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(54) INSULATOR AND METHOD FOR MAKING AN INSULATOR

(57) An insulator comprises a primary conductor (2) extending along a longitudinal axis (A); and an insulating body (4), which surrounds, at least in part, the primary conductor (2) and comprises:

- at least one annular sensor (11; 11a, 11b, 11c), selected from the group comprising a current sensor (11a), a voltage measurement sensor (11b), a voltage detector (11c); and
- a frame (12; 112) configured to support the at least one annular sensor (11; 11a, 11b, 11c) such that the at least one annular sensor (11; 11a, 11b, 11c) is centred on the longitudinal axis (A).

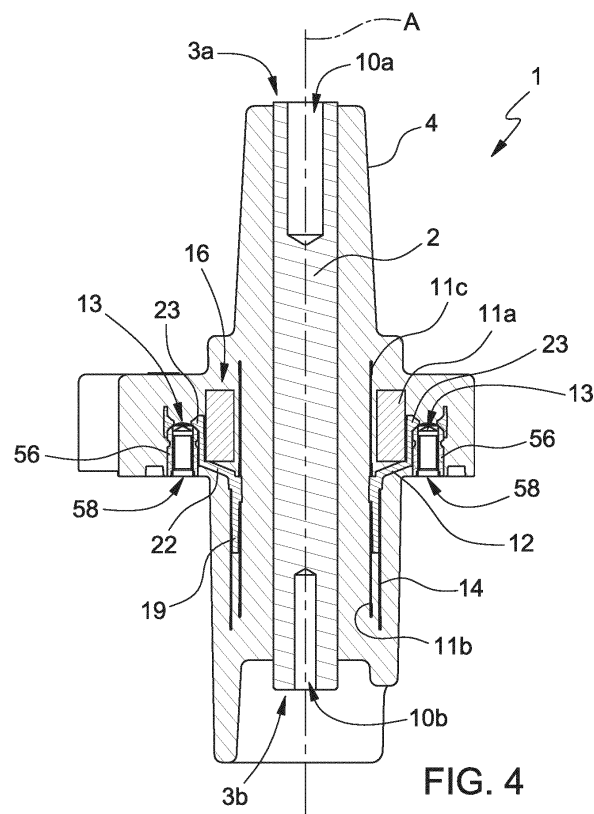


FIG. 4

Description

Cross-reference to related applications

[0001] This patent application claims priority from Italian patent application no. 102022000003494 filed on February 24, 2022, the entire disclosure of which is incorporated herein by reference.

Technical field

[0002] The present invention relates to an insulator and to a method for making an insulator.

[0003] Preferably, the present invention is particularly suitable for making the so-called "pass-through" insulators, which are utilised for allowing a conductor to pass through a metallic wall, insulating the conductors from the latter.

State of the art

[0004] Insulators of known type comprise a primary conductor and an insulating body, which surrounds the primary conductor.

[0005] Normally, inside the insulating body, a voltage detection sensor is arranged and, if required, at least one current measurement sensor and/or a voltage measurement sensor.

[0006] Some examples of insulators of this type are described in documents EP1376621, FR2815762, EP0933639 and US 2020/082961.

[0007] The detection performed by these sensors is strongly dependent on the correct positioning of the same with respect to the conductor.

[0008] Moreover, the increasingly pressing need to reduce the overall bulks of the insulators has even more highlighted the problem of the correct positioning of the sensors and the consequent unreliability of the detected measurements.

Description of the invention

[0009] An object of the present invention is thus to make an insulator which ensures a high detection precision by the sensors integrated therein and which, simultaneously, has a compact structure and is easy and cost-effective to make.

[0010] In accordance with such objects, the present invention relates to an insulator comprising:

a primary conductor extending along a longitudinal axis an insulating body, which surrounds, at least in part, the primary conductor and comprises:

- at least one annular sensor; and
- a frame configured to support the at least one annular sensor such that the at least one annular

sensor is centred on the longitudinal axis; the frame being provided with one or more anchoring elements for coupling the frame to a mould and for centring the at least one annular sensor on the longitudinal axis during the moulding process of the insulating body.

[0011] Thanks to the presence of the frame, the at least one sensor is correctly positioned with respect to the primary conductor ensuring reliable and precise measurements.

[0012] A further object of the present invention is to provide a method for making an insulator which ensures that the sensors integrated in the insulator detect reliable and precise measurements.

[0013] In accordance with such objects, the present invention relates to a manufacturing method as claimed in claim 14.

List of the figures

[0014] Further characteristics and advantages of the present invention will be evident from the following description of a non-limiting example embodiment thereof, with reference to the figures of the accompanying drawings, wherein:

- Figure 1 is a schematic perspective view, with parts removed for clarity, of an insulator according to the present invention;
- Figure 2 is a schematic perspective view, with parts removed for clarity, of the insulator of Figure 1 in a first operating configuration.
- Figure 3 is a schematic perspective view, with parts removed for clarity, of a first detail of the insulator of Figure 1;
- Figure 4 is a schematic section view, with parts removed for clarity, of the insulator of Figure 1;
- Figure 5 is an exploded perspective view, with parts removed for clarity, of a second detail of the insulator of Figure 1;
- Figure 6 is a top perspective view, with parts removed for clarity, of a third detail of the insulator of Figure 1;
- Figure 7 is a bottom perspective view, with parts removed for clarity, of the third detail of the insulator of Figure 6;
- Figures 8-10 schematically illustrate the steps of the method for making the insulator of Figure 1 according to the present invention;
- Figure 11 is a schematic perspective view, with parts removed for clarity, of an insulator according to the present invention in accordance with a second embodiment;
- Figure 12 is a schematic perspective view, with parts removed for clarity, of a first detail of the insulator of Figure 11;
- Figure 13 is a perspective view of a second detail of

the insulator of Figure 11;

- Figures 14 and 15 are perspective and planar section views, with parts removed for clarity, of the insulator of Figure 11;
- Figure 16 is a perspective view of a detail of the insulator according to the present invention in accordance with a further embodiment.

Description of embodiments of the invention

[0015] In Figures 1, 2, 3 and 4, reference numeral 1 indicates an insulator.

[0016] The insulator 1 comprises a primary conductor 2 extending along a longitudinal axis A and provided with a first end 3a and with a second end 3b, and an insulating body 4, which surrounds the primary conductor 2 between the first end 3a and the second end 3b.

[0017] In the non-limiting example described and illustrated herein, the insulator 1 is a pass-through insulator and is utilised for allowing the primary conductor 2 to pass through a wall.

[0018] In accordance with a variation not illustrated, the insulator is not a pass-through insulator and is provided with a first free end and with a second end included in the insulating body.

[0019] Figure 2 represents an example application of the insulator 1 according to the present invention, wherein the insulator 1 is coupled to a wall 5 of a medium voltage electrical switchboard.

[0020] Preferably, as it will be specifically apparent in the following, the insulator 1 is coupled to the wall 5 of the switchboard by means of screws 6. The screws 6 engage respective holes 7 of the wall 5 and respective seats 58 of the insulating body 4 (better visible in Figure 4), which will be specifically described in the following.

[0021] It is understood that the insulator 1 according to the present invention can be utilised for different voltages and for different applications (for example on the connection bars of the electrical switchboards).

[0022] With reference to Figures 1, 3, 4 and 5, the primary conductor 2 is made of a conductive material, preferably copper.

[0023] The first end 3a and the second end 3b are preferably threaded for allowing the coupling to respective conductors (see for example the end 3b in Figure 2).

[0024] In the non-limiting example described and illustrated herein, the first end 3a and the second end 3b are provided with a respective internally threaded hole 10a 10b.

[0025] According to a variation not illustrated, the first end and the second end are not threaded and are shaped to define a specific coupling to the respective conductors.

[0026] With particular reference to Figures 3, 4 and 5, the insulating body 4 comprises at least one sensor 11, and a frame 12 configured to support the at least one sensor 11.

[0027] As it will be specifically apparent in the following, the insulating body 4 is defined by insulating material

(preferably resin), in which the frame 12 and the at least one sensor 11 are embedded. The insulating body 4 made in this manner thus surrounds the primary conductor 2.

[0028] Preferably, the insulating body 4 has the shape of a revolution body.

[0029] The sensor 11 is selected from the group comprising a current sensor, a voltage measurement sensor and a voltage detector.

[0030] In the non-limiting example described and illustrated herein, the insulating body 4 comprises a current sensor 11a, a voltage measurement sensor 11b and a voltage detector 11c, preferably shielded (as it will be specifically apparent in the following).

[0031] In the non-limiting example described and illustrated herein, the frame 12 supports the current sensor 11a, the voltage measurement sensor 11b and the voltage detector 11c.

[0032] Other applications not illustrated provide for the insulator to comprise only a voltage detector and, optionally, a voltage measurement sensor.

