



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
21.08.2019 Bulletin 2019/34

(51) Int Cl.:
H01R 13/66 (2006.01) H01R 24/28 (2011.01)

(21) Application number: **18156945.0**

(22) Date of filing: **15.02.2018**

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
MA MD TN

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(54) **ELECTRICAL CONNECTOR**

(57) An electrical connector (100) for a power cord comprising: a plug housing (120) having at least one elongated electrical power terminal (160) arranged inside a cavity (130) of the plug housing (120), at least one thermal sensor (300) and at least one elongated heat transfer member (200), wherein the heat transfer member (200) comprises first coupling means for mechanically and thermally connecting the electrical power terminal (160) to the elongated heat transfer member (200) on a first end (202) and wherein the elongated heat transfer member (200) comprises second coupling means for mechanically and thermally connecting thermal sensor (300) to the elongated heat transfer member (200) on a second end (204).

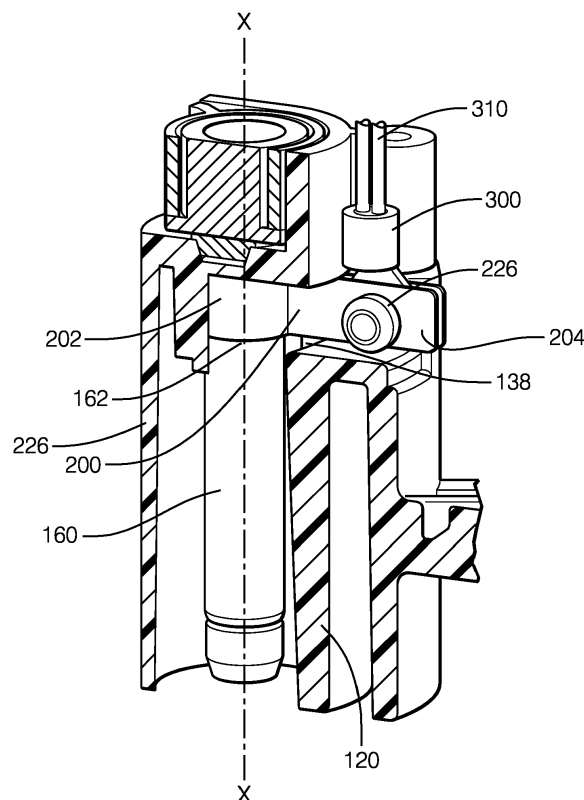


FIG. 3

Description

TECHNICAL FIELD OF INVENTION

[0001] The invention relates to an electrical connector for an electrical power cord for usage in high current charging application like electrical driven vehicles or hybrid vehicles.

BACKGROUND OF INVENTION

[0002] In high current application usually power cords are used that comprise plug connectors having at least one temperature sensor for detecting the temperature of the plug, and a shut-off device for stopping the power supply to a load from the plug when an abnormal temperature rise is detected by the temperature sensor. According to the power cord of this type, even when abnormal heat generation occurs because of a contact failure of the plug pins of the plug at the power socket, fire or damage to the plug due to the heat can be prevented by stopping the power supply.

[0003] In a case where only one temperature sensor is provided, a correlation between the output of the temperature sensor and the temperature of the plug pin farthest from the temperature sensor among the plurality of plug pins becomes relatively low. Accordingly, response to the temperature rise at the corresponding plug pin becomes slow, and safety may be reduced. On the other hand, in a case where a plurality of temperature sensors is provided and the output of each temperature sensor is monitored individually, it may cause an increase in the number of parts and/or complication of a wiring. Document EP2884611 discloses an improved power cord cable that improves safety and avoiding an increase in the number of parts and complication of a wiring.

