**(12) STANDARD PATENT APPLICATION** (11) Application No. **AU 2026201556 A1**
**(19) AUSTRALIAN PATENT OFFICE**

(54) Title
**Electrical sensor assembly**

(51) International Patent Classification(s)
***G01R 15/14*** (2006.01) ***G01R 21/00*** (2006.01)
***G01R 15/16*** (2006.01) ***G01R 21/06*** (2006.01)

(21) Application No: **2026201556** (22) Date of Filing: **2026.02.27**

(43) Publication Date: **2026.03.19**
(43) Publication Journal Date: **2026.03.19**

(62) Divisional of:
**2019401573**

(71) Applicant(s)
**G & W Electric Company**

(72) Inventor(s)
**BAUER, Alberto**

(74) Agent / Attorney
**Griffith Hack, Level 15, 376-390 Collins Street, Melbourne, VIC, 3000, AU**

## ABSTRACT

A sensor assembly includes a connecting bar extending along a longitudinal axis and a tubular body extending along the longitudinal axis and at least partially surrounding the connecting bar such that the tubular body is radially spaced from the connecting bar. The tubular body includes a support member made of insulating material. The tubular body also includes a first section with an electric field sensor comprising a first layer of electrically conductive material on an inner surface of the support member to detect an electric field produced by the connecting bar. The first section also includes a first electric screen comprising a second layer of electrically conductive material on an outer surface of the support member to shield the electric field sensor from outside electrical interference. A second section disposed adjacent the first section includes a second electric screen. A dielectric material at least partially encloses the tubular body.

# ELECTRICAL SENSOR ASSEMBLY

## CROSS-REFERENCE TO RELATED APPLICATIONS

**[0001]** This application is a divisional application of Australian application No. 2019401573, which claims priority to Italian Patent Application No. 102018000011146, filed December 17, 2018, and to Italian Utility Model Application No. 202018000003942, filed December 17, 2018, the entire contents of each of which are incorporated herein by reference.

## FIELD OF THE DISCLOSURE

**[0002]** The present disclosure relates to an electrical sensor assembly, preferably intended for electrical transformers, electrical cabinets and other similar structures, that enables the electric field generated by a live connecting bar to be detected, for example to detect the voltage value of said connecting bar in relation to the detected electric field.

**[0003]** More specifically, the present disclosure relates to a sensor assembly that is able to detect the electric field generated by the connecting bar without being influenced by any surrounding electrical fields, such as the fields generated by other conductors arranged nearby.

## BACKGROUND

**[0004]** Electrical sensor assemblies of the aforementioned type are known, but suffer from a series of drawbacks.

**[0005]** A first drawback is that said known sensor assemblies do not enable the electric field generated by the connecting bar to be detected without being influenced by other surrounding fields.

**[0006]** A second drawback is that said known sensor assemblies are somewhat large.

**[0007]** A third drawback is that said known sensor assemblies do not enable electrical fields and/or related magnitudes to be measured with sufficient accuracy.

**[0008]** A fourth drawback is that said known sensor assemblies are not immune to surrounding electrical fields generated, for example, by other conductors arranged nearby.

**[0009]** A fifth drawback is that said known sensor assemblies do not enable electrical fields and/or related magnitudes to be measured with sufficient accuracy in the presence of temperature variations.

**[0010]** A sixth drawback is that said known sensor assemblies do not retain over time the technical features required to perform the function of the sensor assembly and/or to maintain the required safety level (partial discharges, detachment, rapid ageing, etc.).

**[0011]** A seventh drawback is that said known sensor assemblies are complex and costly to make.

**[0012]** An eighth drawback is that, in said known sensor assemblies, the resin of dielectric material placed about the components of the sensor assembly have cavities (air bubbles), which results in unwanted partial discharging.

**[0013]** A ninth drawback is that, in said known sensor assemblies, said resin is detached from the elements that comprise the capacitive sensor, which results in unwanted partial discharging.

**[0014]** A tenth drawback is that, in said known sensor assemblies, said resin is not perfectly bonded and/or stuck and/or linked to the components that form the sensor assembly and consequently, ageing causes said resin to become detached from said members, which results in unwanted partial discharging. This drawback is particularly common where the sensor assembly is used in an environment in which the operating temperature (hot/cold) varies cyclically.

## SUMMARY

**[0015]** It would be desirable for sensor assemblies to resolve one or more of the aforementioned drawbacks.

**[0016]** The present disclosure provides, in one aspect, a sensor assembly comprising: an electrode extending along a longitudinal axis; a first tubular section extending along the

longitudinal axis and at least partially surrounding the electrode such that the first tubular section is radially spaced from the electrode, the first tubular section including a support layer made of an insulating material, and a first tubular electric field sensor comprising a first layer of electrically conductive material disposed on an inner surface of the support layer, the first electric field sensor configured to detect an electric field produced by the electrode; a first electric screen of electrically conductive material disposed outside the support layer; a second tubular section extending along the longitudinal axis and linked to the first tubular section, the second tubular section including a second layer of electrically conductive material electrically isolated from the first layer of electrically conductive material and from the first electric screen, wherein the second layer of electrically conductive material is configured to function as either (i) a second electric screen to shield the first electric field sensor from outside interference or (ii) a second electric field sensor to detect an electric field produced by the electrode; and a dielectric material at least partially enclosing the first electric screen and the first and second tubular sections, wherein the dielectric material is cast around and within the first and second tubular sections such that the dielectric material fills through openings in the first electric screen.

**[0017]** The present disclosure provides, in another aspect, a sensor assembly including a connecting bar extending along a longitudinal axis and a tubular body extending along the longitudinal axis and at least partially surrounding the connecting bar such that the tubular body is radially spaced from the connecting bar. The tubular body includes a support member made of an insulating material, the support member including an inner surface, an outer surface opposite the inner surface, and a plurality of cantilevered tabs extending parallel to the longitudinal axis. The tubular body also includes an electric field sensor comprising a first layer of electrically conductive material disposed on the inner surface of the support member, the electric field sensor configured to detect an electric field produced by the connecting bar, and a first electric screen comprising a second layer of electrically conductive material disposed on the outer surface of the support member, the first electric screen configured to shield the electric field sensor from outside electrical interference. The sensor assembly also includes a dielectric material at least partially enclosing the tubular body. Adjacent tabs of the plurality of cantilevered tabs are circumferentially spaced in order to form axial through openings therebetween.

**[0018]** The present disclosure provides, in another aspect, a sensor assembly including a connecting bar extending along a longitudinal axis and a body extending along the longitudinal axis and at least partially surrounding the connecting bar such that the body is radially spaced from the connecting bar. The body includes a support member made of an insulating material, with an inner surface and an outer surface. The body also includes a first section having an electric field sensor comprising a first layer of electrically conductive material disposed on the inner surface of the support member, the electric field sensor configured to detect an electric field produced by the connecting bar, and a first electric screen comprising a second layer of electrically conductive material disposed on the outer surface of the support member. The body also includes a second section having a second electric screen comprising a third layer of electrically conductive material, and a third section including a third electric screen comprising a fourth layer of electrically conductive material. The sensor assembly also includes a dielectric material at least partially enclosing the body. The first section is disposed between the second section and the third section along the longitudinal axis, and the first layer, the second layer, the third layer, and the fourth layer are electrically isolated from one another.

**[0019]** The present disclosure provides, in another aspect, a sensor assembly comprising: an electrode extending along a longitudinal axis; a first tubular section extending along the longitudinal axis and at least partially surrounding the electrode such that the first tubular section is radially spaced from the electrode, the first tubular section including a support layer made of an insulating material, and a first electric field sensor comprising a first layer of electrically conductive material disposed on an inner surface of the support layer, the first electric field sensor configured to detect an electric field produced by the electrode; a first electric screen of electrically conductive material disposed outside the support layer; a second tubular section electrically isolated from the first tubular section and spaced from the first tubular section axially along the longitudinal axis, the second tubular section including wire mesh or a second layer of electrically conductive material, wherein the wire mesh or second layer of electrically conductive material can be configured to function as either (i) a second electric screen or (ii) a second electric field sensor to detect an electric field produced by the electrode; and a dielectric material at least partially enclosing the first electric screen and the first and second tubular sections, wherein the dielectric material fills through openings in the first electric screen.

**[0020]** The present disclosure provides, in another aspect, a sensor assembly comprising: an electrode extending along a longitudinal axis; a tubular section extending along the longitudinal axis and at least partially surrounding the electrode such that the tubular section is radially spaced from the electrode, the tubular section including a first layer of an electrically insulating material, a second layer of an electrically conductive material disposed on an inner surface of the first layer of insulating material, wherein the second layer of electrically conductive material is configured as an electric field sensor to detect an electric field produced by the electrode, and a third layer of an of electrically conductive material disposed on an outer surface of the first layer of an insulating material, wherein the third layer of electrically conductive material is configured as an electric screen; and a mass of dielectric material at least partially enclosing the electrode and the tubular section, wherein the mass of dielectric insulating material fills through openings in the tubular section, wherein the first layer of electrically insulating material includes a first plurality of through openings, each configured as an elongated slit that has a length extending in a direction parallel to the longitudinal axis, and the first plurality of through openings includes a first row of circumferentially spaced through openings and a second row of circumferentially spaced through openings with each through opening of the first row of through openings aligned with a through opening of the second row of through openings in a direction parallel to the longitudinal axis, wherein the second layer of electrically conductive material includes a second plurality of through openings, each configured as an elongated slit that has a length extending in a direction parallel to the longitudinal axis, and the second plurality of through openings includes a first row of circumferentially spaced through openings and a second row of circumferentially spaced through openings and each through opening of the first row of through openings is aligned with a through opening of the second row of through openings in a direction parallel to the longitudinal axis, wherein the third layer of electrically conductive material includes a third plurality of through openings, each configured as an elongated slit that has a length extending in a direction parallel to the longitudinal axis, and the third plurality of through openings includes a first row of circumferentially spaced through openings and a second row of circumferentially spaced through openings and each through opening of the first row of through openings is aligned with a through opening of the second row of through openings in a direction parallel to the longitudinal axis, wherein each through opening of the first plurality of through openings is aligned with a through opening of the second plurality of through openings, and wherein each

through opening of the third plurality of through openings is aligned with a through opening in the first and second pluralities of through openings.

**[0021]** The present disclosure provides, in another aspect, sensor assembly comprising: an electrode extending along a longitudinal axis; a tubular section extending along the longitudinal axis and at least partially surrounding the electrode such that the tubular section is radially spaced from the electrode, the tubular section including a first layer of insulating material, a second layer of electrically conductive material disposed on an inner surface of the first layer of insulating material, and an electric screen comprising a third layer of electrically conductive material disposed on an outer surface of the first layer of insulating material; and a mass of dielectric material at least partially enclosing the electrode and the tubular section, wherein the mass of dielectric insulating material fills through openings in the tubular section, wherein an axial length of the second layer of electrically conductive material is coextensive with an axial length of the third layer of electrically conductive material.

**[0022]** The present disclosure provides, in another aspect, a sensor assembly comprising: an electrode extending along a longitudinal axis; a tubular body extending along the longitudinal axis and at least partially surrounding the electrode such that the tubular body is radially spaced from the electrode, wherein the sensor assembly further comprises a dielectric material at least partially enclosing the tubular body, the tubular body including a first tubular section including a first tubular electric field sensor comprising a first layer of electrically conductive material disposed on an inner surface of insulating material, wherein the first tubular electric field sensor is configured to detect an electric field produced by the electrode, and a first tubular electric screen comprising a second layer of electrically conductive material and disposed outside the insulating material, the first tubular electric screen electrically isolated from the first layer of electrically conductive material and configured to shield the first tubular electric field sensor from outside electrical interference, wherein the first layer of electrically conductive material has a first axial end and the first tubular electric screen extends beyond the first axial end of the first layer of electrically conductive material, and wherein the dielectric material fills through openings in the first tubular electric screen; and a second tubular section extending along the longitudinal axis and linked to the first tubular section, the second tubular section comprising a third layer of electrically conductive material electrically isolated from the first layer of

electrically conductive material and comprising a distinct structure formed apart from the second layer of electrically conductive material, wherein the second tubular section is configured to function as either (i) a second electric screen to shield from outside electrical interference, or (ii) a second electric field sensor to detect an electric field produced by the electrode, and wherein the dielectric material is cast around and within the first and second tubular sections.