[0033] The current sensor 11a, the voltage measurement sensor 11b and the voltage detector 11c have an annular shape and are arranged concentric with respect to the longitudinal axis A along which the primary conductor 2 extends.

[0034] In order to make the insulator 1 more compact, the frame 12 is configured such that the current sensor 11a is arranged around the voltage detector 11c.

[0035] Preferably, the frame 12 is further shaped such that the voltage detector 11c and the voltage measurement sensor 11b are substantially arranged axially aligned.

[0036] The current sensor 11a is preferably a Rogowski coil. The voltage measurement sensor 11b and the voltage detector 11c are cylindrical sensors.

[0037] Preferably, the voltage measurement sensor 11b is provided with an annular shielding element 14, which extends around the voltage measurement sensor 11b for ensuring an effective shielding against the external interferences ensuring a reliable and precise detection of the amplitude of the voltage signal.

[0038] The voltage detector 11c is defined by an annular element configured to detect the presence of voltage and does not compulsorily require any shielding. With reference to Figure 5, the frame 12 is made of an insulating material and has a substantially annular structure arranged around the primary conductor 2.

[0039] Practically, the voltage detector 11c substantially detects the presence of voltage in the primary conductor 2 (sensor of ON/OFF type), whereas the voltage measurement sensor 11b is capable of measuring the level of voltage in the primary conductor 2.

[0040] In particular, the frame 12 is centred with respect to the longitudinal axis A along which the primary conductor 2 extends.

[0041] Preferably, the frame 12 is made of a high temperature resistant material (for example above 150°C).

[0042] In the non-limiting example described and illustrated herein, the frame 12 is made of a preferably glass-fibre reinforced thermoplastic material.

[0043] As it will be specifically apparent in the following, the structure of the frame 12 is such to facilitate, during the moulding, a complete filling of the spaces by the insulating material so as to prevent the forming of cavities which can facilitate, in use, the onset of partial discharges.

[0044] For such reason, the structure of the frame 12 is reticulated as much as possible so as to facilitate the passage of the insulating material during the moulding process.

[0045] As it will be specifically apparent in the following, in fact, the frame 12 has a structure defined by elements whose walls are open as much as possible, so as to facilitate the passage of the insulating material and a complete filling of the spaces during the moulding process.

[0046] As already mentioned, the frame 12 is configured to support the at least one sensor 11.

[0047] The frame 12 is further configured to define one or more anchoring elements 13 which will be utilised, during the moulding process, for coupling the frame 12 to a mould and centring the at least one sensor 11 with respect to the primary conductor 2. The same anchoring elements 13, during use, will be utilised for the fixing to a supporting structure (in the non-limiting example described and illustrated herein, the wall 5).

[0048] As it will be specifically apparent in the following, the anchoring elements 13 ensure that the positioning of the frame 12 and, consequently, of the at least one sensor 11 with respect to the primary conductor 2 is precise and firm during the moulding process.

[0049] In the example described and illustrated herein, the frame 12 defines an annular seat 16 for housing the current sensor 11a, an axial annular wall 18 configured to support the voltage detector 11c and an axial annular wall 19 configured to support the voltage measurement sensor 11b.

[0050] With reference to Figures 6 and 7, the annular seat 16 extends around the annular wall 18.

[0051] The annular seat 16 is defined by the axial annular wall 18 and by a plurality of containment arms 21, which protrude from the annular wall 18. Each containment arm 21 is provided with a bottom 22 transverse to the longitudinal axis A and with an axial outer containment edge 23.

[0052] Preferably, the bottom 22 is inclined with respect to the longitudinal axis A (aspect better visible in the section view of Figure 4). The inclination of the bottom 22 is such to facilitate the uniform filling of the spaces with the insulating material cast during moulding.

[0053] Preferably, the bottom 22 is provided with one or more openings 24, capable of lightening the structure and facilitating the filling of the spaces with the insulating material.

[0054] The outer containment edge 23 has a curved profile substantially parallel to the annular wall 18.

[0055] In the non-limiting example described and illustrated herein, the containment arms 21 are four.

[0056] Each containment arm 21 is provided with a respective anchoring element 13 for coupling the frame 12 to a respective coupling element 55 of a mould 50 during the moulding process of the insulating body 4.

[0057] Preferably, each anchoring element 13 is coupled to the outer containment edge 23.

[0058] Advantageously, the anchoring elements 13 are configured to allow the coupling to the respective coupling elements 55 of the mould 50 during the moulding and to allow, when the moulding process is ended, coupling the insulator 1 to the wall 5 to which the insulator 1 will have to be fixed.

[0059] Preferably, each anchoring element 13 is defined by an axially extending cylindrical structure 25 internally provided with a reduction ring 26 suitable to define an inner through hole 27. The reduction ring 26 is substantially arranged in a middle zone of the cylindrical structure 25.

[0060] In this manner, each cylindrical structure 25 defines two respective cylindrical anchoring seats 28, the inputs of which are arranged at 180° from one another.

[0061] This allows, as it will be specifically apparent in the following, being able to couple the frame 12 indifferently to coupling elements 55 of the mould 50 arranged on one part or on the other part of the mould.

[0062] Advantageously, the anchoring elements 13 ensure that the positioning of the frame 12 and, consequently, of the current sensor 11a, of the voltage measurement sensor 11b and of the voltage detector 11c is precise.

[0063] The annular wall 18 and the axial annular wall 19 are axially aligned and are separated by an annular edge 29, which separates the inner surface 30 of the annular wall 18 and the inner surface 31 of the annular wall 19.

[0064] Preferably, the annular edge 29 is segmented for facilitating the filling of the spaces with the insulating material.

[0065] The annular wall 18 and the annular wall 19 are coupled to the voltage detector 11c and to the voltage measurement sensor 11b, respectively, preferably with interference.

[0066] In the following, a type of specific coupling will be described. It is understood that variations not illustrated can provide for coupling systems with interference of different type.

[0067] The axial annular wall 18 is provided with a plurality of axial through grooves 32, adapted to lighten the structure and to facilitate the uniform filling of the spaces with the insulating material poured during the moulding.

[0068] Practically, the axial grooves 32 of the annular wall 18 define first axial fins 33.

[0069] Along the inner surface 30, the annular wall 18 is preferably provided with a plurality of first preferably axial ribs 35, which radially protrude from the inner surface 30.

[0070] Preferably, each first fin 33 is provided with at least one respective first rib 35.

[0071] The first ribs 35 are preferably shaped to have a radial thickness substantially increasing towards the annular edge 29.

[0072] In this manner, the annular voltage detector 11c is keyed along the inner surface 30 and interference locked by the ribs 35.

[0073] The axial annular wall 19 has a structure substantially similar to the annular wall 18 and is provided with a plurality of axial through grooves 42, adapted to lighten the structure and to facilitate the uniform filling of the spaces with the insulating material cast during the moulding.

[0074] Practically, the axial grooves 42 of the annular wall 19 define second axial fins 43.

[0075] Preferably, the first fins 33 are arranged circumferentially offset with respect to the second fins 43.

[0076] Along the inner surface 31, the annular wall 19 is preferably provided with a plurality of second preferably axial ribs 45, which radially protrude from the inner surface 31.

[0077] Preferably, each second fin 43 is provided with at least one respective second rib 45.

[0078] The first ribs 45 are preferably shaped to have a radial thickness substantially increasing towards the annular edge 29.

[0079] In this manner, the annular voltage measurement sensor 11b is keyed along the inner surface 31 and interference locked by the ribs 45.

[0080] Preferably, the frame 12 also supports the annular shielding element 14 associated with the voltage measurement sensor 11b.

[0081] Specifically, the annular shielding element 14 surrounds the outer surface 46 of the annular wall 19 and is dimensioned to be interference coupled to the annular wall 19.

[0082] Figures 8-10 illustrate the main steps of the method for making the insulator 1 according to the present invention.

[0083] The method for making the insulator 1 provides for utilising an injection moulding technique of a liquid insulating material, preferably resin.

[0084] The injection moulding provides for the insulating material to be injected at the melted state, by means of the rotation of a screw (not illustrated), into a mould 50 in which the shape of the insulating body 4 is obtained in negative.

[0085] The mould 50 is composed of two parts: a lower base 51 and an upper covering element (not illustrated for simplicity).

[0086] The insulating material is injected by means of a feeding channel 53 partly visible in Figures 8-10.

[0087] The lower base 51 and the upper covering element are provided with respective cavities (in Figure 8 only the cavity 54 of the lower base is visible) shaped in such a way as to define, when coupled together, the desired shape of the insulating body 4.