[0004] The document discloses a power cord including: a plug having a plurality of plug pins and a plurality of PTC (Positive Temperature Coefficient) thermistors, at least one of which is provided for each of the plug pins to detect a temperature of the corresponding plug pin. The PTC thermistors form one series circuit. Each thermal sensor includes a temperature detection element, and a metal-made holder that holds the temperature detection element. The holder has the same structure as well-known lug terminal, as a whole. The holder includes a fixed portion that has an annular shape and is to be fixed to a corresponding plug pin by a screw and a body portion that houses the temperature detection element therein. The fixed portion of each thermal sensor is fixed on one surface of the corresponding plug pin, which faces outside in a horizontal direction. Unfortunately, the plug pins in the disclosed power cord have to have openings for the screw that are screwed in to hold thermal sensor close to the plug pin, that may weaken the plug pin and support corrosion when different metals are used. Furthermore, the plug housing has to be designed to provide space for thermal sensor adjacent to the plug pins that

limits the freedom to the design the plug housing. Finally, thermal sensors have to be screwed to the plug pins before the plug pins are mounted into the plug housing. That limits the opportunities that are given by preassembly in various locations while production of the power cord.

[0005] There is a need in the art to provide an electrical connector for a high current power cord, that provide means to reliably detect abnormal heat generation at the electrical pins and is flexible to manufacture.

[0006] An electrical connector for an electrical power cord according claim 1 solve these and other objects, which become apparent upon reading the following description.

SUMMARY OF THE INVENTION

[0007] The present application relates to an electrical connector for a power cord comprising: a plug housing having at least one elongated electrical power terminal arranged inside a cavity of the plug housing, at least one thermal sensor and at least one elongated heat transfer member. The heat transfer member comprises first coupling means for mechanically and thermally connecting the electrical power terminal to the elongated heat transfer member on a first end. The elongated heat transfer member comprises second coupling means for mechanically and thermally connecting thermal sensor to the elongated heat transfer member on a second end.

[0008] The disclosed invention provides an electrical connector employing an elongated heat transfer member for transferring a portion of the heat generated in the electrical connector while charging. The elongated heat transfer member transfers the heat from a contact region to a sensor region where a thermal sensor is attachable to sense the temperature of the elongated heat transfer member. The first end of the elongated heat transfer member is located inside the terminal cavity and the second end is located outside the terminal cavity. That makes the assembly process easier because the second end is easy accessible to attach the thermal sensor. Furthermore, there is no need to seal the heat transfer member or the thermal sensor because there are located in the wet area of the electrical connector. The thermal sensor senses the temperature and a computing device calculates, starting from that value, the temperature of the electrical power terminal. The value is important to control the charging process. The design provides fast and exact measure values because the elongated heat transfer member is in direct contact the electrical power terminal.

[0009] According to a preferred embodiment, the cavity comprises a cavity opening arranged parallel in relation to a terminal surface of the elongated electrical power terminal. The first coupling means comprises a circular curved area defining the first end of the elongated heat transfer member. The circular curved area is arranged inside the cavity surrounding the elongated electrical

power terminal The second coupling means comprises two straight portions, each starting from an end of the circular curved area, protruding through the cavity opening to outside the cavity. The circular curved area is adapted to the outer shape of the elongated electrical power terminal that has a round cross section in this embodiment. This makes sure that the elongated heat transfer member is in close contact to the elongated electrical power terminal to enable improved heat transfer. The heat is transferred further from the curved area by the two straight portions. The two straight portions connect the inside of the cavity to the outside of the cavity. That makes it easy to attach the thermal sensor, outside the cavity, to the heat transfer member while assembly of the electrical connector.

[0010] Preferably, the two straight portions are arranged having an angle in between each other and wherein an inner diameter of the circular curved area is bigger than an outer diameter of the elongated electrical power terminal that is surrounded, when thermal sensor is not connected to the two straight portions. This design makes it possible to preassemble the heat transfer member to the plug housing. The heat transfer member can be assembled without the electrical power terminal or before the electrical power terminal is inserted into the plug housing. After insertion of the electrical power terminal the two straight portions are moved towards each other to reduce the inner diameter and bring the circular curved area in contact to the electrical power terminal. In this embodiment the usage of flexible material, for example spring steel, for making the heat transfer member is recommended. The preassembled electrical connector may be shipped to a distant production plant for finally assembly. That makes the production of the electrical connector more flexible.

[0011] Advantageously, the two straight portions are parallel and in contact to each other and the inner diameter of the circular curved area is the same as the outer diameter of the elongated electrical power terminal that is surrounded, when thermal sensor is mechanically and thermally connected to the two straight portions. This design provides a robust heat transfer part to the thermal sensor.

