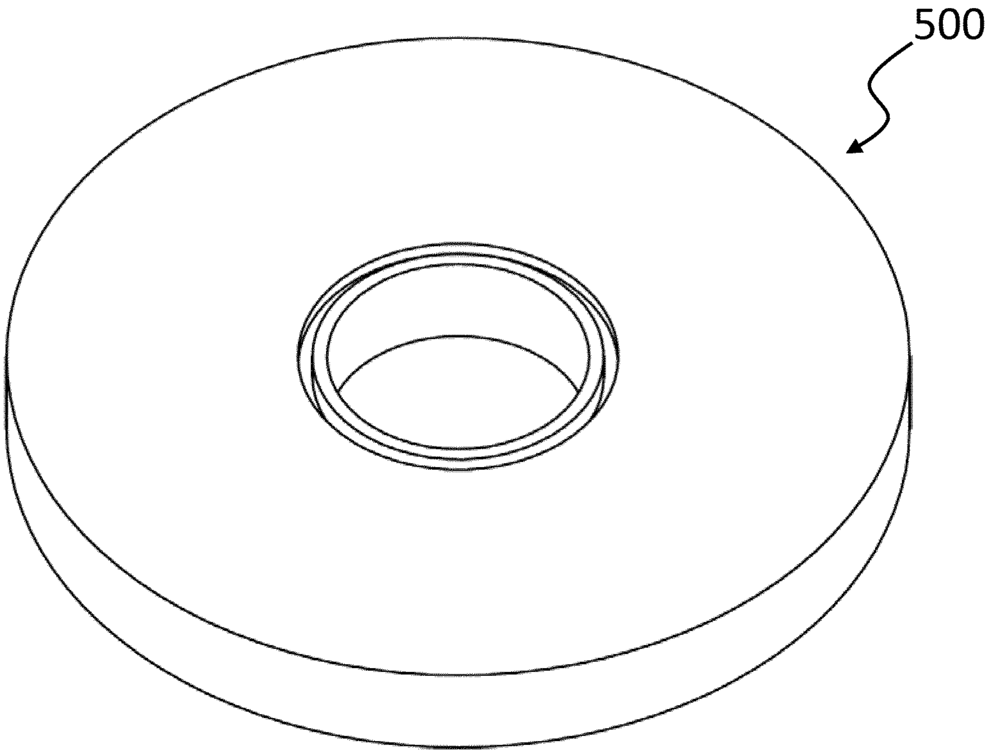

FIG. 5

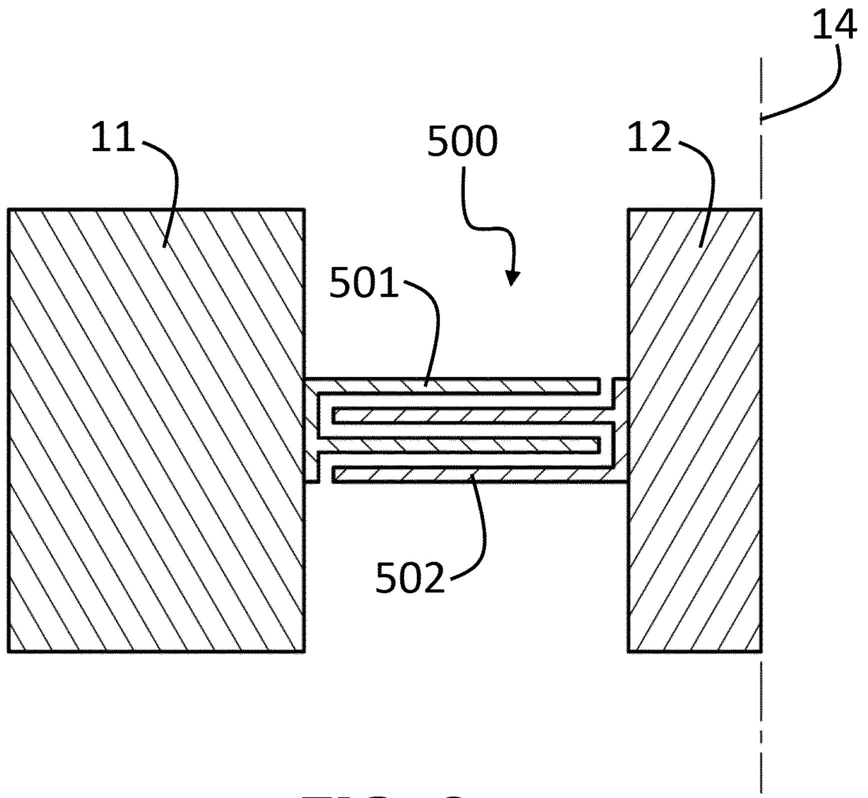

FIG. 6

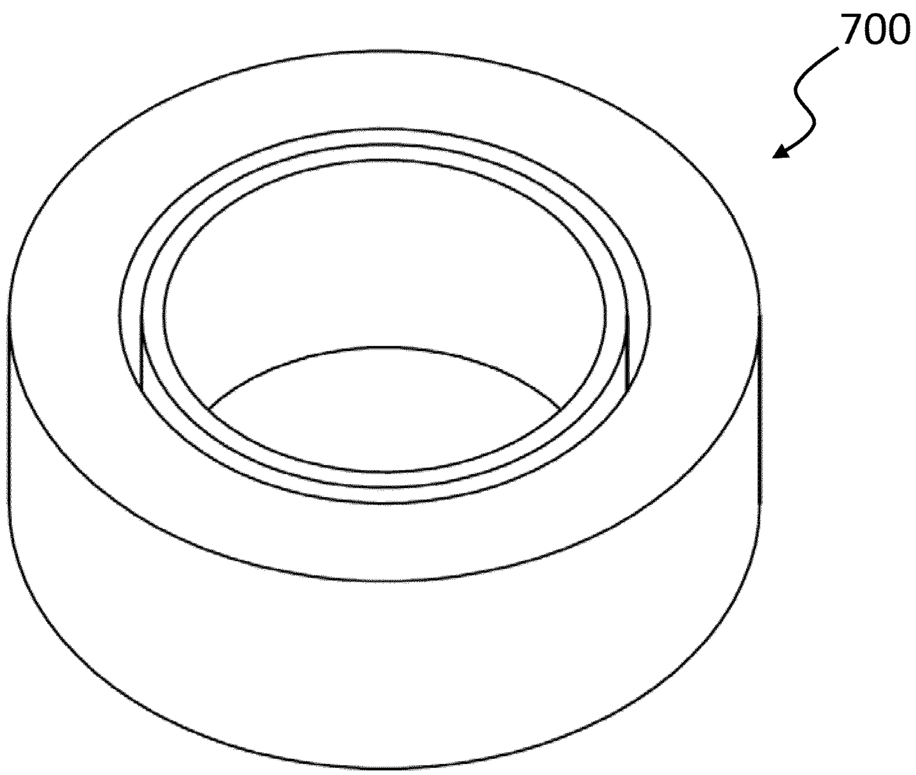

FIG. 7

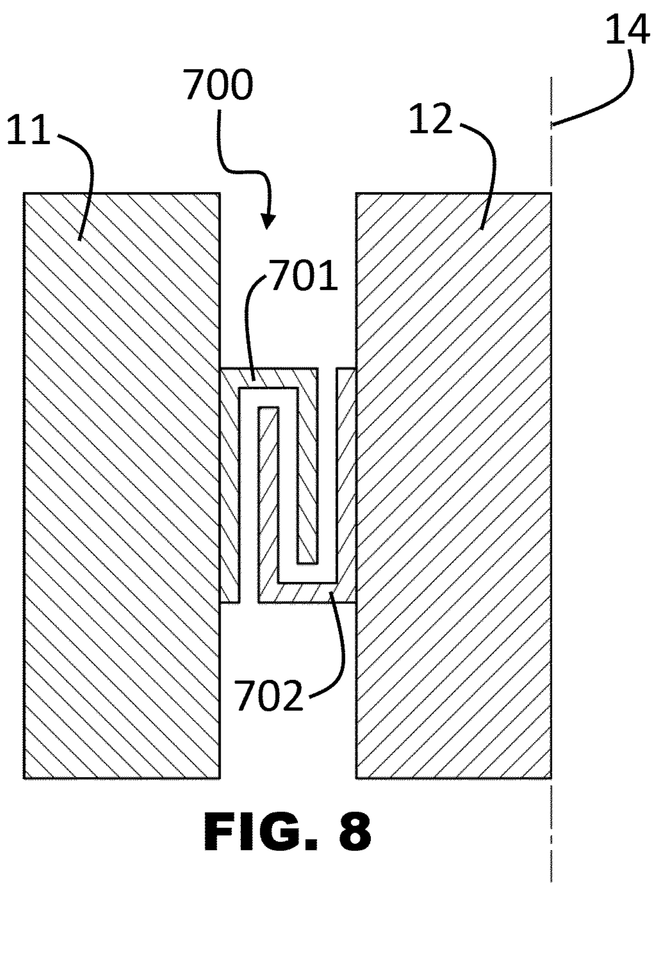

FIG. 8

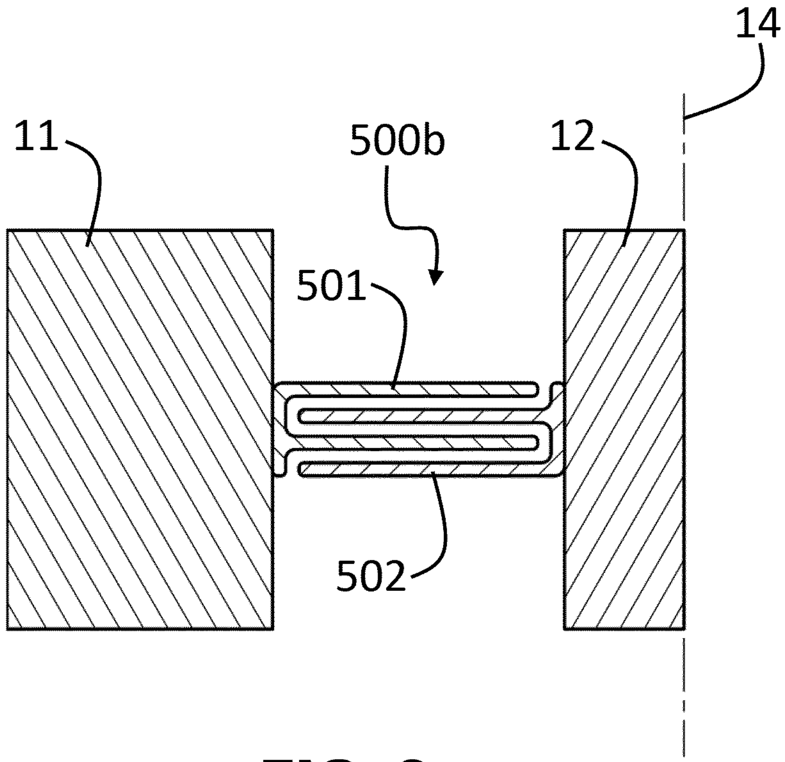

FIG. 9

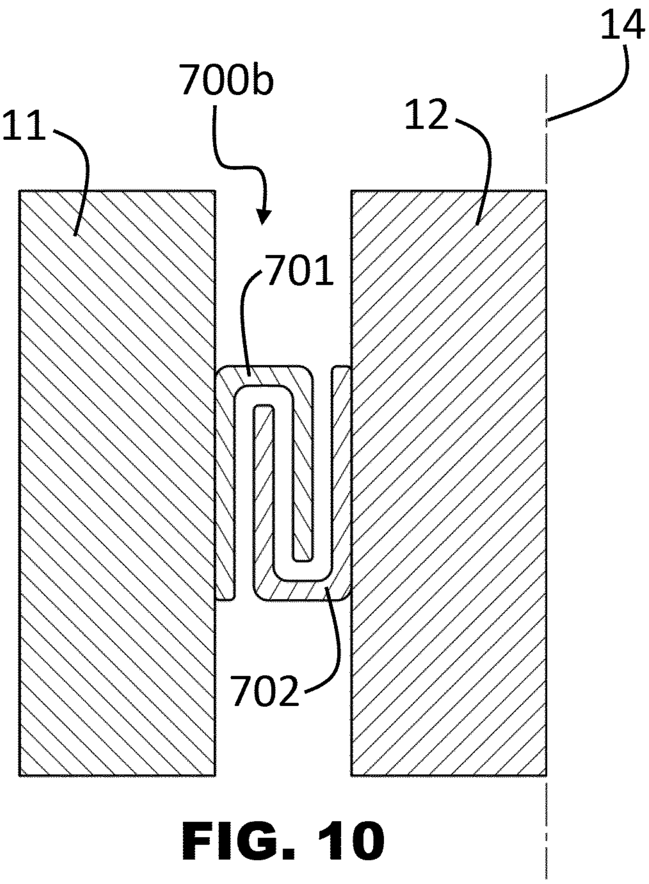

FIG. 10

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2023/056299

A. CLASSIFICATION OF SUBJECT MATTER
INV. G08C17/06 H04Q9/00 H04B5/00
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G08C H04Q H04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	WO 03/023731 A1 (HASSAN HALIL [GB]) 20 March 2003 (2003-03-20) page 1, paragraph 1-2 