[0088] When the cavity 54 of the lower base 51 and the cavity of the upper covering element are suitably dimensioned on the basis of the desired geometry of the insulating body 4, the process for making the insulator 1 provides for positioning the primary conductor 2 in the cavity 54 of the lower base 51 along a longitudinal axis A, screwing the end 3b of the primary conductor 2 to a fixing element (not visible in the accompanying figures), fixing the anchoring elements 13 of the frame 12 to one or more coupling elements 55 of the mould 50, positioning the upper covering element of the mould 50 and, finally, injecting the insulating material. The coupling elements 55 are fixed elements of the mould 50. The anchoring elements 13 are configured for a firm coupling to the coupling elements 55 so as to prevent the shifting of the frame 12 during the moulding and to maintain the centring for the entire moulding process. Obviously, the frame 12 is previously coupled to the at least one sensor 11 (in the non-limiting example described and illustrated herein, the frame 12 is coupled to the current sensor 11a, to the voltage measurement sensor 11b and to the voltage detector 11c) before being fixed to the coupling elements 55 of the mould 50.

[0089] Preferably, the coupling elements 55 are defined by pins of the mould 50. Therefore, the step of fixing the anchoring elements 13 of the frame 12 to one or more coupling elements 55 of the mould 50 provides for the coupling elements 55 (pins) of the mould 50 to engage respective anchoring elements 13 of the frame 12.

[0090] In the non-limiting example described and illustrated herein, the anchoring elements 13 comprise bushes 56, which engage the anchoring seats 28 facing the coupling elements 55. Each bush 56 defines a respective preferably axial seat 58.

[0091] Advantageously, in fact, cylindrical structures 25 allow fixing the frame 12 both to coupling elements 55 which are arranged on the lower base 51 of the mould 50 and to coupling elements 55 which are arranged on the upper covering element of the mould 50. It is sufficient, in fact, to position the bushes 56 in the anchoring seats 28 facing the coupling elements 55.

[0092] Preferably, the bushes 56 are preassembled to the frame 12 (i.e. are inserted in the cylindrical anchoring seats 28 of the cylindrical structures 25, as is illustrated in Figure 4).

[0093] Once the preassembling is ended, the frame 12 is positioned such that the seats 58 of the bushes 56 are engaged by the pins 55 of the mould 50.

[0094] A variation not illustrated provides for the coupling elements of the mould to be defined by seats of the mould and for the anchoring elements of the frame to comprise pins configured to engage said seats.

[0095] The coupling elements 55 are arranged in such a way as to ensure the centring of the frame 12 and of the at least one sensor 11 with respect to the longitudinal axis A along which the primary conductor 2 in the mould is arranged.

[0096] In this manner, at the end of the injection mould-

ing process, the frame 12 will be centred with respect to the longitudinal axis A and, consequently, also the current sensor 11a, the voltage measurement sensor 11b and the voltage detector 11c will be arranged concentric to the primary conductor 2.

[0097] Before positioning the upper covering element of the mould 50, the method further provides for fixing the cables of the sensors (not illustrated) to a special insert 57 connected to the lower base 51.

[0098] Once the moulding is ended, the bushes 56 of the anchoring elements 13 can be utilised for coupling the insulator 1 to a supporting structure (i.e. the wall 5 in the example described and illustrated herein).

[0099] Practically, the anchoring elements 13 of the frame 12 can thus be utilised for coupling the insulator 1 to the wall 5 to which the insulator 1 will have to be fixed.

[0100] As is illustrated in Figure 2, in fact, the screws 6 engage respective holes 7 of the wall 5 and respective anchoring elements 13 (in the specific example, the bushes 56) incorporated in the insulating body 4 during the moulding process.

[0101] Figure 16 illustrates a variation of the frame 12 illustrated in Figures 3-5.

[0102] In accordance with such variation, the frame 12 is provided with a side appendix 66 for supporting a printed circuit board (not illustrated for simplicity). Also the appendix 66 is defined by walls provided with one or more openings for defining passage zones of the insulating material during the moulding process. Obviously, the shape of the mould 50 depends on the structure of the frame utilised and on the geometry that one wants to give to the insulating body 4. In the case of the frame 12 illustrated in Figure 16 the mould 50 will have to have a shape different from the one illustrated in Figure 8, mainly because the frame 12 also supports the printed circuit board, which entails the presence of the appendix 66 of the frame 12 to be considered in the mould 50.

[0103] Figures 11-15 illustrate a further embodiment of an insulator 100 according to the present invention.

[0104] In the following, the same reference numerals utilised for Figures 1-10 will be used for indicating identical or similar parts.

[0105] The insulator 100 substantially differs from the insulator 1 for the presence of a frame 112 having a different structure from the frame 12.

[0106] The frame 112, like the frame 12, supports the at least one sensor 11.

[0107] In the specific example described and illustrated herein, the frame 112 supports the current sensor 11a, the voltage measurement sensor 11b and the voltage detector 11c.

[0108] The current sensor 11a, the voltage measurement sensor 11b and the voltage detector 11c have the same structure described in the foregoing.

[0109] The frame 112 is shaped such that the current sensor 11a, the voltage measurement sensor 11b and the voltage detector 11c are arranged concentric with respect to the longitudinal axis A along which the primary

conductor 2 extends.

[0110] The frame 112 is configured such that the current sensor 11a is arranged around the voltage detector 11c.

5 **[0111]** Preferably, the frame 112 is further shaped such that the voltage detector 11c and the voltage measurement sensor 11b are substantially arranged axially aligned.

10 **[0112]** The frame 112 is also configured to support the annular shielding element 14 around the voltage measurement sensor 11b.

[0113] Preferably, the frame 112 is shaped to also support a printed circuit board 114 connected to respective connectors 115.

15 **[0114]** The frame 112 is made of an insulating material and has a substantially annular structure arranged around the primary conductor 2 and provided with a side appendix 116 for supporting the printed circuit board 114.

20 **[0115]** According to a variation not illustrated, the appendix 116 is not present and the printed circuit board is external to the pass-through insulator 100.

[0116] Preferably, the frame 112 is made of a high temperature resistant material.

25 **[0117]** In the non-limiting example described and illustrated herein, the frame 112 is made of a preferably glass-fibre reinforced thermoplastic material.

30 **[0118]** With reference to Figures 12, 13 and 14, the frame 112 comprises a hollow body 117 shaped to support, as already aforementioned, the at least one sensor 11 and preferably also the printed circuit board 114.

35 **[0119]** In particular, the hollow body 117 is shaped in such a way as to be filled with insulating material 118 (visible in Figure 15) by means of vacuum moulding for fixing in a definitive and lasting manner the parts supported by the frame 112 (i.e. the at least one sensor 11 and preferably also the printed circuit board 114) to the frame 112.

[0120] The hollow body 117 is thus defined by closed walls shaped to define one or more housing cavities fillable during the vacuum moulding.

40 **[0121]** In particular, the hollow body 117 is shaped to define a cavity 120 within which the sensors 11a, 11c, 11b, the shield 14 and the printed circuit board are housed 114.

45 **[0122]** With reference to Figures 13 and 14, in particular, the cavity 120 is defined by an outer wall 122 and by an inner wall 123, at least in part facing one another, and by a base 124 which connects the outer wall 122 to the inner wall 123.

50 **[0123]** With reference to Figures 13-15, the inner wall 123 is cylindrical and centred on the axis A, whereas the outer wall 122 comprises a first cylindrical portion 125 (it too centred on the axis A), a second truncated cone portion 126 diverging starting from the first portion 125, a third annular portion 127 extending transverse to the axis A, and a fourth portion 128, which comprises four appendices 130, preferably semicircular, which protrude from the third portion 127 substantially to the vertexes of a

quadrilateral which circumscribes the third portion 127 (see Figure 13 in particular). The fourth portion 128 preferably also comprises a planar part 131 arranged between two appendixes 130 and extending from the third portion 127 transverse to the axis A. The appendixes 130 are provided with respective through holes 132.

[0124] Finally, the outer wall 122 also comprises a perimeter edge 134 substantially parallel to the axis A, which protrudes from the perimeter of the fourth portion 128.

[0125] The perimeter edge 134 thus follows the path defined by the perimeter of the fourth portion 128. Preferably, the perimeter edge 134 has a recess 135, configured to allow housing the connectors 115 connected to the printed circuit board 114, as it will be specifically apparent in the following.

[0126] The base 124 connects the inner wall 123 to the outer wall 122 and is provided with a step 138, which substantially defines an annular seat 139 proximal to the outer wall 122 and an annular rise 140 proximal to the inner wall 123.

[0127] The voltage measurement sensor 11b is arranged resting on the annular rise 140 and in contact with the inner wall 123. The voltage detector 11c is arranged in contact with the inner wall 123 and axially spaced apart from the voltage measurement sensor 11b by an annular spacer 144.

[0128] As already mentioned in the foregoing, the voltage detector 11c and the voltage measurement sensor 11b are substantially arranged axially aligned and spaced apart by the spacer 144.

[0129] Around the voltage measurement sensor 11b and inserted in the annular seat 139, the shield 14 is arranged.

[0130] Preferably, the spacer 144 has a radial thickness such to also ensure a suitable spacing between the voltage measurement sensor 11b and the shield 14.