**[0023]** The present disclosure provides, in another aspect, a sensor assembly comprising: an electrode extending along a longitudinal axis; and a tubular body extending along the longitudinal axis and at least partially surrounding the electrode such that the tubular body is radially spaced from the electrode, wherein the sensor assembly further comprises a dielectric material at least partially enclosing the tubular body, the tubular body including a first tubular section including a first tubular electric field sensor configured to detect an electric field produced by the electrode, a second tubular section comprising electrically conductive material, wherein the second tubular section extends along the longitudinal axis and is linked to and electrically isolated from the first tubular section, and a first tubular electric screen comprising electrically conductive material and electrically isolated from the first tubular electric field sensor, wherein the first tubular electric screen extends along the longitudinal axis between the first tubular section and the second tubular section, wherein the dielectric material fills through openings in the first tubular electric screen, wherein the electrically conductive material of the second tubular section comprises a distinct structure formed apart from the first tubular electric screen and is configured to function as either (i) a second electric screen to shield the first electric field sensor from outside electrical interference, or (ii) a second electric field sensor to detect an electric field produced by the electrode, and wherein the dielectric material is cast around and within the first and second tubular sections.

**[0024]** The present disclosure provides, in another aspect, a sensor assembly comprising: an electrode extending along a longitudinal axis; a tubular body extending along the longitudinal axis and at least partially surrounding the electrode such that the tubular body is radially spaced from the electrode, wherein the sensor assembly further comprises a dielectric material at least partially enclosing the tubular body, the tubular body including a first tubular section extending along the longitudinal axis and including a first tubular electric field sensor configured to detect an electric field produced by the electrode, a second tubular section extending along the

longitudinal axis and comprising electrically conductive material, wherein the second section is linked to and electrically isolated from the first tubular section, and a first tubular electric screen comprising electrically conductive material, wherein the first tubular electric screen is electrically isolated from the first tubular electric field sensor and comprises a distinct structure formed apart from the second tubular section, wherein the second tubular section is configured to function as either (i) a second electric screen to shield the first electric field sensor from outside electrical interference, or (ii) a second electric field sensor to detect an electric field produced by the electrode, and wherein the dielectric material is cast around and within the first and second tubular sections such that the dielectric material fills through openings in the first tubular electric screen.

**[0025]** The present disclosure provides, in another aspect, a sensor assembly comprising: an electrode extending along a longitudinal axis; a tubular section extending along the longitudinal axis and at least partially surrounding the electrode such that the tubular section is radially spaced from the electrode, the tubular section including a first section comprising a first layer made of an electrically insulating material, a second layer made of an electrically conductive material disposed on an inner surface of the first layer made of insulating material, wherein the second layer made of electrically conductive material is configured as a first electric field sensor to detect an electric field produced by the electrode, and a third layer made of an of electrically conductive material disposed on an outer surface of the first layer made of an insulating material, wherein the third layer made of electrically conductive material is configured as a first electric screen; a second section comprising electrically conductive material, wherein the second section extends along the longitudinal axis such that the second section is linked to and electrically isolated from the first section; and wherein the second section is configured to function as either (i) a second electric screen to shield the first electric field sensor from outside electrical interference, or (ii) a second electric field sensor to detect an electric field produced by the electrode, and a mass of dielectric material at least partially enclosing the electrode and the tubular section such that the dielectric material is cast around and within the first and second sections, wherein the mass of dielectric insulating material fills through openings in the first electric screen.

**[0026]** The present disclosure provides, in another aspect, a sensor assembly comprising: an electrode extending along a longitudinal axis; a tubular body extending along the longitudinal axis and at least partially surrounding the electrode such that the tubular body is radially spaced from the electrode, the tubular body including a first layer made of an electrically insulating material and comprising a first plurality of through openings, each configured as an elongated slit that has a length extending in a direction parallel to the longitudinal axis, a second layer made of an electrically conductive material disposed on an inner surface of the first layer, wherein the second layer is configured as a first electric field sensor to detect an electric field produced by the electrode and comprises a second plurality of through openings, each configured as an elongated slit that has a length extending in a direction parallel to the longitudinal axis, a third layer made of an electrically conductive material disposed on an outer surface of the first layer, wherein the third layer is configured as a first electric screen and comprises a third plurality of through openings, each configured as an elongated slit that has a length extending in a direction parallel to the longitudinal axis, and a fourth layer made of an electrically conductive material disposed on an inner or outer surface of the first layer, wherein the fourth layer extends along the longitudinal axis and is linked to and electrically isolated from the second layer and the third layer; and a mass of dielectric material at least partially enclosing the electrode and the tubular body, wherein the first, second, third, and fourth layers are molded within the mass of dielectric insulating material, and wherein the mass of dielectric material fills the first, second, and third pluralities of through openings, wherein the fourth layer is configured to function as either (i) a second electric screen to shield the first electric field sensor from outside electrical interference independently of the first electric screen, or (ii) a second electric field sensor to detect an electric field produced by the electrode, wherein each through opening of the first plurality of through openings is aligned with a through opening of the second plurality of through openings, and wherein each through opening of the third plurality of through openings is aligned with a through opening in the first and second pluralities of through openings.

**[0027]** The present disclosure provides, in another aspect, a sensor assembly comprising: an electrode extending along a longitudinal axis; a tubular body extending along the longitudinal axis and at least partially surrounding the electrode such that the tubular body is radially spaced from the electrode, wherein the sensor assembly further comprises a dielectric material at least partially enclosing the tubular body, wherein the dielectric material fills through openings in the

tubular body, the tubular body including a first tubular section extending along the longitudinal axis and including a first electric field sensor configured to detect an electric field produced by the electrode, wherein the first section includes a layer of electrically conductive material, a second tubular section extending along the longitudinal axis, wherein the second section is linked to and electrically isolated from the first section, wherein the second section includes a layer of electrically conductive material disposed on an inner or outer surface of insulating material, and a first electric screen comprising electrically conductive material and electrically isolated from the first electric field sensor of the first section and the layer of electrically conductive material of the second section, wherein the first electric screen is disposed outside the first section, wherein the second tubular section is configured to function as either (i) a second electric screen to shield the first electric field sensor from outside electrical interference independently of the first electric screen, or (ii) a second electric field sensor to detect an electric field produced by the electrode, and wherein the dielectric material is cast around and within the first and second tubular sections and the first electric screen.

**[0028]** Other features and aspects of the disclosure will become apparent by consideration of the following detailed description and accompanying drawings.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0029]** FIG. 1 is a schematic view of a first embodiment of a sensor assembly according to the present disclosure;

**[0030]** FIG. 1A is a schematic view of a tubular body in the embodiment in FIG. 1, laid flat;

**[0031]** FIG. 2 is a schematic view of a second embodiment of a sensor assembly according to the present disclosure;

**[0032]** FIG. 2A is a schematic view of a tubular body in the embodiment in FIG. 2, laid flat;

**[0033]** FIG. 3 is a schematic view of a third embodiment of a sensor assembly according to the present disclosure;

**[0034]** FIG. 3A is a schematic view of a tubular body in the embodiment in FIG. 3, laid flat;

**[0035]** FIG. 4 is a schematic view of a fourth embodiment of a sensor assembly according to the present disclosure;

**[0036]** FIG. 4A is a schematic view of a tubular body in the embodiment in FIG. 4, laid flat;

**[0037]** FIG. 5 is a schematic view of a fifth embodiment of a sensor assembly according to the present disclosure;

**[0038]** FIG. 5A is a schematic view of a tubular body in the embodiment in FIG. 5, laid flat.

**[0039]** Before any embodiments of the disclosure are explained in detail, it is to be understood that the disclosure is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The disclosure is capable of other embodiments and of being practiced or of being carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting.

## DETAILED DESCRIPTION

**[0040]** With reference to attached FIGS. 1 to 5A, a sensor assembly according to embodiments of the present disclosure extends along a first longitudinal axis Y1 and includes a connecting bar B extending longitudinally along a respective second longitudinal axis Y2; a tubular body extending longitudinally along a third longitudinal axis Y3; a mass of dielectric material 40.1 / 40.2 / 40.3 / 40.4 / 40.5 designed to at least partially enclose the components of the sensor assembly, in which said tubular body is positioned coaxially about said connecting bar B and is spaced radially apart from said central connecting bar B.

**[0041]** Again with reference to attached FIGS. 1 to 5A, said tubular body has a first tubular section 10.1 / 10.2 / 10.3 / 10.4 / 10.5, which in the illustrated embodiments includes: a first self-supporting tubular laminar element or support member 11.1 / 11.2 / 11.3 / 11.4 / 11.5 made of insulating material; a first thin layer of electrically conductive material 12.1 / 12.2 / 12.3 / 12.4 / 12.5 applied to one or more inner faces of said first self-supporting tubular laminar element 11.1 / 11.2 / 11.3 / 11.4 / 11.5; and a second thin layer of electrically conductive material 13.1 / 13.2 /

13.3 / 13.4 / 13.5 applied to one or more outer faces of said first self-supporting tubular laminar element 11.1 / 11.2 / 11.3 / 11.4 / 11.5.

**[0042]** The first self-supporting tubular laminar element 11.1 / 11.2 / 11.3 / 11.4 / 11.5 may perform the function of a supporting structure and, more specifically, the function of a tubular element not liable to suffer from deformation when casting resin and providing support using layers of conductive material.

**[0043]** The first thin layer of electrically conductive material 12.1 / 12.2 / 12.3 / 12.4 / 12.5 may function as an electric field sensor and, more specifically, is able to form a first electrode for a capacitive coupling with the central bar B as second electrode.

**[0044]** The second thin layer of electrically conductive material 13.1 / 13.2 / 13.3 / 13.4 / 13.5 may function as an electric screen and, more specifically, by connection to ground or to a known potential, an electric screen able to screen or shield the electric field sensor formed by the first thin layer of electrically conductive material 12.1 / 12.2 / 12.3 / 12.4 / 12.5 from external electrical fields or interference.

**[0045]** The tubular body of the sensor assembly can also include a second tubular section 20.1 / 20.2 / 20.3 / 20.4 / 20.5; in which said second tubular section 20.1 / 20.2 / 20.3 / 20.4 / 20.5 is positioned axially beside a first axial end (10sx) of the first tubular section 10.1 / 10.2 / 10.3 / 10.4 / 10.5; in which said second tubular section 20.1 / 20.2 / 20.3 / 20.4 / 20.5 may function as an electric screen, by connecting to ground or to a reference potential, as explained below.

**[0046]** Furthermore, the tubular body of the sensor assembly can also include a third tubular section 30.1 / 30.2 / 30.3 / 30.4 / 30.5; in which said third tubular section (30.1 / 30.2 / 30.3 / 30.4 / 30.5) is positioned axially beside a second axial end 10dx of the first tubular section 10.1 / 10.2 / 10.3 / 10.4 / 10.5; in which said third tubular section 30.1 / 30.2 / 30.3 / 30.4 / 30.5 may function as an electric screen, by connecting to ground or to a reference potential.

**[0047]** Said second tubular section 20.1 / 20.2 / 20.3 / 20.4 / 20.5 and/or said third tubular section 30.1 / 30.2 / 30.3 / 30.4 / 30.5 can also perform the function of an electric field sensor in order to detect the presence or absence of voltage on the connecting bar B.