[0012] According to another preferred embodiment, the cavity comprises a support surface arranged opposite to a terminal surface of the elongated electrical power terminal. The first coupling means comprises a first flat straight tongue defining the first end of the elongated heat transfer member. The first flat straight tongue is arranged in between the support surface and the terminal surface of the elongated electrical power terminal thereby mechanically and thermally connecting the elongated heat transfer member to the electrical power terminal. The cavity comprises a cavity opening to outside the cavity. The second coupling means comprises a second flat straight tongue, protruding through the cavity opening to outside the cavity. This embodiment provides an even simpler assembly because the elongated heat transfer

member can be stickled through the cavity opening, while assembly the electrical connector, as one of the final production step in the production processes. In applications where small contact areas are sufficient, this embodiment is recommended. The first and second flat straight tongues have not to be strictly straight but can also be bend, e.g. the first flat tongue can be arc shaped to follow the shape of the electrical power terminal. This increases the contact area between the first flat tongue and the elongated electrical power terminal. This design also provides the opportunity of easy adaptation to a variety of different electrical power terminals.

[0013] Preferably, the elongated heat transfer member comprises at least one layer of material with high thermal conductivity. A layer of material with high thermal conductivity improves the thermal resistance of the elongated heat transfer member. That results in a faster transfer of the heat to the sensor and the opportunity to improve the charging process.

[0014] Advantageously, the elongated heat transfer member comprises at least one layer of highly oriented pyrolytic graphite. The layer of highly oriented pyrolytic graphite provides increased heat transfer properties. This material is offered on the market.

[0015] According to another preferred embodiment, the elongated heat transfer member comprises a flat flexible structure, wherein the flat flexible structure comprises highly oriented pyrolytic graphite. A metal part, a plastic part, or a foil, coated with highly oriented pyrolytic graphite can define the flexible structure. The layer of highly oriented pyrolytic graphite does the heat transfer. If a foil defines the elongated heat transfer member, another layer of the foil can provide or improve the mechanical properties that are necessary to define the elongated heat transfer member. The foil is in contact with the elongated electrical power terminal. The foil can be e.g. wrapped around, or glued or clamped to the elongated electrical power terminal.

[0016] Preferably, the first end of the elongated heat transfer member is defined by a part of the flat flexible structure. Dependent on the application the elongated heat transfer member can comprise flexible and rigid portions.

[0017] Advantageously, the first end is arranged in a plane, perpendicular to an extension axis of the elongated electrical power terminal. This design allows an easy alignment of the first end.

[0018] Preferably, the first end comprises an opening that receives the elongated electrical power terminal. The dimension of the opening is designed to tightly surround the elongated electrical power terminal. The opening is smaller than the diameter of the elongated electrical power terminal. When the elongated electrical power terminal is inserted into the opening the opening is widened to flexibly enclose the elongated electrical power terminal.

[0019] Advantageously, the opening is defined by cross shaped cuts in the flat flexible structure. When a

foil defines the flat flexible structure, the opening can easily be provided by cross shaped cuts in the foil. The cuts provide areas that are able to fold away from the plane of the not cut foil. When the elongated electrical power terminal is inserted into the opening, the parts of the foil, separated by the cuts, fold away from the plane of the not cut foil. The folded parts of the foil surround the elongated electrical power terminal and increase the thermal contact area.

[0020] Preferably, the first end and the second end are arranged in different planes. Dependent on the application the ends have to be in different planes. The flexibility of the elongated heat transfer member solves this requirement.

[0021] Preferably, the first end is attached to a sleeve shaped carrier, wherein the sleeve shaped carrier is located inside the cavity, thereby radially surrounding the elongated electrical power terminal. In case, the flexible first end needs mechanical support the sleeve shaped carrier can provide it. A further advantage is that the sleeve shaped carrier can be an interface for mechanically adapting different cavity sizes to the size of the first end of the elongated heat transfer member.