[0131] The current sensor 11a is arranged around the voltage detector 11c resting on the annular portion 127 of the outer wall 122.

[0132] The printed circuit board 114 rests on the planar part 131 of the outer wall 122 and the connectors 115 engage the recess 135 of the outer wall 122.

[0133] When the current sensor 11a, the voltage detector 11c and the voltage measurement sensor 11b and the printed circuit board 114 are positioned, the through holes 132 of the appendixes 130 are engaged with bushes 145 (visible in Figure 12) and the hollow body 117 is filled with insulating material 118 (preferably the same utilised for the insulating body 4) by means of a vacuum moulding process.

[0134] When the moulding process is ended, a single block is obtained comprising the frame 112, the at least one sensor 11 and the connectors 115 ready for the direct connection. The bushes 145 and the through holes 132 define anchoring elements 133 of the frame 112 and allow the coupling to the mould 50 during the moulding of the insulating body 4.

[0135] Moreover, the anchoring elements 133 will allow, when the moulding process is ended, coupling the insulator 100 to the structure to which it will have to be fixed (i.e. the wall 5 in the non-limiting example described and illustrated herein).

[0136] Specifically, the bushes 145 define respective seats 146, which will be engaged, during the positioning of the frame 112 in the mould 50, by the coupling elements 55 of the mould 50.

[0137] According to a variation not illustrated, the bushes 145 which engage the through holes 132 extend within the hollow body 117 so as to define through seats 146, whose inputs are arranged at 180° from one another for allowing the coupling on both sides of the frame 112.

[0138] This allows, as it will be specifically apparent in the following, being able to couple the frame 112 indifferently to coupling elements of the mould 50 arranged on one part or on the other part of the mould.

[0139] Advantageously, the anchoring elements 133 ensure that the positioning of the frame 112 in the mould is precise.

[0140] The insulator 100 is substantially made in a manner similar to the insulator 1 with the sole difference of providing, before the final moulding illustrated in Figures 8-10, for an intermediate moulding process, preferably a vacuum moulding process, for fixing the sensors 11a, 11b 11c and the printed circuit board 14 in the hollow body 117. Obviously, the shape of the mould 50 depends on the structure of the frame utilised and on the geometry which one wants to give to the insulating body 4. In the case of the insulator 100, the mould 50 will have to have a shape different from the one illustrated in Figure 8, mainly because the frame 112 also supports the printed circuit board 114, which entails the presence of the appendix 116 of the frame 112 to be considered in the mould 50.

[0141] When the hollow body 117 is filled with the insulating material 118, the frame 112 is fixed to the mould 50 by means of the anchoring elements 133. In other words, the coupling elements 55 of the mould 50 cooperate with the respective anchoring elements 133 of the frame 112.

[0142] As is illustrated in the non-limiting example described in Figure 8, the anchoring elements 55 are defined by pins which engage the seats 146 of the bushes 145 of the anchoring elements 133.

[0143] The coupling elements 55 are arranged in such a way as to ensure the centring of the frame 112 with respect to the longitudinal axis A along which the primary conductor 2 in the mould is arranged.

[0144] In this manner, at the end of the injection moulding process, the frame 112 will be centred with respect to the longitudinal axis A and, consequently, also the current sensor 11a, the voltage measurement sensor 11b and the voltage detector 11c will be arranged centred in a precise manner.

[0145] Advantageously, since the board is integrated in the intermediate block, in this step it will not be neces-

sary to connect the cables as provided for the insulator 1 since said cables will be passing in the cavities of the mould 50.

[0146] Once the moulding process is ended, the anchoring elements 133 can be utilised for coupling the insulator 100 to the wall 5 to which the insulator 100 is to be fixed.

[0147] The structure of the frame 12 and 112, thus allows supporting the current sensor 11a, the voltage measurement sensor 11b and the voltage detector 11c in a firm manner and, simultaneously, ensures a correct positioning of the same with respect to the primary conductor 2 during the moulding process of the insulating body 4.

[0148] Moreover, the particular structure of the frame 12, 112 allows optimizing the spaces, which allows reducing the overall bulks of the insulator 1, 100.

[0149] Practically, the insulator 1, 100 according to the present invention has a high performance thanks to the centring of the sensors 11 and, simultaneously, is compact.

[0150] Moreover, the structure of the frame 12, 112 supports all the adopted sensors 11 ensuring, with only one element, a precise collocation of all the sensors 11.

[0151] The frame 12, 112 has a very compact structure and this allows the integration in insulators having already known shapes and substantially exploiting the moulds currently in use.

[0152] Advantageously, the structure of the anchoring elements 13, 133 of the frame 12, 112 further allows it to be adapted to the various applications making seats for the fixing in the fittest position for the desired application.

[0153] In conclusion, the insulator 1, 100 according to the present invention is compact and has reduced dimensions and is provided with precise and reliable functions for detecting the presence of voltage and for measuring voltage and current. In particular, the secure centring of the three sensors 11a, 11b and 11c, the shielding to the voltage measurement sensor 11b defined by the annular shielding element 14 and the positioning of the voltage measurement sensor 11c which is concentric and inside the current sensor 11a, allows significantly lessening the possible interference of the external electromagnetic fields ensuring the precision and the reliability of the measurements.

[0154] Finally, it is evident that modifications and variations can be made to the insulator and to the method described herein without thereby departing from the scope of the appended claims.

Claims

1. Insulator comprising:

a primary conductor (2) extending along a longitudinal axis (A);

an insulating body (4), which surrounds, at least in part, the primary conductor (2) and comprises:

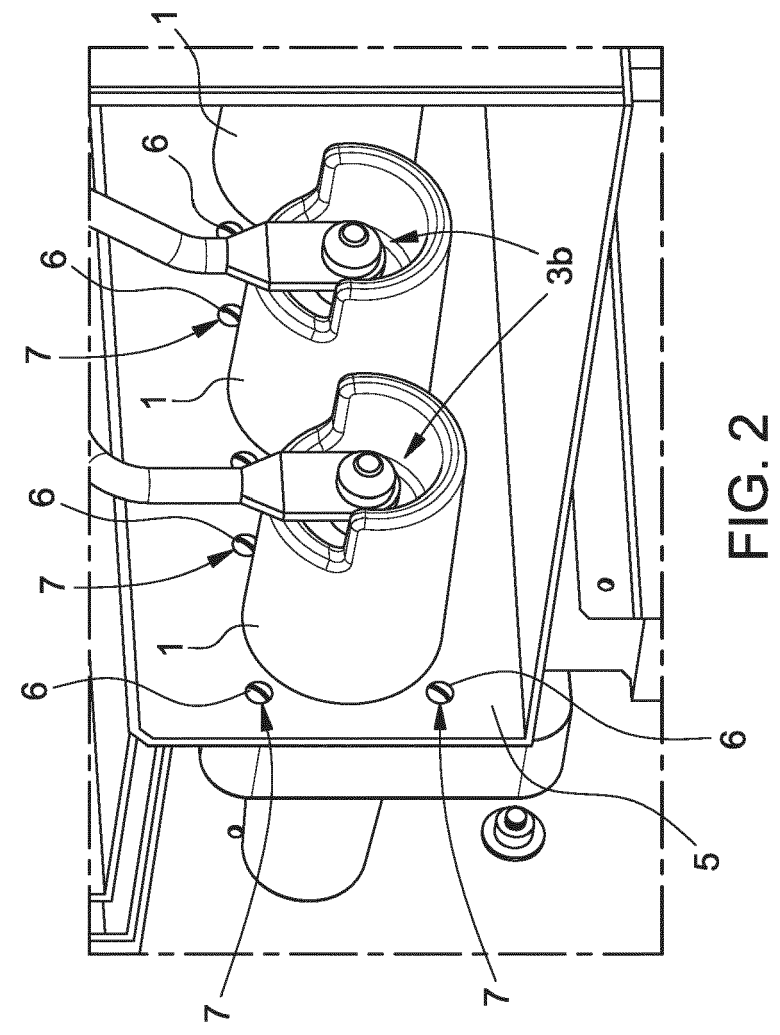
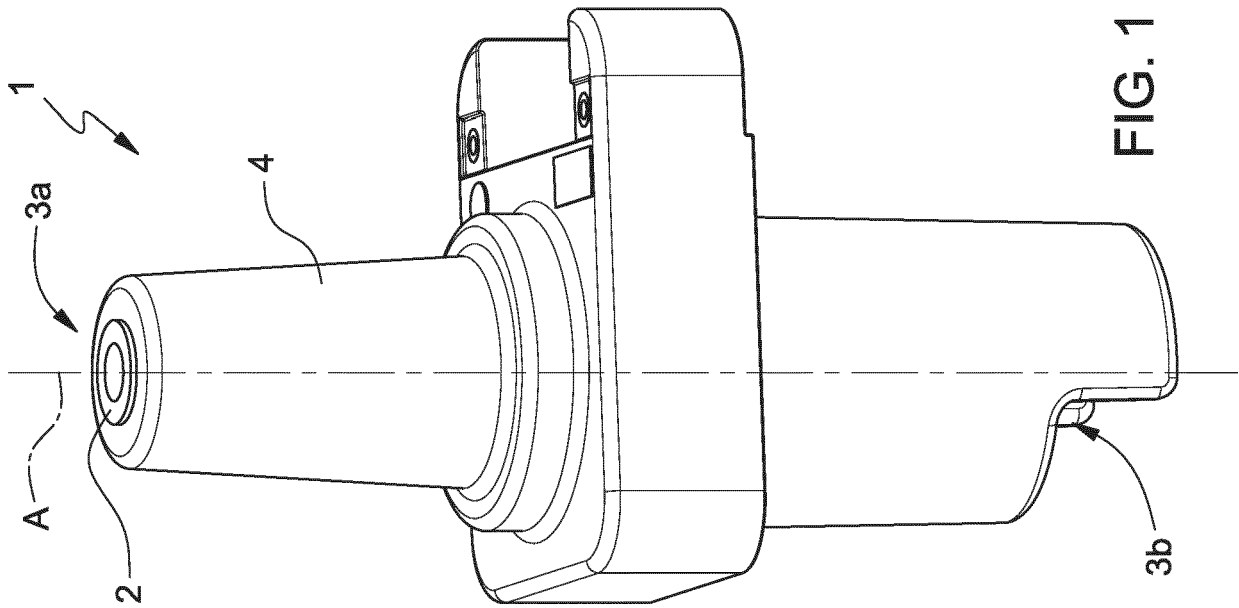
- at least one annular sensor (11; 11a, 11b, 11c); and
- a frame (12; 112) configured to support the at least one annular sensor (11; 11a, 11b, 11c) such that the at least one annular sensor (11; 11a, 11b, 11c) is centred on the longitudinal axis (A);
- the frame (12; 112) being provided with one or more anchoring elements (13; 133) for coupling the frame (12; 112) to a mould (50) and for centring the at least one annular sensor (11; 11a, 11b, 11c) on the longitudinal axis (A) during the moulding process of the insulating body (4).