**[0048]** The second tubular section 20.1 / 20.2 / 20.3 / 20.4 / 20.5 and/or said third tubular section 30.1 / 30.2 / 30.3 / 30.4 / 30.5 are associated with and/or linked to said first tubular section 10.1 / 10.2 / 10.3 / 10.4 / 10.5. Preferably, said first tubular section 10.1 / 10.2 / 10.3 / 10.4 / 10.5 and/or said second tubular section 20.1 / 20.2 / 20.3 / 20.4 / 20.5 and/or said third tubular section 30.1 / 30.2 / 30.3 / 30.4 / 30.5 includes one or more through-openings 14.1 / 14.2 / 14.3 / 14.4 / 14.5 / 21.1 / 21.2 / 21.3 / 21.4 / 21.4 / 31.1 / 31.2 / 31.3 / 31.4 / 31.5, which are wide enough to enable a resin of dielectric material in liquid/paste state to pass through said first through-openings 14.1 / 14.2 / 14.3 / 14.4 / 14.5; 21.1 / 21.2 / 21.3 / 21.4 / 21.5; 31.1 / 31.2 / 31.3 / 31.4 / 31.4 / 31.5.

**[0049]** With reference to FIGS. 1 and 1A, said first tubular section 10.1 can be made using a conductive double-sided Vetronite board (for example a copper double-sided Vetronite board - PCB) including a self-supporting lamina of insulating material 11.1 able to perform the support function, a first thin inner layer 12.1 of electrically conductive material detached from other layers of conductive material applied to said self-supporting lamina of insulating material 11.1 and a first thin outer layer 13.1 of conductive material applied to said self-supporting lamina of insulating material 11.1; in which the first thin inner layer 12.1 may function as an electric field sensor, i.e. to form a capacitive coupling with the bar B; and in which the first thin outer layer 13.1 may function as an electric screen, for example by means of a connection to ground.

**[0050]** Preferably, the first thin inner layer 12.1 of conductive material has an axial length D1.1 that is less than the axial length D2.1 of the first thin outer layer 13.1 of conductive material, preferably but without limitation as shown in FIG. 1A.

**[0051]** With reference to the aforementioned structural description, said first tubular section 10.1 may be made using a single conductive double-sided Vetronite board (for example a copper double-sided Vetronite board - PCB), for example etched by photoengraving or mechanical milling and wrapped into a tube shape.

**[0052]** Again with reference to FIGS. 1 and 1A, said second tubular section 20.1 and/or said third tubular section 30.1 can be made from a wire mesh, preferably electrically disconnected from other conductive elements, in which said wire mesh can be connected to ground in order to

perform the function as an electric screen, and in which, where desired, said wire mesh can form a capacitive coupling with the bar B to detect the presence or absence of voltage on said bar B.

**[0053]** With reference to FIGS. 2 and 2A, said sensor assembly, and more specifically said tubular body including said first, second and third tubular sections 20.2 / 10.2 / 30.2, can include: a self-supporting lamina of insulating material 23.2 / 11.2 / 33.2 able to perform the support function; a first thin inner layer 12.2 of electrically conductive material applied to said self-supporting lamina of insulating material 23.2 / 11.2 / 33.2 and electrically disconnected from the other layers of conductive material; a first thin outer layer 25.2 of conductive material applied to said self-supporting lamina of insulating material 23.2 / 11.2 / 33.2; a second thin outer layer 13.2 of conductive material applied to said self-supporting lamina of insulating material 23.2 / 11.2 / 33.2; a third thin outer layer 35.2 of conductive material applied to said self-supporting lamina of insulating material 23.2 / 11.2 / 33.2, in which said layers have specific axial lengths, preferably but without limitation as shown in FIG. 2A.

**[0054]** The first thin inner layer 12.2 may function as an electric field sensor, i.e. to form a capacitive coupling with the bar B; the first thin outer layer 25.2 may function as an electric screen, for example by connection to ground, and/or the function of detecting the presence or absence of voltage on the bar B; the second thin outer layer 13.2 may function as an electric screen, for example by means of a connection to ground; the third thin outer layer 35.2 may function as an electric screen, for example by means of a connection to ground; and/or the function of detecting the presence or absence of voltage on the bar B.

**[0055]** Preferably, with reference to the aforementioned structural description, said first tubular section 10.2, said second tubular section 20.2 and said third tubular section 30.2 are made using a single conductive double-sided Vetronite board (for example a copper double-sided Vetronite board - PCB), for example etched by photoengraving or mechanical milling and wrapped into a tube shape.

**[0056]** With reference to FIGS. 3 and 3A, said sensor assembly, and more specifically said tubular body including said first, second and third tubular sections 20.3 / 10.3 / 30.3, can include: a self-supporting lamina of insulating material 23.3 / 11.3 / 33.3 able to perform the function of support lamina; a first thin inner layer 24.3 of conductive material applied to said self-supporting

lamina of insulating material 23.3 / 11.3 / 33.3; a second thin inner layer 12.3 of conductive material applied to said self-supporting lamina of insulating material 23.3 / 11.3 / 33.3 and electrically disconnected from the other layers of conductive material; a third thin inner layer 34.3 of conductive material applied to said self-supporting lamina of insulating material 23.3 / 11.3 / 33.3; a first thin outer layer 13.3 of conductive material applied to said self-supporting lamina of insulating material 23.3 / 11.3 / 33.3; in which said layers have specific axial lengths, preferably but without limitation as shown in FIG. 3A.

**[0057]** The first thin inner layer 24.3 may function as an electric screen, for example by connection to ground, and/or the function of detecting the presence or absence of voltage on the bar B.

**[0058]** The second thin inner layer 12.3 may function as an electric field sensor, i.e. to form a capacitive coupling with the bar B.

**[0059]** The third thin inner layer 34.3 of conductive material may function as an electric screen, for example by connection to ground, and/or the function of detecting the presence or absence of voltage on the bar B.

**[0060]** The first thin outer layer 13.3 may function as an electric screen, for example by means of a connection to ground.

**[0061]** Preferably, with reference to the aforementioned structural description, said first tubular section 10.3, said second tubular section 20.3 and said third tubular section 30.3 are made using a single conductive double-sided Vetronite board (for example a copper double-sided Vetronite board - PCB), for example etched by photoengraving or mechanical milling and wrapped into a tube shape.

**[0062]** With reference to FIGS. 4-4A and 5-5A, the second tubular section 20.4 / 20.5 and/or said third tubular section 30.4 / 30.5 includes one or more cantilevered tabs 22.4, 32.4 / 22.5, 32.5.

**[0063]** More specifically, with reference to FIGS. 4-4A and 5-5A, the sensor assembly according to the present invention, in which said sensor assembly extends along a first

longitudinal axis Y1, in which said sensor assembly comprises: a connecting bar B extending longitudinally along a respective second longitudinal axis Y2; a tubular body extending longitudinally along a third longitudinal axis Y3; a mass of dielectric material 40.4 / 40.5 designed to at least partially enclose the components of the sensor assembly; in which said tubular body is positioned coaxially about said connecting bar B; in which said tubular body is spaced apart radially from said central connecting bar B; has a tubular body with one or more cantilevered tabs 22.4, 32.4 / 22.5, 32.5.

**[0064]** Said tabs 22.4, 32.4 / 22.5, 32.5 are preferably oriented axially Y4 such that the free ends thereof 23.4, 33.4 / 23.5, 33.5 form at least one axial end of said tubular body, thereby forming crenelated axial ends.

**[0065]** Again preferably, two or more tabs 22.4 / 22.4, 32.4 / 32.4 / 22.5 / 22.5, 32.5 / 32.5, positioned side by side, are provided, in which the axial edge of a first tab 22.4, 32.4 / 22.5, 32.5 is spaced apart D4.4 / D4.5 circumferentially from the axial edge of a second tab 22.4, 32.4 / 22.5, 32.5 positioned next to said first tab 22.4, 32.4 / 22.5, 32.5 in order to form axial through-openings 21.4 / 21.5.

**[0066]** Said through-openings 21.4 are wide enough to enable a resin of dielectric material in liquid/paste state to pass through said through-openings 21.4.

**[0067]** Again preferably, said tabs 22.4, 32.4 / 22.5, 32.5 are flexible and, more specifically, have a degree of flexibility selected in consideration of the shrinkage characteristics of the resin used in the casting, in order to enable said tabs to flex during the shrinkage phases of the resin that occur during solidification of said resin.

**[0068]** With reference to FIGS. 4 and 4A, said sensor assembly, and more specifically said tubular body including said first, second and third tubular sections 20.4 / 10.4 / 30.4, can include: a self-supporting lamina of insulating material 23.4 / 11.4 / 33.4 able to perform the support function; a first thin inner layer 12.4 of electrically conductive material applied to said self-supporting lamina of insulating material 23.4 / 11.4 / 33.4 and electrically disconnected from the other layers of conductive material; a first thin outer layer 25.4 of conductive material applied to said self-supporting lamina of insulating material 23.4 / 11.4 / 33.4; a second thin outer layer

13.4 of conductive material applied to said self-supporting lamina of insulating material 23.4 / 11.4 / 33.4; a third thin outer layer 35.4 of conductive material applied to said self-supporting lamina of insulating material 23.4 / 11.4 / 33.4.

**[0069]** The first thin inner layer 12.4 may function as an electric field sensor, i.e. to form a capacitive coupling with the bar B.

**[0070]** The first thin outer layer 25.4 may function as an electric screen, for example by connection to ground, and/or the function of detecting the presence or absence of voltage on the bar B.

**[0071]** The second thin outer layer 13.4 may function as an electric screen, for example by means of a connection to ground.

**[0072]** The third thin outer layer 35.4 may function as an electric screen, for example by connection to ground, and/or the function of detecting the presence or absence of voltage on the bar B.

**[0073]** Preferably, with reference to the aforementioned structural description, said first tubular section 10.4, said second tubular section 20.4 and said third tubular section 30.4 are made using a single copper double-sided Vetronite board (PCB), for example etched by photoengraving or mechanical milling and wrapped into a tube shape.

**[0074]** With reference to FIGS. 5 and 5A, said sensor assembly, and more specifically said tubular body including said first, second and third tubular sections 20.5 / 10.5 / 30.5, can include: a self-supporting lamina of insulating material 23.5 / 11.5 / 33.5 able to perform the support function; a first thin outer layer 13.5 of conductive material applied to said self-supporting lamina of insulating material 23.5 / 11.5 / 33.5; a first thin inner layer 24.5 of conductive material applied to said self-supporting lamina of insulating material 23.5 / 11.5 / 33.5; a second thin inner layer 12.5 of conductive material applied to said self-supporting lamina of insulating material 23.5 / 11.5 / 33.5; and a third thin inner layer 34.5 of conductive material applied to said self-supporting lamina of insulating material 23.4 / 11.4 / 33.4.

**[0075]** The first thin outer layer 13.5 may function as an electric screen, for example by means of a connection to ground.

**[0076]** The first thin inner layer 24.5 may function as an electric screen, for example by connection to ground, and/or the function of detecting the presence or absence of voltage on the bar B.

**[0077]** The second thin inner layer 12.5 may function as an electric field sensor, i.e. to form a capacitive coupling with the bar B.

**[0078]** The third thin inner layer 34.5 may function as an electric screen, for example by connection to ground, and/or the function of detecting the presence or absence of voltage on the bar B.

**[0079]** Preferably, with reference to the aforementioned description, said first tubular section 10.5, said second tubular section 20.5 and said third tubular section 30.5 are made using a single copper double-sided Vetronite board (PCB), for example etched by photoengraving or mechanical milling and wrapped into a tube shape.