Description of the preferred embodiments

[0022] In the following, the invention is described exemplarily with reference to the enclosed figures, in which

Fig. 1a and 1b show an electrical power cord disclosed in prior art;
 Fig. 2 shows a perspective, view to an electrical power cord comprising the inventive electrical connector;
 Fig. 3 shows a cut view of the electrical connector;
 Fig. 4 shows a perspective, view to a preassembled connector with inserted elongated heat transfer member;
 Fig. 5 shows a perspective, view to an elongated heat transfer member according to the first embodiment of the invention;
 Fig. 6 shows a perspective, view to the connector face, in a preassembled state;
 Fig. 7 shows a cut view to the cavity in a preassembled state, wherein the cut is carried out along a mating axis;
 Fig. 8 shows a perspective, view to the cavity to the connector face, in a finally assembled state;
 Fig. 9 shows a cut view to the cavity in a finally assembled state, wherein the cut is carried out along the mating axis,
 Fig. 10 shows a perspective, view to a preassembled connector with pre aligned elongated heat transfer member;
 Fig. 11 shows a cut view to the cavity in an assembled state, wherein the cut is

Fig. 12

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Fig. 13

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Fig. 14

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Fig. 15

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carried out perpendicular to the mating axis along cut line C2;

shows a perspective, view to a flexible elongated heat transfer member and the elongated electrical power terminal aligned to each other, in a preassembled state;

shows a perspective, view to a flexible elongated heat transfer member and the elongated electrical power terminal aligned to each other, in a fully assembled state;

shows a perspective, view to a flexible elongated heat transfer member attached to a carrier;

shows a perspective, view to a flexible elongated heat transfer member and the elongated electrical power terminal inserted in the plug housing, in a fully assembled state;

[0023] Figure 1a and figure 1b shows a power cord known from prior art. The power cord comprises a plug 1, male connectors 11 and thermal sensors 5. The thermal sensors 5 being configured to detect a temperature of a corresponding male connector. Each thermal sensor 5 is provided to be in contact with the corresponding male connector 11 in one-to one. The thermal sensors 5 are screwed directly to the male connectors 11.

[0024] Figure 2 shows a perspective, view to an electrical power cord 10 comprising the inventive electrical connector 100. Two high power cables 11 protrude out of a plug housing 120. The plug housing 120 having two elongated electrical power terminals 160 arranged inside a cavity 130 of the plug housing 120 (not shown here). and two thermal sensors 300 and two elongated heat transfer members 200. The two thermal sensors 300 are electrically connected to a control device by electrical wires 310. The electrical connector 100 has a mating axis X to mate to a counter connector along.

[0025] Figure 3 shows a cut view of the electrical connector 100. The heat transfer member 200 comprises first coupling means for mechanically and thermally connecting the electrical power terminal 160 to the elongated heat transfer member 200 on a first end 202 and the elongated heat transfer member 200 comprises second coupling means for mechanically and thermally connecting thermal sensor 300 to the elongated heat transfer member 200 on a second end 204. The cavity 130 comprises a cavity opening 138 arranged parallel in relation to a terminal surface 162 of the elongated electrical power terminal 160.

[0026] Figure 4 shows a perspective, view to a preassembled connector 100 with in to the plug housing 120 inserted elongated heat transfer member 200

[0027] Figure 5 shows a perspective, view to an elongated heat transfer member 200 according to the first embodiment of the invention. The first coupling means com-

prises a circular curved area 206 defining the first end 202 of the elongated heat transfer member 200. The circular curved area 206 is adapted to be arranged inside the cavity 130 surrounding the elongated electrical power terminal 160. The second coupling means comprises two straight portions 208, each starting from an end of the circular curved area 206, adapted to protrude through the cavity opening 139 to outside the cavity 130. The two straight portions 208 are arranged having an angle 210 in between each other and wherein an inner diameter 207 of the circular curved area 206 is bigger than an outer diameter 164 of the elongated electrical power terminal 160 that is surrounded, when thermal sensor 300 is not connected to the two straight portions 208.

[0028] Figure 6 shows a perspective, view to the connector face, in a preassembled state. The two straight portions 208 are arranged having an angle 210 in between each other and the inner diameter 207 of the circular curved area 206 is bigger than an outer diameter 164 of the elongated electrical power terminal 160 that is surrounded, when thermal sensor 300 is not connected to the two straight portions 208.