2. Insulator according to claim 1, wherein the at least one sensor (11; 11a, 11b, 11c) and the frame (12; 112) are embedded in at least one insulating material.
3. Insulator according to claim 1 or 2, wherein the frame (12; 112) is made of a high temperature resistant insulating material.
4. Insulator according to any one of the preceding claims, comprising an annular voltage measurement sensor (11b), configured to detect the voltage value in the primary conductor (2); the frame (12; 112) being configured to support the voltage measurement sensor (11b).
5. Insulator according to claim 4, comprising an annular shielding element (14), which extends around the voltage measurement sensor (11b); the frame (12; 112) being configured to support the annular shielding element (14).
6. Insulator according to any one of the preceding claims, comprising an annular voltage detector (11c) configured to detect the presence of voltage in the primary conductor (2); the frame (12; 112) being configured to support the annular voltage detector (11c).
7. Insulator according to any one of the preceding claims, comprising an annular current sensor (11a); the frame (12) being configured to support the annular current sensor (11a).
8. Insulator according to any one of the preceding claims, comprising an annular current sensor (11a), an annular voltage detector (11c) and an annular voltage measurement sensor (11b); the frame (12) being configured such that the annular current sensor (11a) is arranged around the annular voltage detector (11c).

9. Insulator according to claim 8, wherein the frame (12) is configured such that the voltage detector (11c) and the voltage measurement sensor (11b) are substantially axially aligned.
10. Insulator according to any one of the preceding claims, wherein the anchoring elements (13; 133) of the frame (12; 112) are configured to allow, during use, coupling the insulator (1) to a supporting wall (5) of the insulator (1).
11. Insulator according to any one of the preceding claims, wherein each anchoring element (13; 133) defines an axially extending seat (58; 146).
12. Insulator according to any one of the preceding claims, wherein the frame (12) has a substantially reticulated structure to facilitate the penetration of the insulating material during the moulding process.
13. Insulator according to any one of claims 1 to 12, wherein the frame (112) comprises a hollow body (117) shaped to define at least one cavity (120) within which the at least one annular sensor (11; 11a, 11b, 11c) is housed; the cavity (120) being filled with insulating material (118).
14. A method for making an insulator (1; 100); the insulator (1; 100) comprising a primary conductor (2) and an insulating body (4), which surrounds, at least in part, the primary conductor (2) and is provided with at least one annular sensor (11; 11a, 11b, 11c) and with a frame (12; 112) configured to support the at least one annular sensor (11; 11a, 11b, 11c); the method comprising the steps of:
- providing an injection moulding mould comprising a lower base (51) and an upper covering element which can be coupled together; the lower base (51) and the upper covering element being provided with respective cavities (54) shaped in such a way as to define, when coupled together, the desired shape of the insulating body (4);
 - positioning the primary conductor (2) in the cavity (54) of the lower base (51) along a longitudinal axis (A), fixing one end (3b) of the primary conductor (2) to a fixing element of the cavity (54);
 - fixing at least one anchoring element (13; 133) of the frame (12; 112) to one or more coupling elements (55) of the mould (50) arranged in such a way that the at least one annular sensor (11; 11a, 11b, 11c) supported by the frame (12) is centred on the longitudinal axis (A) ;
 - coupling the upper covering element of the mould (50) to the lower base (51);
 - injecting the insulating material into the cavities (54) of the lower base (51) and of the upper cov-

ering element.

15. Method according to claim 14, wherein the at least one annular sensor (11; 11a, 11b, 11c) is selected from the group comprising a current sensor (11a), a voltage measurement sensor (11b), a voltage detector (11c).
16. Method according to claim 14 or 15, comprising the step of coupling the at least one annular sensor (11; 11a, 11b, 11c) to the frame (12; 112) before fixing the at least one anchoring element (13; 133) of the frame (12; 112) to one or more coupling elements (55) of the mould (50).
17. Method according to claim 16, wherein the step of coupling the at least one annular sensor (11; 11a, 11b, 11c) to the frame (112) comprises arranging the at least one annular sensor (11; 11a, 11b, 11c) in a cavity (120) of a defined hollow body (117) of the frame (112) and filling the cavity (120) with insulating material.