**[0080]** Although the disclosure has been described in detail with reference to certain preferred embodiments, variations and modifications exist within the scope and spirit of one or more independent aspects of the disclosure as described. In addition, some aspects of the present disclosure may include, but are not limited to:

**[0081]** Aspect 1. Sensor assembly regarding a through isolator, wherein said sensor assembly extends along a first longitudinal axis (Y1), wherein said sensor assembly comprises: a connecting bar (B) extending longitudinally along a respective second longitudinal axis (Y2); a tubular body extending longitudinally along a third longitudinal axis (Y3); a mass of dielectric material (4.1 / 40.2 / 40.3 / 40.4 / 40.5) able for incorporating at least partially the components of the sensor assembly; wherein said tubular body is positioned coaxially around said connecting bar (B); wherein said tubular body is radially spaced with respect to said central connecting bar (B); characterized by the fact that said tubular body comprises a first tubular section (10.1 / 10.2 / 10.3 / 10.4 / 10.5) comprising: a first self-supporting tubular laminar element (11.1 / 11.2 / 11.3 / 11.4 / 11.5) made of insulating material; a first thin layer of electrically conductive material

(12.1 / 12.2 / 12.3 / 12.4 / 12.5) applied on one or more inner faces of said first self-supporting tubular laminar element (11.1 / 11.2 / 11.3 / 11.4 / 11.5); a second thin layer of electrically conductive material (13.1 / 13.2 / 13.3 / 13.4 / 13.5) applied on one or more external faces of said first self-supporting tubular laminar element (11.1 / 11.2 / 11.3 / 11.4 / 11.5); by the fact that said first self supporting tubular laminar element (11.1 / 11.2 / 11.3 / 11.4 / 11.5) is able to perform the function of supporting structure; by the fact that said first thin layer of electrically conductive material (12.1 / 12.2 / 12.3 / 12.4 / 12.5) is able to perform the function of an electric field sensor; by the fact that said second thin layer of electrically conductive material (13.1 / 13.2 / 13.3 / 13.4 / 13.5) is able to perform the function of an electric screen; by the fact to further comprising a second tubular section (20.1 / 20.2 / 20.3 / 20.4 / 20.5); by the fact that said second tubular section (20.1 / 20.2 / 20.3 / 20.4 / 20.5) is positioned axially at the side of a first axial end (10sx) of the first tubular section (10.1 / 10.2 / 10.3 / 10.4 / 10.5); and by the fact that said second tubular section (20.1 / 20.2 / 20.3 / 20.4 / 20.5) is able to perform the function of electric screen.

**[0082]** Aspect 2. Sensor assembly according to aspect 1, characterized by the fact that it further comprises a third tubular section (30.1 / 30.2 / 30.3 / 30.4 / 30.5); by the fact that said third tubular section (30.1 / 30.2 / 30.3 / 30.4 / 30.5) is positioned axially at the side of a second axial end (10dx) of the first tubular section (10.1 / 10.2 / 10.3 / 10.4 / 10.5); and by the fact that said third tubular section (30.1 / 30.2 / 30.3 / 30.4 / 30.5) is able to perform the function of electric screen.

**[0083]** Aspect 3. Sensor assembly according to aspect 1 or 2, characterized by the fact that said first tubular section (10.1) is made by means of a double-sided plain copper PCB and by the fact that said second tubular section (20.1) and/or said third tubular section (30.1) are made of a wire mesh.

**[0084]** Aspect 4. Sensor assembly according to one of aspects 1 to 3, characterized in that it comprises: a self-supporting lamina of insulating material (23.2 / 11.2 / 33.2) suitable for carrying out the support function; a first thin inner layer (12.2) of conductive material applied to said self-supporting lamina of insulating material (23.2 / 11.2 / 33.2) and electrically disconnected with respect the other layers of conductive material; a first thin outer layer (25.2) of conductive material applied to said self-supporting lamina of insulating material (23.2 / 11.2 /

33.2); a second thin outer layer (13.2) of conductive material applied to said self-supporting lamina of insulating material (23.2 / 11.2 / 33.2); and a third thin outer layer (35.2) of conductive material applied to said self-supporting lamina of insulating material (23.2 / 11.2 / 33.2) and by the fact that the first thin inner layer (12.2) is able to perform the function of sensor of the electric field generated by the connecting bar (B), the first thin outer layer (25.2) is able to perform the function of an electric screen, the second thin outer layer (13.2) is suitable to perform the function of an electric screen; and the third thin outer layer (35.2) is adapted to perform the function of an electric screen.

**[0085]** Aspect 5. Sensor assembly according to aspect 4, characterized by the fact that said first tubular section (10.2) said second tubular section (20.2) and said third tubular section (30.2) are made by means of a double-sided plain copper PCB.

**[0086]** Aspect 6. Sensor assembly according to aspect 1 or 2, characterized by the fact that it comprises: a self-supporting foil of insulating material (23.3 / 11.3 / 33.3) suitable for carrying out the supporting foil function; a first thin inner layer (24.3) of conductive material applied to said self-supporting lamina of insulating material (23.3 / 11.3 / 33.3); a second thin inner layer (12.3) of conductive material applied to said self-supporting lamina of insulating material (23.3 / 11.3 / 33.3) and electrically disconnected from the other layers of conductive material; a third thin inner layer (33.3) of conductive material applied to said self-supporting lamina of insulating material (23.3 / 11.3 / 33.3); a first thin outer layer (13.3) of conductive material applied to said self-supporting lamina of insulating material (23.3 / 11.3 / 33.3); and by the fact that the first thin inner layer (24.3) is able to perform the function of an electric screen, the second thin inner layer (12.3) is able to perform the function of sensor of the electric field generated by the connecting bar (B), the third thin inner layer (34.3) is able to perform the function of an electric screen, the first thin outer layer (13.3) is able to perform the function of an electric screen.

**[0087]** Aspect 7. Sensor assembly according to aspect 6, characterized by the fact that said first tubular section (10.3) said second tubular section (20.3) and said third tubular section (30.3) are made by means of double-sided plain copper PCB.

**[0088]** Aspect 8. Sensor assembly according to any one of aspects 1 to 7, characterized by the fact that said second tubular section (20.4 / 20.5) and/or said third tubular section (30.4 / 30.5) comprises one or more tabs (22.4, 32.4 / 22.5, 32.5) supported in an by cantilever manner.

**[0089]** Aspect 9. Sensor assembly regarding a through isolator, wherein said sensor assembly extends along a first longitudinal axis (Y1), wherein said sensor assembly comprises: a connecting bar (B) extending longitudinally along a respective second longitudinal axis (Y2); a tubular body extending longitudinally along a third longitudinal axis (Y3); a mass of dielectric material (40.4 / 40.5) able for incorporating at least partially the components of the sensor assembly; wherein said tubular body is positioned coaxially around said connecting bar (B); wherein said tubular body is radially spaced with respect to said central connecting bar (B); characterized by the fact that said tubular body comprises one or more tabs (22.4, 32.4 / 22.5, 32.5) supported in a cantilever manner.

**[0090]** Aspect 10. Sensor assembly according to aspect 8 or 9, characterized by the fact that said tabs (22.4, 32.4 / 22.5, 32.5) are axially oriented (Y4) in order to configure with their free ends (23.4, 33.4 / 23.5, 33.5) at least one axial end of the tubular body.

**[0091]** Aspect 11. Sensor assembly according to aspect 8, 9 or 10, characterized by the fact to comprises two or more tabs (22.4 / 22.4, 32.4 / 32.4 / 22.5 / 22.5, 32.5 / 32.5) positioned side by side.

**[0092]** Aspect 12. Sensor assembly according to aspect 11, characterized by the fact that the axial edge of a first tab (22.4, 32.4 / 22.5, 32.5) is circumferentially spaced (D4.4 / D4.5) with respect to the axial edge of a second tab (22.4, 32.4 / 22.5, 32.5) positioned next to said first tab (22.4, 32.4 / 22.5, 32.5) in order to form axial through openings (21.4 / 21.5).

**[0093]** Aspect 13. Sensor assembly according to one of the aspects from 8 to 12, characterized by the fact that said tabs (22.4, 32.4 / 22.5, 32.5) are flexible.

**[0094]** Aspect 14. Sensor assembly according to one of the aspects from 1 to 13, characterized by the fact that at least one axial end of said tubular body has the shape.

**[0095]** Aspect 15. Sensor assembly according to one of the aspects from 8 to 14, characterized by the fact that it comprises: a self-supporting foil of insulating material (23.4 / 11.4 / 33.4) able for carrying out the support function; a first thin inner layer (12.4) of conductive material electrically applied to said self-supporting lamina of insulating material (23.4 / 11.4 / 33.4) and disconnected from the other layers of conductive material; a first thin outer layer (25.4) of conductive material applied to said self-supporting lamina of insulating material (23.4 / 11.4 / 33.4); a second thin outer layer (13.4) of conductive material applied to said self-supporting lamina of insulating material (23.4 / 11.4 / 33.4); a third thin outer layer (35.4) of conductive material applied to said self-supporting lamina of insulating material (23.4 / 11.4 / 33.4); and by the fact that the first thin inner layer (12.4) is able to detect the electric field generated by the connecting rod (B), the first thin outer layer (25.4) is able to perform the function of an electric screen, the second thin outer layer (13.4) is able to perform the function of an electric screen, the third thin outer layer (35.4) is able to perform the function of an electric screen.

**[0096]** Aspect 16. Sensor assembly according to aspect 15, characterized by the fact that said first tubular section (10.4) said second tubular section (20.4) and said third tubular section (30.4) are made by are made by means of a double-sided plain copper PCB.

**[0097]** Aspect 17. Sensor assembly according to one of the aspects from 8 to 24, characterized by the fact that it comprises: a self-supporting foil of insulating material (23.5 / 11.5 / 33.5) suitable for carrying out the support function; a first thin outer layer (13.5) of conductive material applied to said self-supporting lamina of insulating material (23.5 / 11.5 / 33.5); a first thin inner layer (24.5) of conductive material applied to said self-supporting lamina of insulating material (23.5 / 11.5 / 33.5); a second thin inner layer (12.5) of conductive material applied to said self-supporting lamina of insulating material (23.5 / 11.5 / 33.5); a third thin inner layer (34.5) of conductive material applied to said self-supporting lamina of insulating material (23.4 / 11.4 / 33.4); and by the fact that the first thin outer layer (13.5) is able to perform the function of an electric screen, the first thin inner layer (24.5) is able to perform the function of an electric screen, the second thin inner layer (12.5) is able to perform the electric field generated by the connecting bar (B), the third thin inner layer (34.5) is able to perform the function of an electric screen.

**[0098]** Aspect 18. Sensor assembly according to aspect 17, characterized by the fact that said first tubular section (10.5) said second tubular section (20.5) and said third tubular section (30.5) are made by a double-sided plain copper PCB.

**[0099]** In the claims which follow and in the preceding description of the invention, except where the context requires otherwise due to express language or necessary implication, the word “comprise” or variations such as “comprises” or “comprising” is used in an inclusive sense, i.e. to specify the presence of the stated features but not to preclude the presence or addition of further features in various embodiments of the invention.

**[00100]** Various features of the disclosure are set forth in the following claims.

CLAIMS

1. A sensor assembly comprising:

an electrode extending along a longitudinal axis;

a first tubular section extending along the longitudinal axis and at least partially surrounding the electrode such that the first tubular section is radially spaced from the electrode, the first tubular section including

a support layer made of an insulating material, and

a first tubular electric field sensor comprising a first layer of electrically conductive material disposed on an inner surface of the support layer, the first electric field sensor configured to detect an electric field produced by the electrode;

a first electric screen of electrically conductive material disposed outside the support layer;

a second tubular section extending along the longitudinal axis and linked to the first tubular section, the second tubular section including a second layer of electrically conductive material electrically isolated from the first layer of electrically conductive material and from the first electric screen, wherein the second layer of electrically conductive material is configured to function as either (i) a second electric screen to shield the first electric field sensor from outside interference or (ii) a second electric field sensor to detect an electric field produced by the electrode; and

a dielectric material at least partially enclosing the first electric screen and the first and second tubular sections, wherein the dielectric material is cast around and within the first and second tubular sections such that the dielectric material fills through openings in the first electric screen.