[0029] Figure 7 shows a cut view to the cavity 130 in a preassembled state. The cut is carried out along a mating axis X. The inner diameter 207 of the circular curved area 206 is bigger than an outer diameter 164 of the elongated electrical power terminal 160 that is surrounded. The circular curved area 206 is not fully in touch with the elongated electrical power terminal 160 when thermal sensor 300 is not connected to the two straight portions 208.

[0030] Figure 8 shows a perspective, view to the connector face, in a finally assembled state. The two straight portions 208 are parallel and in contact to each other and the inner diameter 207 of the circular curved area 206 is the same as the outer diameter 164 of the elongated electrical power terminal 160 that is surrounded, when the thermal sensor 300 is mechanically and thermally connected to the two straight portions 208.

[0031] Figure 9 shows a cut view to the cavity 130 in a finally assembled state, wherein the cut is carried out along the mating axis X. The inner diameter 207 of the circular curved area 206 is the same as the outer diameter 164 of the elongated electrical power terminal 160 that is surrounded, when the thermal sensor 300 is mechanically and thermally connected to the two straight portions 208.

[0032] Figure 10 shows a perspective, view to a pre-assembled connector 100 with pre aligned elongated heat transfer member 200. The elongated heat transfer member 200 in a second embodiment of the invention has first coupling means that comprises a first flat straight tongue 210 defining the first end 202 of the elongated heat transfer member 200 and the second coupling means comprises a second flat straight tongue 212.

[0033] Figure 11 shows a cut view to the cavity 13 in an assembled state, wherein the cut is carried out perpendicular to the mating axis along cut line C2. The cavity

130 comprises a support surface 140 arranged opposite to a terminal surface 162 of the elongated electrical power terminal 160. The first coupling means comprises a first flat straight tongue 210 defining the first end 202 of the elongated heat transfer member 200. The first flat straight tongue 210 is arranged in between the support surface 140 and the terminal surface 162 of the elongated electrical power terminal 160 thereby mechanically and thermally connecting the elongated heat transfer member 200 to the electrical power terminal 160. The cavity comprises a cavity opening 138 to outside the cavity 130. The second coupling means comprises a second flat straight tongue 212, protruding through the cavity opening 138 to outside the cavity 130. The second flat straight tongue 210 comprises an opening 224 to attach the thermal sensor 300 to the elongated heat transfer member 200. In this embodiment the second flat straight tongue 210 and the thermal sensor are fixed by a screw 226 to the housing 120 thereby attaching the elongated heat transfer member 200 to the thermal sensor 300.

[0034] Figure 12 shows a perspective, view to a flexible elongated heat transfer member 200 and the elongated electrical power terminal 160 aligned to each other, in a preassembled state. The elongated heat transfer member 200 comprises a flat flexible structure 220, wherein the flat flexible structure 220 comprises highly oriented pyrolytic graphite. The first end 202 of the elongated heat transfer member 200 is defined by a part of the flat flexible structure 220. The first end 202 is arranged in a plane, perpendicular to an extension axis X of the elongated electrical power terminal 160. The first end 202 comprises an opening 222 that receives the elongated electrical power terminal 160. The opening 222 is defined by cross shaped cuts 222 in the flat flexible structure 220.

[0035] Figure 13 shows a perspective, view to a flexible structure 220 and the elongated electrical power terminal 160 aligned to each other, in a fully assembled state. The elongated electrical power terminal 160 protrudes through the opening 222 in the first end 202. The first end 202 surrounds the elongated electrical power terminal 160 tightly.

[0036] Figure 14 shows a perspective, view to a flexible structure 220 attached to a carrier 400. The first end 202 is attached to the sleeve shaped carrier 400. The sleeve shaped carrier 400 is adapted to be located inside the cavity 130, thereby radially surrounding the elongated electrical power terminal 160. The first end 202 is attached to the sleeve shaped carrier 400 in a way to keep it in a plane perpendicular to the mating axis X.