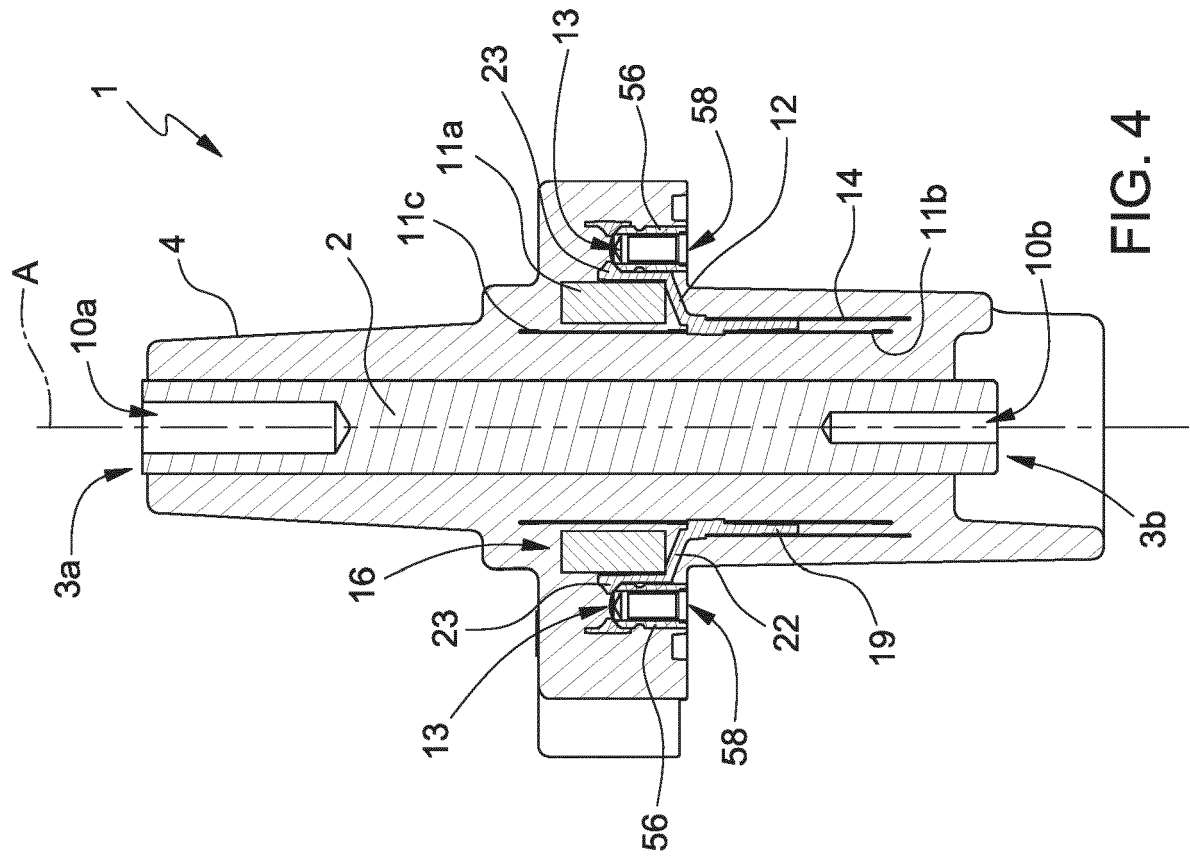


FIG. 4

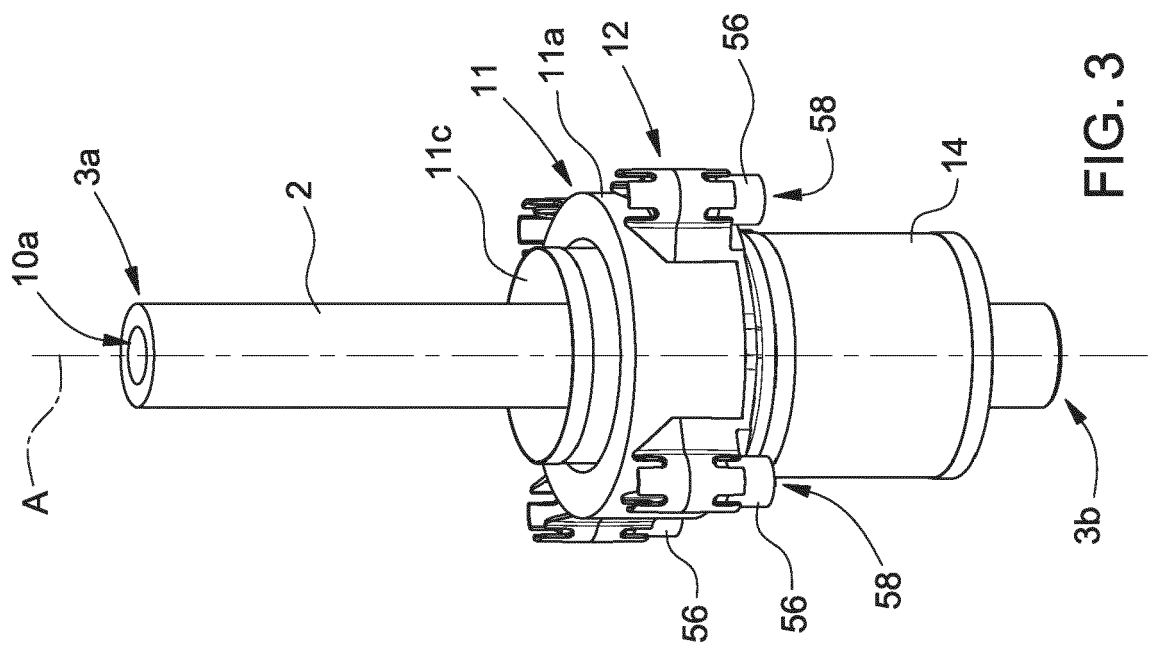


FIG. 3