2. The sensor assembly of claim 1, wherein the second tubular section is immediately adjacent the first tubular section, and the second layer of electrically conductive material comprises wire mesh.

3. The sensor assembly of claim 1 or 2, wherein an axial length of the first layer of electrically conductive material is less than an axial length of the first electric screen and the first electric screen extends to and is disposed outside the second tubular section.

4. The sensor assembly of any one of the preceding claims,

wherein the support layer of insulating material includes a first plurality of through openings, each configured as an elongated slit that has a length extending in a direction parallel to the longitudinal axis, and the first plurality of through openings includes a first row of circumferentially spaced through openings and a second row of circumferentially spaced through openings with each through opening of the first row of through openings aligned with a through opening of the second row of through openings in a direction parallel to the longitudinal axis,

wherein the first layer of electrically conductive material includes a second plurality of through openings, each configured as an elongated slit that has a length extending in a direction parallel to the longitudinal axis, and the second plurality of through openings includes a first row of circumferentially spaced through openings and a second row of circumferentially spaced through openings and each through opening of the first row of through openings is aligned with a through opening of the second row of through openings in a direction parallel to the longitudinal axis, and

wherein each through opening of the first plurality of through openings is aligned with a through opening of the second plurality of through openings.

5. The sensor assembly of any one of the preceding claims, wherein an axial length of the first layer of electrically conductive material is coextensive with an axial length of the support layer of insulating material.

6. The sensor assembly of claim 1, wherein the support layer of electrically insulating material includes a first plurality of through openings, each configured as an elongated slit that has a length extending in a direction parallel to the longitudinal axis, the first layer of electrically conductive material includes a second plurality of through openings, each configured as an elongated slit that has a length extending in a direction parallel to the longitudinal axis, wherein

the first electric screen includes a third plurality of through openings, each configured as an elongated slit that has a length extending in a direction parallel to the longitudinal axis,

wherein each through opening of the first plurality of through openings is aligned with a through opening of the second plurality of through openings, and

wherein each through opening of the third plurality of through openings is aligned with a through opening in the first and second pluralities of through openings.

7. The sensor assembly of claim 1, wherein the second tubular section is configured to form a capacitive coupling with the electrode to detect the presence or absence of voltage on the electrode, and wherein the second layer of electrically conductive material is offset from the first layer of electrically conductive material in a direction along the longitudinal axis.

8. A sensor assembly comprising:

an electrode extending along a longitudinal axis;

a tubular body extending along the longitudinal axis and at least partially surrounding the electrode such that the tubular body is radially spaced from the electrode, wherein the sensor assembly further comprises a dielectric material at least partially enclosing the tubular body, the tubular body including

a first tubular section including a first tubular electric field sensor comprising a first layer of electrically conductive material disposed on an inner surface of insulating material, wherein the first tubular electric field sensor is configured to detect an electric field produced by the electrode, and

a first tubular electric screen comprising a second layer of electrically conductive material and disposed outside the insulating material, the first tubular electric screen electrically isolated from the first layer of electrically conductive material and configured to shield the first tubular electric field sensor from outside electrical interference, wherein the first layer of electrically conductive material has a first axial end and the first tubular electric screen extends beyond the first axial end of the first layer of electrically conductive material, and wherein the dielectric material fills through openings in the first tubular electric screen; and

a second tubular section extending along the longitudinal axis and linked to the first tubular section, the second tubular section comprising a third layer of electrically conductive material electrically isolated from the first layer of electrically conductive material and comprising a distinct structure formed apart from the second layer of electrically conductive material,

wherein the second tubular section is configured to function as either (i) a second electric screen to shield from outside electrical interference, or (ii) a second electric field sensor to detect an electric field produced by the electrode, and

wherein the dielectric material is cast around and within the first and second tubular sections.

9. The sensor assembly of claim 8, wherein the tubular body includes a printed circuit board.

10. The sensor assembly of claim 8 or 9, wherein the tubular body is flexible.

11. The sensor assembly of any one of claims 8-10, wherein an axial length of the first electric field sensor is less than an axial length of the first electric screen.

12. A sensor assembly comprising:

an electrode extending along a longitudinal axis; and

a tubular body extending along the longitudinal axis and at least partially surrounding the electrode such that the tubular body is radially spaced from the electrode, wherein the sensor assembly further comprises a dielectric material at least partially enclosing the tubular body, the tubular body including

a first tubular section including a first tubular electric field sensor configured to detect an electric field produced by the electrode,

a second tubular section comprising electrically conductive material, wherein the second tubular section extends along the longitudinal axis and is linked to and electrically isolated from the first tubular section, and

a first tubular electric screen comprising electrically conductive material and electrically isolated from the first tubular electric field sensor, wherein the first tubular electric screen extends along the longitudinal axis between the first tubular section and the second tubular section, wherein the dielectric material fills through openings in the first tubular electric screen,

wherein the electrically conductive material of the second tubular section comprises a distinct structure formed apart from the first tubular electric screen and is configured to function as either (i) a second electric screen to shield the first electric field sensor from outside electrical interference, or (ii) a second electric field sensor to detect an electric field produced by the electrode, and

wherein the dielectric material is cast around and within the first and second tubular sections.

13. The sensor assembly of claim 12, wherein the first tubular electric screen is disposed outside the first tubular section.

14. The sensor assembly of claim 12 or 13, wherein the first tubular section comprises a first layer of electrically conductive material disposed on an inner surface of insulating material and the second tubular section comprises a second layer of electrically conductive material disposed on an inner surface or outer surface of insulating material.

15. A sensor assembly comprising:

an electrode extending along a longitudinal axis;

a tubular body extending along the longitudinal axis and at least partially surrounding the electrode such that the tubular body is radially spaced from the electrode, wherein the sensor assembly further comprises a dielectric material at least partially enclosing the tubular body, the tubular body including

a first tubular section extending along the longitudinal axis and including a first tubular electric field sensor configured to detect an electric field produced by the electrode,

a second tubular section extending along the longitudinal axis and comprising electrically conductive material, wherein the second section is linked to and electrically isolated from the first tubular section, and

a first tubular electric screen comprising electrically conductive material, wherein the first tubular electric screen is electrically isolated from the first tubular electric field sensor and comprises a distinct structure formed apart from the second tubular section,

wherein the second tubular section is configured to function as either (i) a second electric screen to shield the first electric field sensor from outside electrical interference, or (ii) a second electric field sensor to detect an electric field produced by the electrode, and

wherein the dielectric material is cast around and within the first and second tubular sections such that the dielectric material fills through openings in the first tubular electric screen.

16. The sensor assembly of claim 15, wherein an axial length of the electric field sensor is less than an axial length of the first electric screen.

17. The sensor assembly of claim 15 or 16, wherein the first electric screen is disposed outside the first section.

18. A sensor assembly comprising:

an electrode extending along a longitudinal axis;

a tubular section extending along the longitudinal axis and at least partially surrounding the electrode such that the tubular section is radially spaced from the electrode, the tubular section including

a first section comprising

a first layer made of an electrically insulating material,

a second layer made of an electrically conductive material disposed on an inner surface of the first layer made of insulating material, wherein the second layer made of electrically conductive material is configured as a first electric field sensor to detect an electric field produced by the electrode, and

a third layer made of an of electrically conductive material disposed on an outer surface of the first layer made of an insulating material, wherein the third layer made of electrically conductive material is configured as a first electric screen;

a second section comprising electrically conductive material, wherein the second section extends along the longitudinal axis such that the second section is linked to and electrically isolated from the first section; and

wherein the second section is configured to function as either (i) a second electric screen to shield the first electric field sensor from outside electrical interference, or (ii) a second electric field sensor to detect an electric field produced by the electrode, and

a mass of dielectric material at least partially enclosing the electrode and the tubular section such that the dielectric material is cast around and within the first and second sections, wherein the mass of dielectric insulating material fills through openings in the first electric screen.

19. A sensor assembly comprising:

an electrode extending along a longitudinal axis;

a tubular body extending along the longitudinal axis and at least partially surrounding the electrode such that the tubular body is radially spaced from the electrode, the tubular body including

a first layer made of an electrically insulating material and comprising a first plurality of through openings, each configured as an elongated slit that has a length extending in a direction parallel to the longitudinal axis,

a second layer made of an electrically conductive material disposed on an inner surface of the first layer, wherein the second layer is configured as a first electric field sensor to detect an electric field produced by the electrode and comprises a second plurality of through openings, each configured as an elongated slit that has a length extending in a direction parallel to the longitudinal axis,

a third layer made of an electrically conductive material disposed on an outer surface of the first layer, wherein the third layer is configured as a first electric screen and comprises a third plurality of through openings, each configured as an elongated slit that has a length extending in a direction parallel to the longitudinal axis, and

a fourth layer made of an electrically conductive material disposed on an inner or outer surface of the first layer, wherein the fourth layer extends along the longitudinal axis and is linked to and electrically isolated from the second layer and the third layer; and

a mass of dielectric material at least partially enclosing the electrode and the tubular body, wherein the first, second, third, and fourth layers are molded within the mass of dielectric insulating material, and wherein the mass of dielectric material fills the first, second, and third pluralities of through openings,

wherein the fourth layer is configured to function as either (i) a second electric screen to shield the first electric field sensor from outside electrical interference independently of the first electric screen, or (ii) a second electric field sensor to detect an electric field produced by the electrode,

wherein each through opening of the first plurality of through openings is aligned with a through opening of the second plurality of through openings, and

wherein each through opening of the third plurality of through openings is aligned with a through opening in the first and second pluralities of through openings.

20. A sensor assembly comprising:

an electrode extending along a longitudinal axis;

a tubular body extending along the longitudinal axis and at least partially surrounding the electrode such that the tubular body is radially spaced from the electrode, wherein the sensor assembly further comprises a dielectric material at least partially enclosing the tubular body, wherein the dielectric material fills through openings in the tubular body, the tubular body including

a first tubular section extending along the longitudinal axis and including a first electric field sensor configured to detect an electric field produced by the electrode, wherein the first section includes a layer of electrically conductive material,

a second tubular section extending along the longitudinal axis, wherein the second section is linked to and electrically isolated from the first section, wherein the second section includes a layer of electrically conductive material disposed on an inner or outer surface of insulating material, and

a first electric screen comprising electrically conductive material and electrically isolated from the first electric field sensor of the first section and the layer of electrically conductive material of the second section, wherein the first electric screen is disposed outside the first section,

wherein the second tubular section is configured to function as either (i) a second electric screen to shield the first electric field sensor from outside electrical interference independently of the first electric screen, or (ii) a second electric field sensor to detect an electric field produced by the electrode, and

wherein the dielectric material is cast around and within the first and second tubular sections and the first electric screen.