page 2, paragraph 2-3 page 3, paragraphs 2, 3 page 6, paragraph 1-2 claim 1 figures 3, 6 page 4, paragraph 6-7 page 5, paragraph 4-7 -----	1-11
A	EP 2 642 669 A1 (ASA RT S R L [IT]) 25 September 2013 (2013-09-25) paragraph [0001] paragraph [0005] paragraph [0011] - paragraph [0016] claim 1 figures 1, 2 -----	1
	-/--	

[x] Further documents are listed in the continuation of Box C.

[x] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
30 May 2023	07/06/2023

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Barbelanne, Alain

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 242 666 A (HUNT GERALD P [US] ET AL) 30 December 1980 (1980-12-30) column 1, line 65 - column 2, line 13 column 2, lines 43-49 column 3, lines 15-23 column 3, lines 52-63 column 5, lines 5-21 claim 1 figure 2 -----	1
Y	WO 2021/148831 A1 (TOTAL SE [FR]) 29 July 2021 (2021-07-29) page 1, lines 3-12 page 1, line 21 - page 2, line 14 page 6, lines 4-17 page 7, lines 4-13 page 8, lines 22-34 page 13, lines 3-5 page 14, lines 23-27 claims 1-2, 5, 15 -----	1-11
Y	US 10 309 516 B2 (SIEMENS AG [DE]; FLENDER GMBH [DE]) 4 June 2019 (2019-06-04) column 3, lines 4-9 claims 1-2, 10-12 -----	1-11

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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