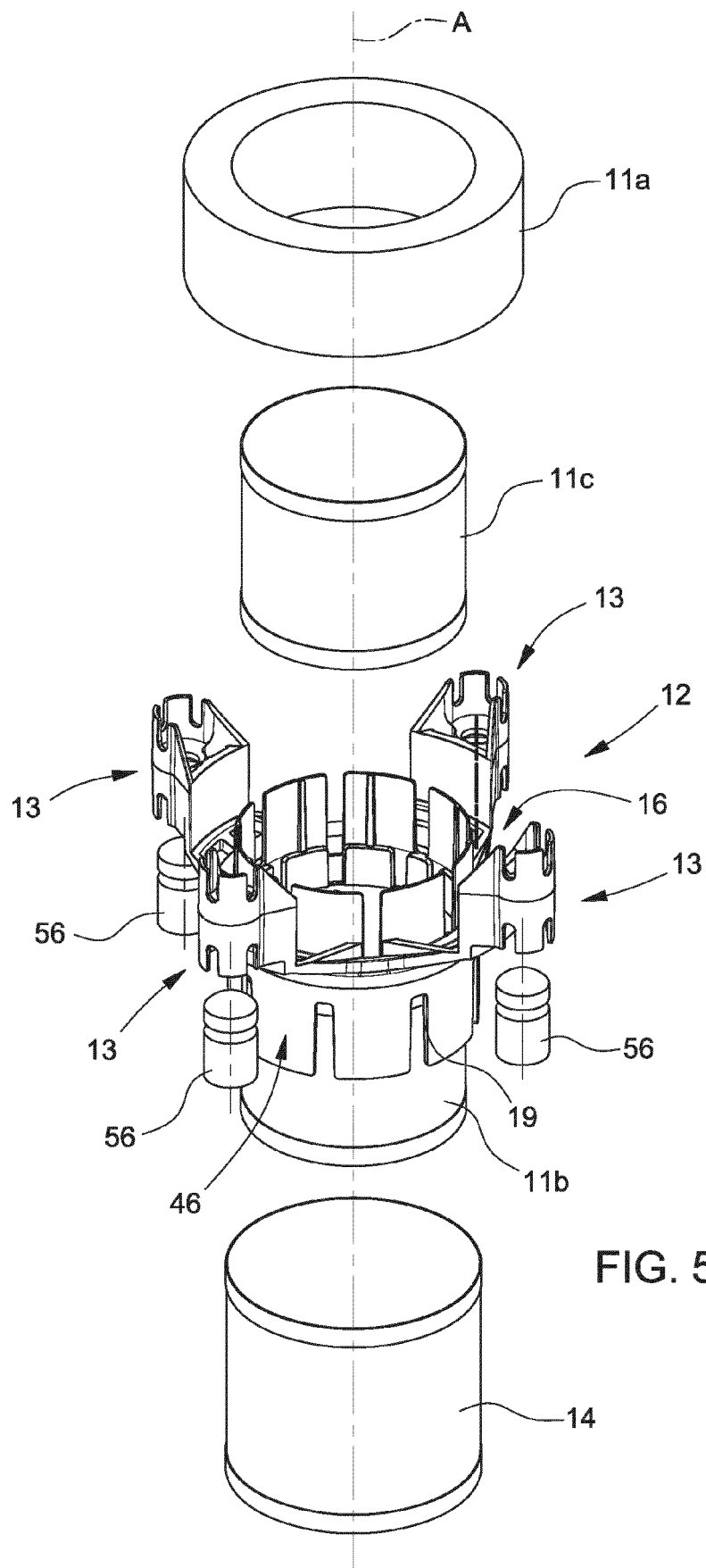
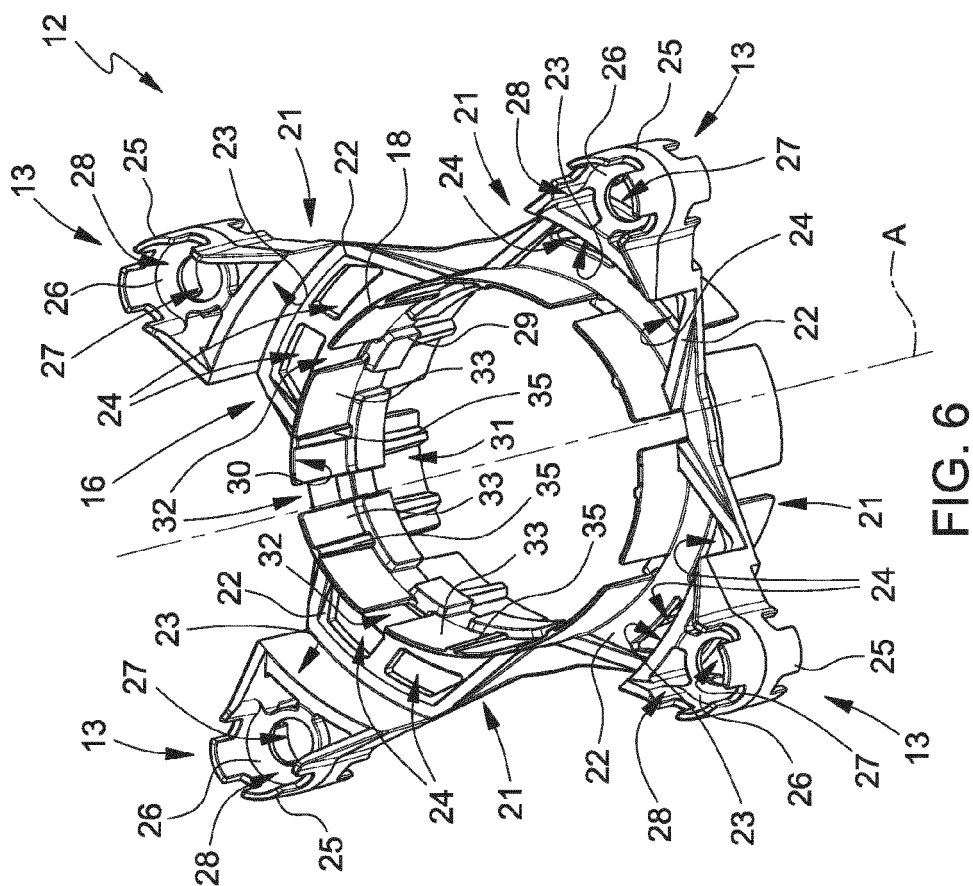
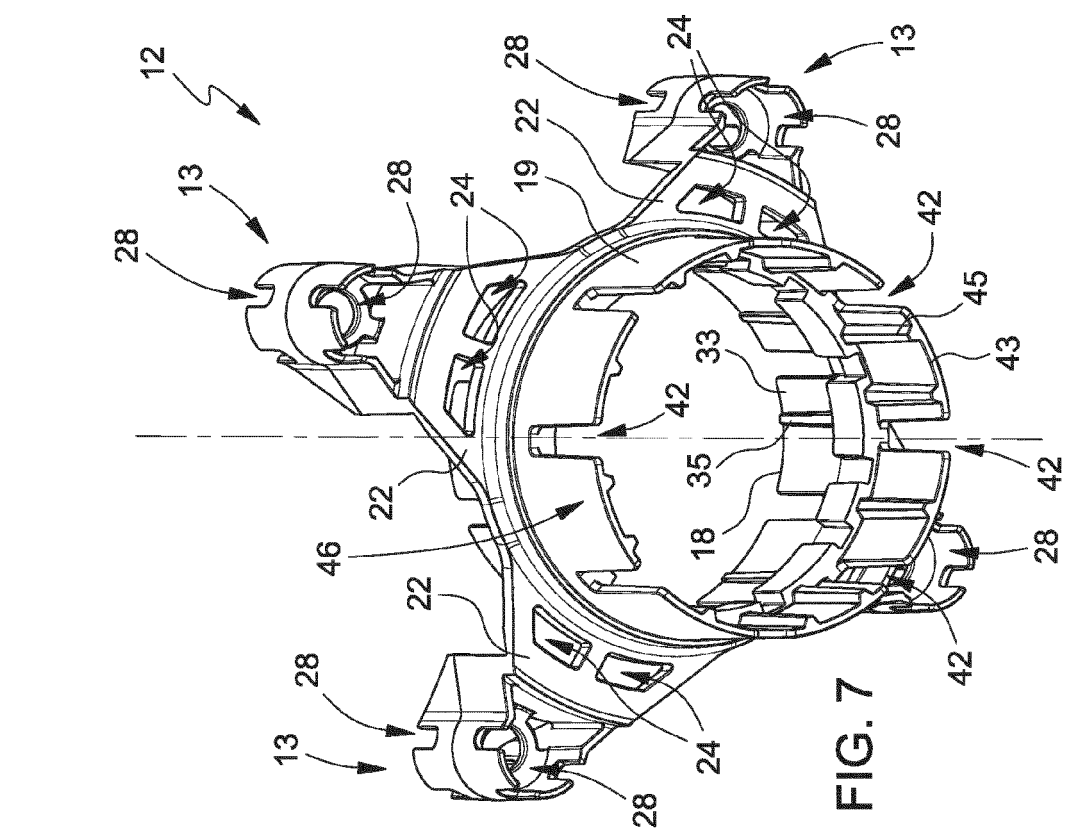