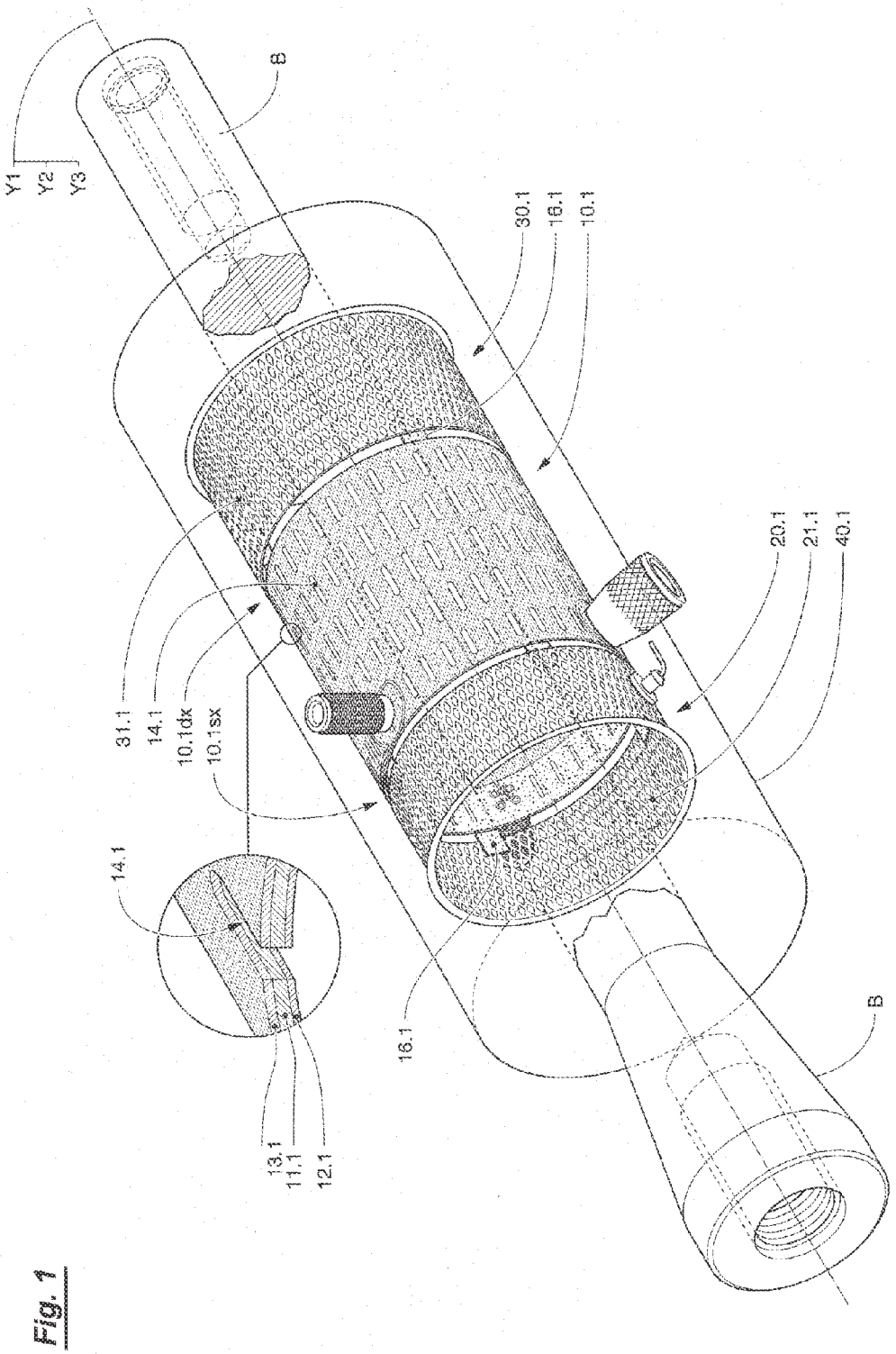


Fig. 1

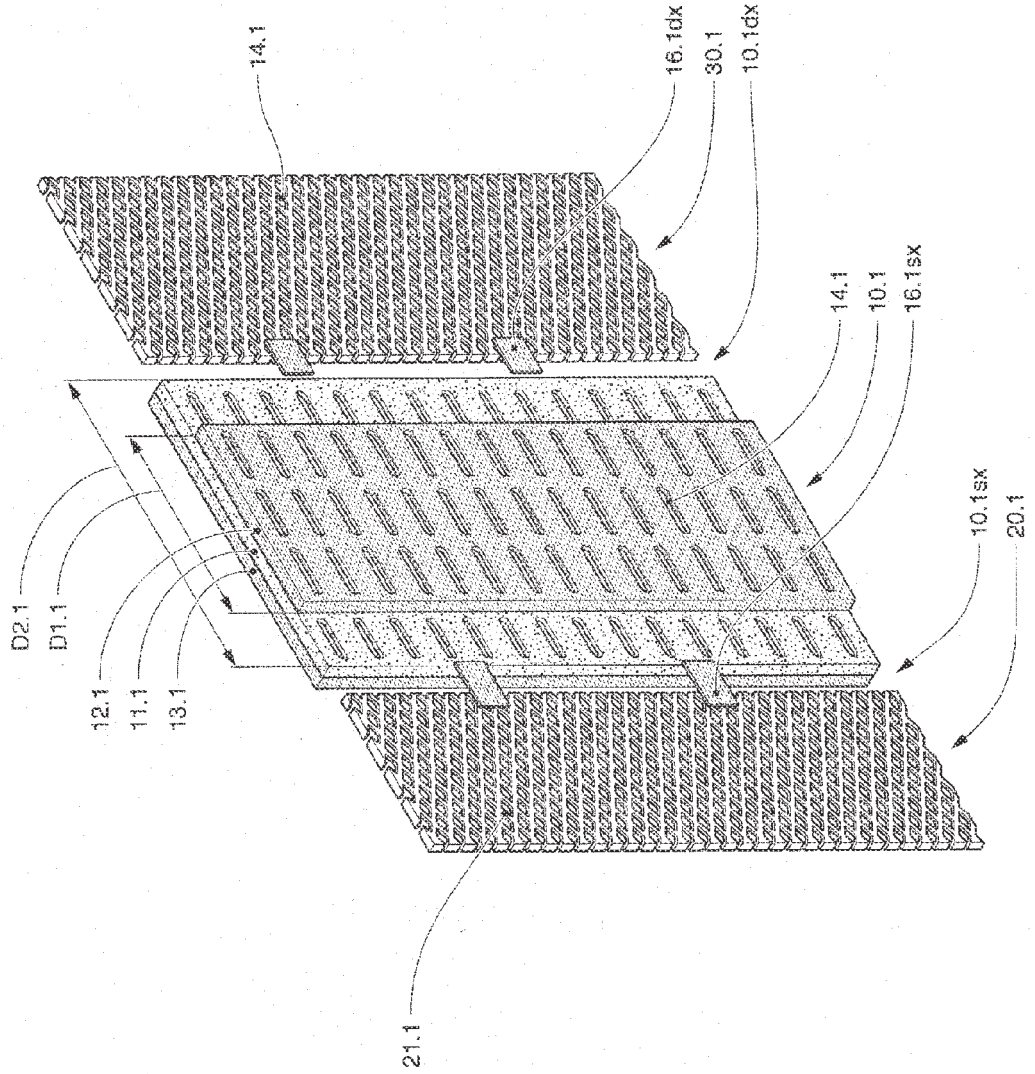


*Fig. 1A*

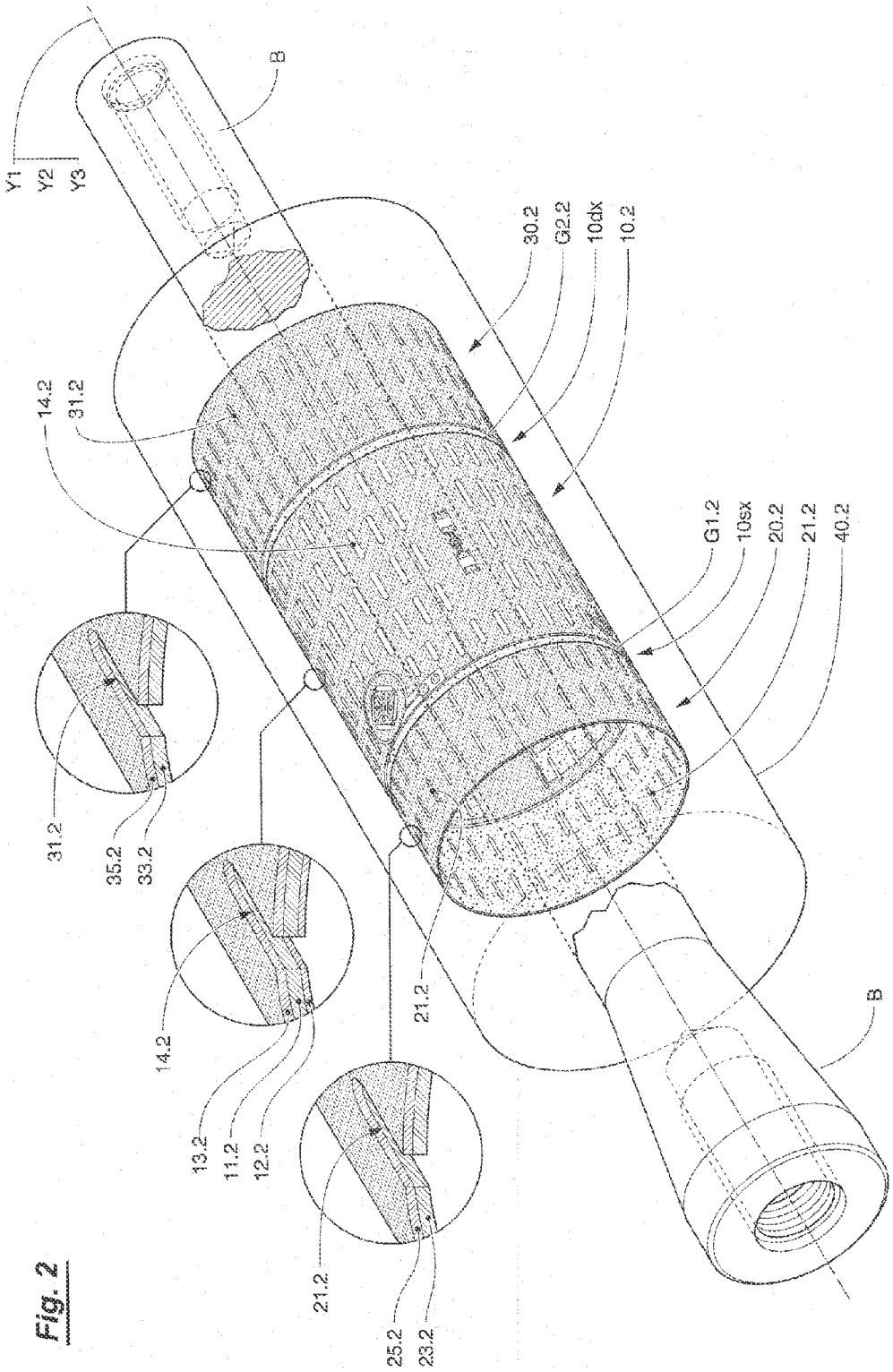


Fig. 2

2026201556 27 Feb 2026



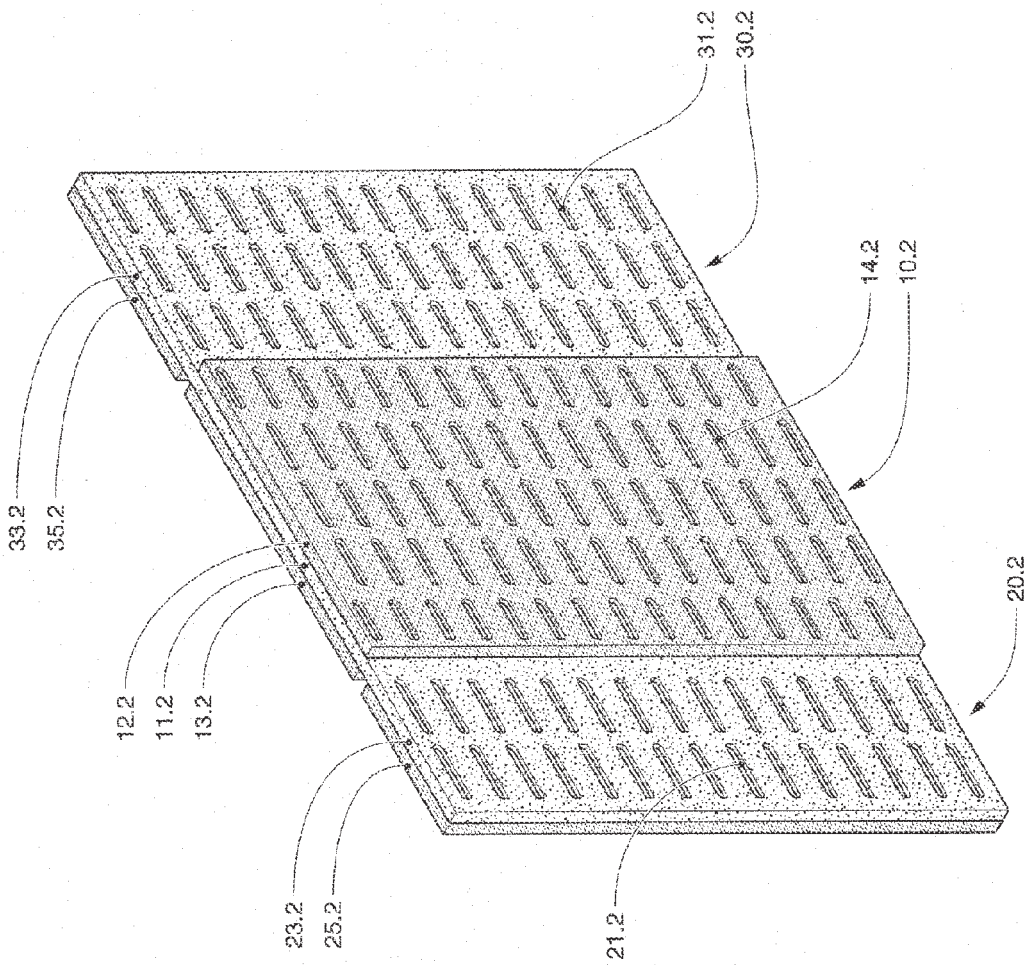


*Fig. 2A*

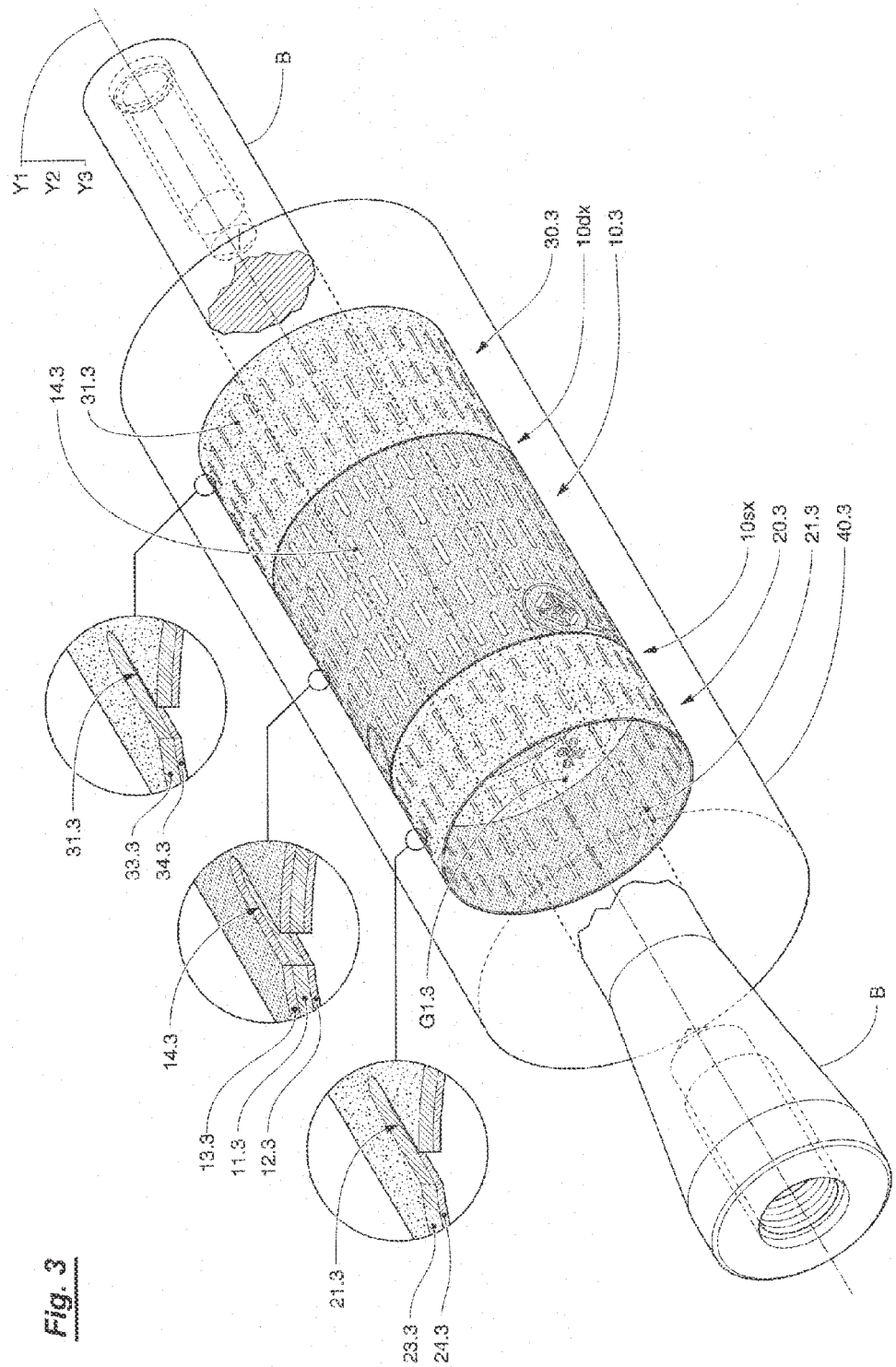


*Fig. 3*

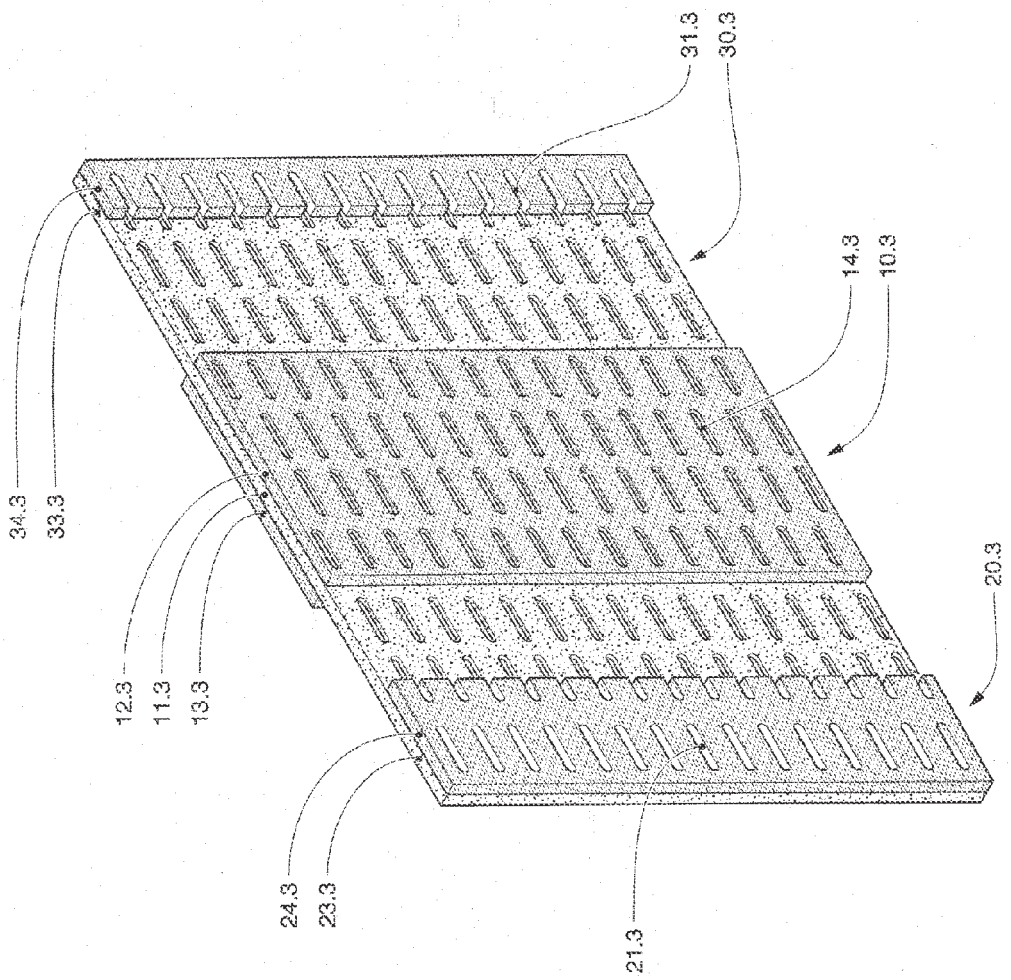


Fig. 3A

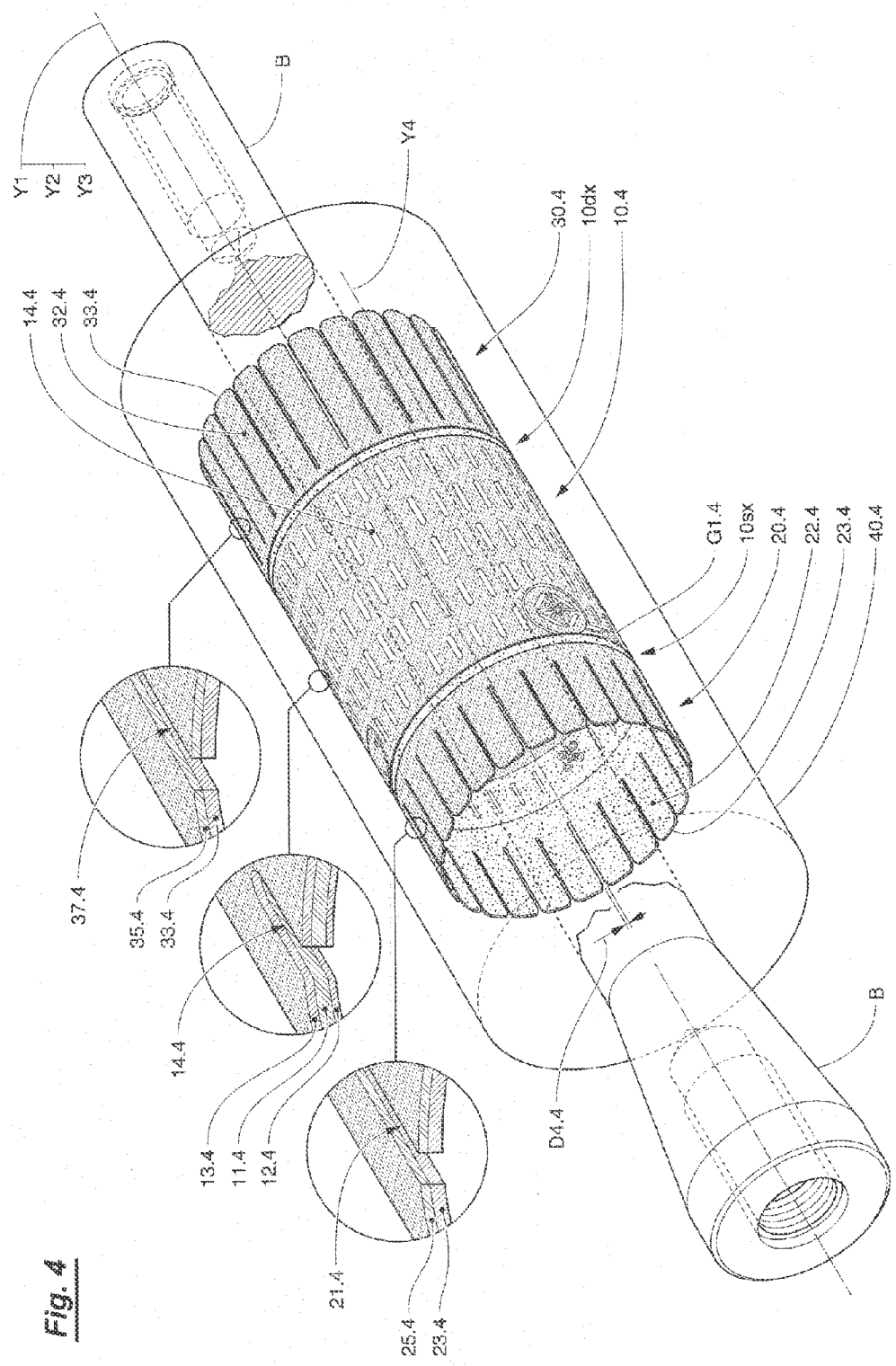