FIG. 5



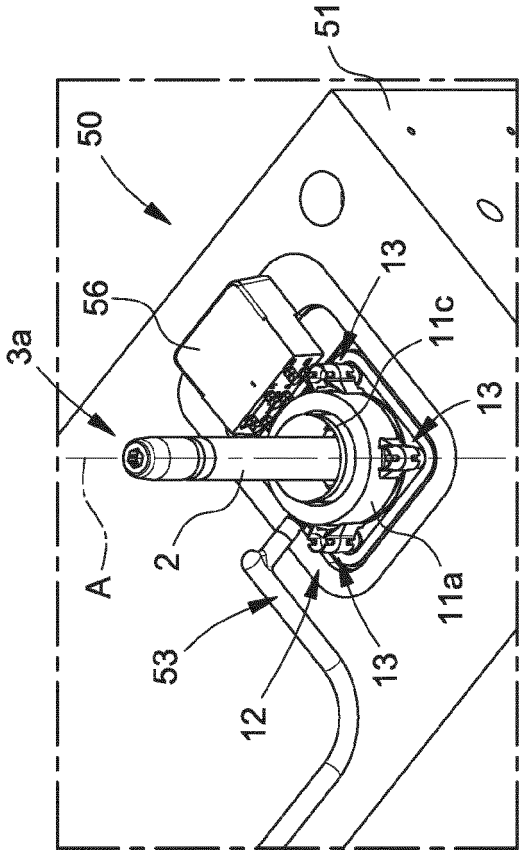


FIG. 9

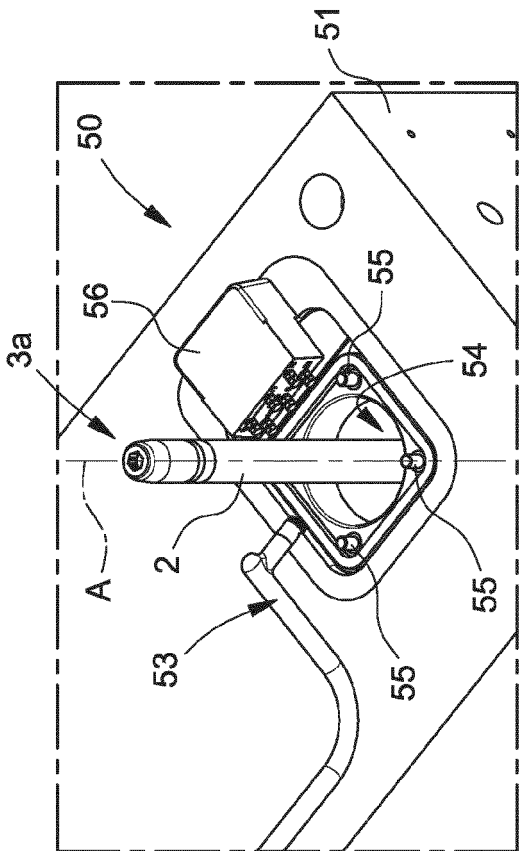


FIG. 8

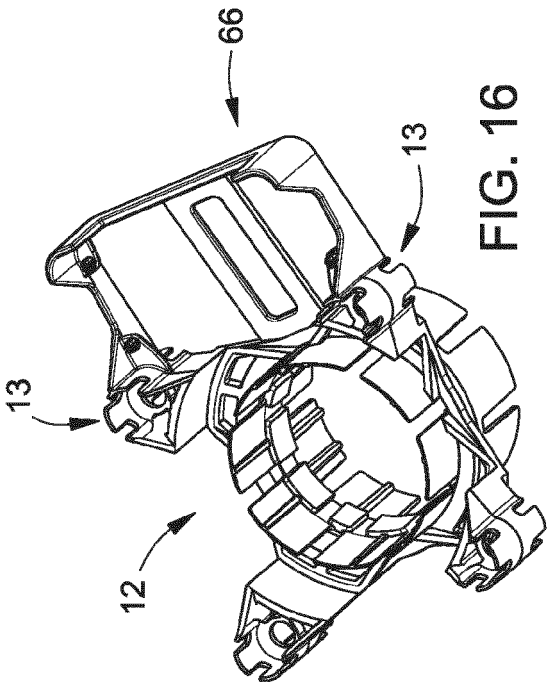


FIG. 16

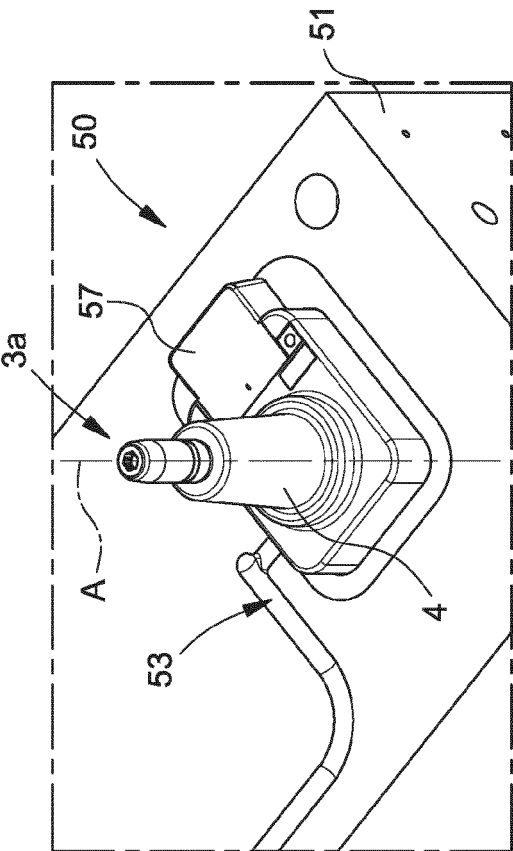


FIG. 10

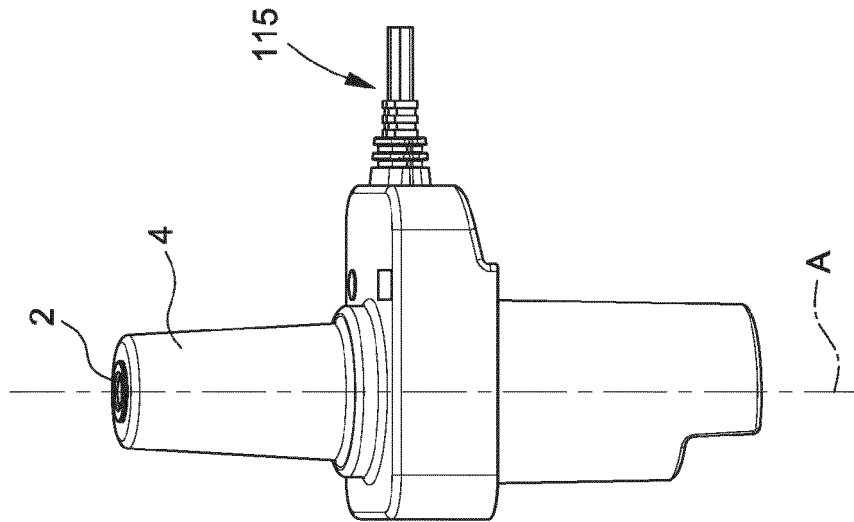


FIG. 11

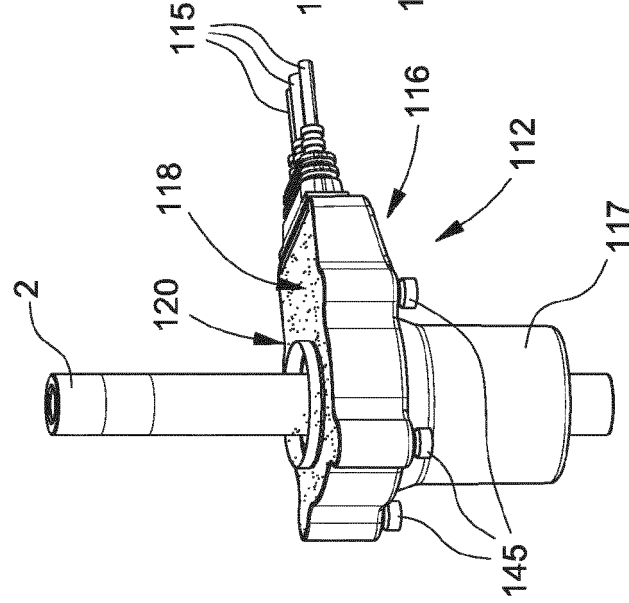


FIG. 12

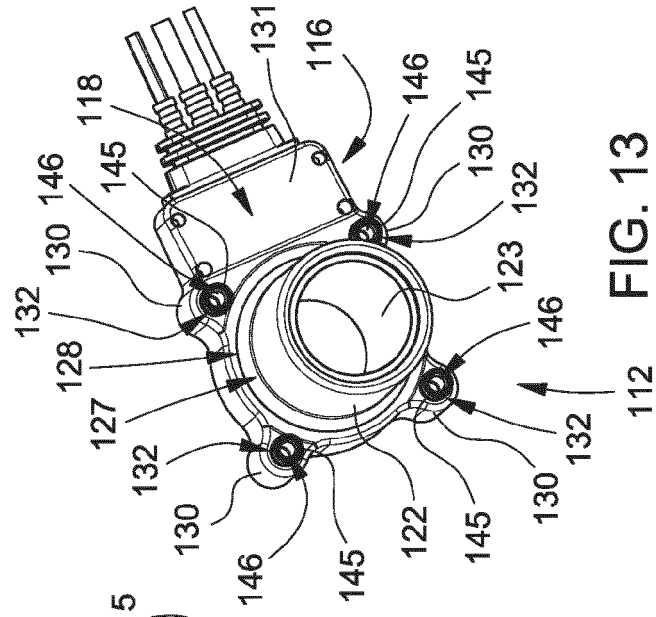


FIG. 13

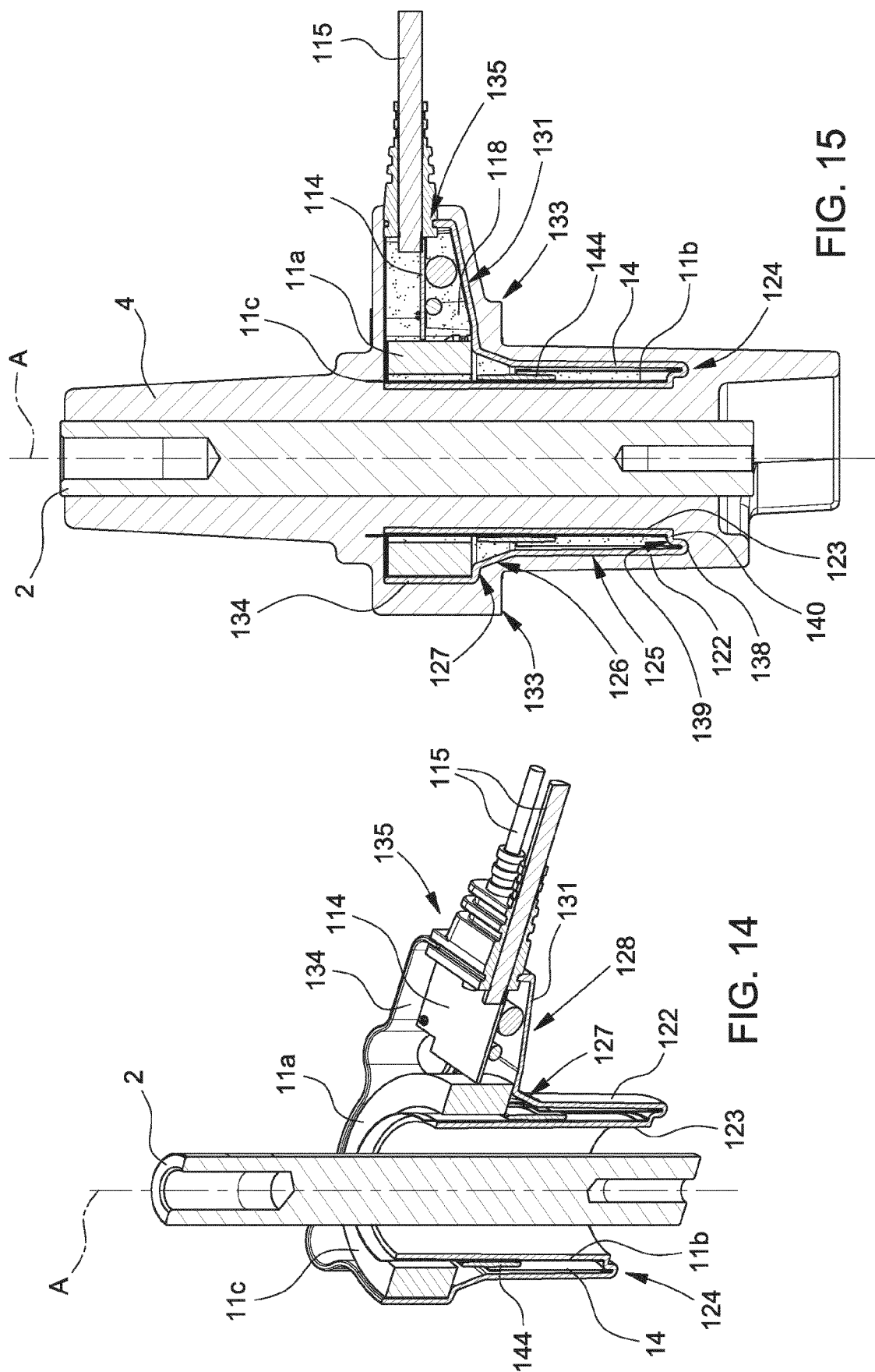


FIG. 15

FIG. 14



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Application Number

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The present search report has been drawn up for all claims			

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EPO FORM 1503 03.82 (P04C01)

Place of search	Date of completion of the search	Examiner
The Hague	11 July 2023	Alberti, Michele
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