Fig. 4

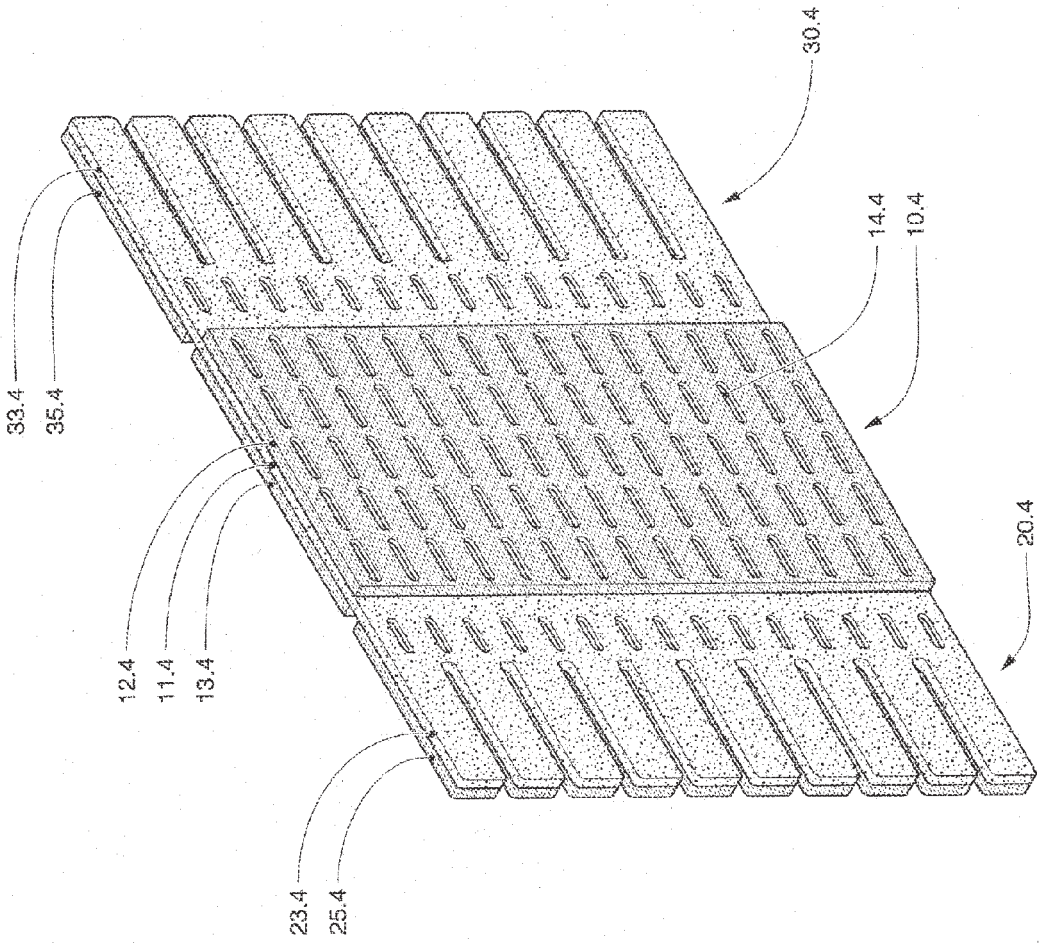


Fig. 4A

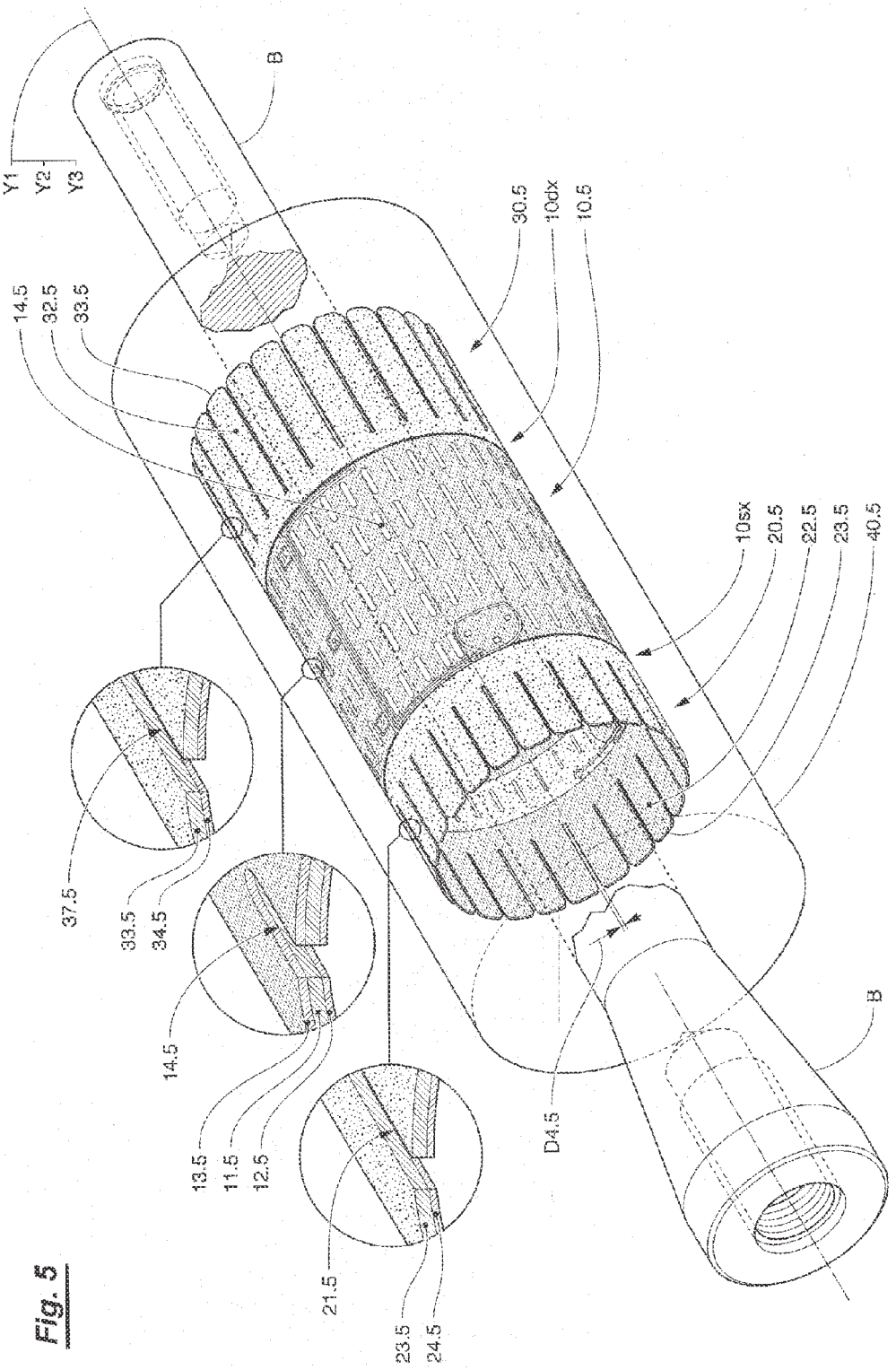


Fig. 5

2026201556 27 Feb 2026



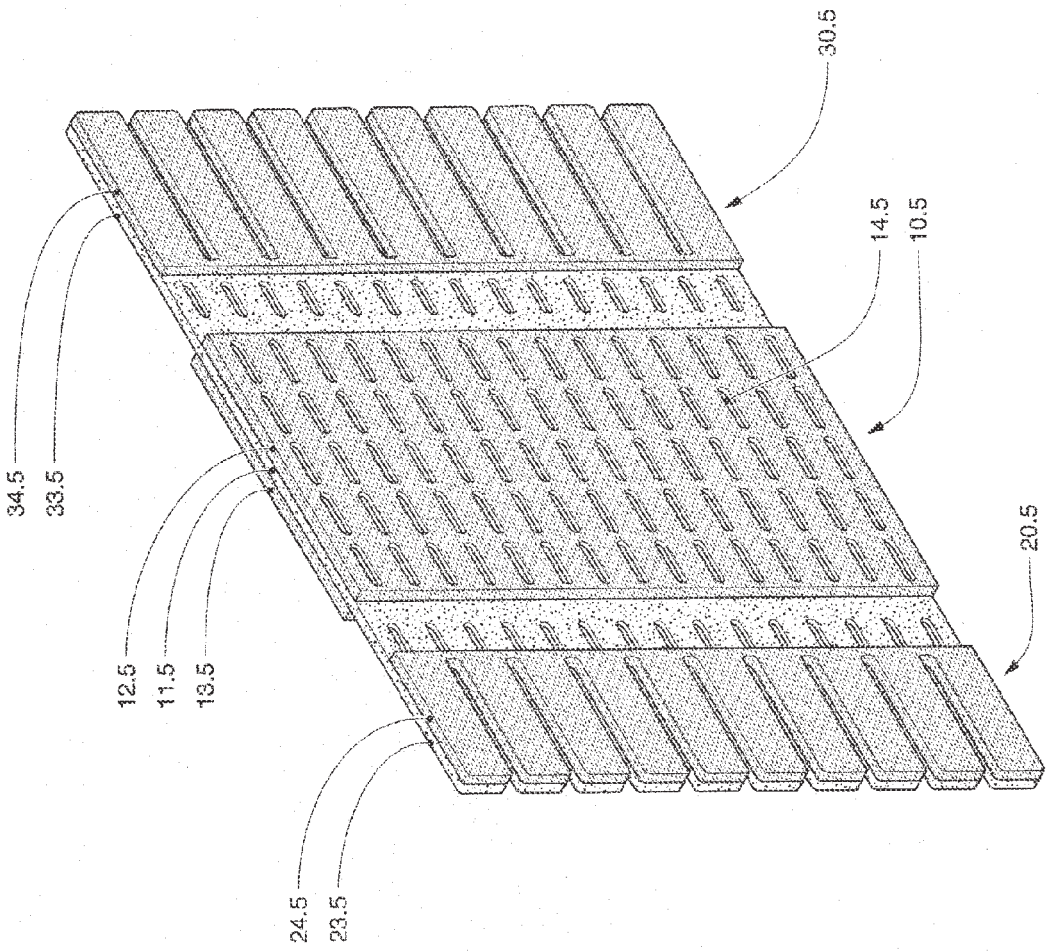


Fig. 5A