[0037] Figure 15 shows a perspective, view to a flexible elongated heat transfer member 220 and the elongated electrical power terminal 160 inserted in the plug housing 120, in a fully assembled state. The first end 202 and the second end 204 are arranged in different planes.

Claims

1. An electrical connector (100) for a power cord comprising: a plug housing (120) having at least one elongated electrical power terminal (160) arranged inside a cavity (130) of the plug housing (120), at least one thermal sensor (300) and at least one elongated heat transfer member (200), wherein the heat transfer member (200) comprises first coupling means for mechanically and thermally connecting the electrical power terminal (160) to the elongated heat transfer member (200) on a first end (202) and wherein the elongated heat transfer member (200) comprises second coupling means for mechanically and thermally connecting thermal sensor (300) to the elongated heat transfer member (200) on a second end (204).
2. An electrical connector (100) according to claim 1, wherein the cavity (130) comprises a cavity opening (138) arranged parallel in relation to a terminal surface (162) of the elongated electrical power terminal (160), wherein the first coupling means comprises a circular curved area (206) defining the first end (202) of the elongated heat transfer member (200), wherein the circular curved area (206) is arranged inside the cavity (130) surrounding the elongated electrical power terminal (160) and wherein the second coupling means comprises two straight portions (208), each starting from an end of the circular curved area (206), protruding through the cavity opening (139) to outside the cavity (130).
3. An electrical connector (100) according to the preceding claim, wherein the two straight portions (208) are arranged having an angle (210) in between each other and wherein an inner diameter (207) of the circular curved area (206) is bigger than an outer diameter (164) of the elongated electrical power terminal (160) that is surrounded, when thermal sensor (300) is not connected to the two straight portions (208).
4. An electrical connector (100) according to the preceding claim, wherein the two straight portions (208) are parallel and in contact to each other and the inner diameter (207) of the circular curved area (206) is the same as the outer diameter (164) of the elongated electrical power terminal (160) that is surrounded, when thermal sensor (300) is mechanically and thermally connected to the two straight portions (208).
5. An electrical connector (100) according to claim 1, wherein the cavity (130) comprises a support surface (140) arranged opposite to a terminal surface (162) of the elongated electrical power terminal (160), wherein the first coupling means comprises a first flat straight tongue (210) defining the first end (202) of the elongated heat transfer member (200), wherein the first flat straight tongue (210) is arranged in between the support surface (140) and the terminal surface (162) of the elongated electrical power terminal (160) thereby mechanically and thermally connecting the elongated heat transfer member (200) to the electrical power terminal (160), wherein the cavity comprises a cavity opening (138) to outside the cavity (130) and wherein the second coupling means comprises a second flat straight tongue (212), protruding through the cavity opening (138) to outside the cavity (130).
6. An electrical connector (100) according to any preceding claim, wherein the elongated heat transfer member (200) comprises at least one layer of material with high thermal conductivity.
7. An electrical connector (100) according to any preceding claim, wherein the elongated heat transfer member (200) comprises at least one layer of highly oriented pyrolytic graphite.
8. An electrical connector (100) according to claim 1, wherein the elongated heat transfer member (200) comprises a flat flexible structure (220), wherein the flat flexible structure (220) comprises highly oriented pyrolytic graphite.
9. An electrical connector (100) according to the preceding claim, wherein the first end (202) of the elongated heat transfer member (200) is defined by a part of the flat flexible structure (220).
10. An electrical connector (100) according to the preceding claim, wherein the first end (202) is arranged in a plane, perpendicular to an extension axis (X) of the elongated electrical power terminal (160).
11. An electrical connector (100) according to any of claims 8 to 10, wherein the first end (202) comprises an opening (222) that receives the elongated electrical power terminal (160).
12. An electrical connector (100) according to the preceding claim, wherein the opening (222) is defined by cross shaped cuts in the flat flexible structure (220).
13. An electrical connector (100) according to any of claims 9 to 13, wherein the first end (202) and the second end (204) are arranged in different planes.
14. An electrical connector (100) according to any of claims 8 to 13, wherein the first end (202) is attached to a sleeve shaped carrier (400), wherein the sleeve shaped carrier (400) is located inside the cavity (130), thereby radially surrounding the elongated

electrical power terminal (160).

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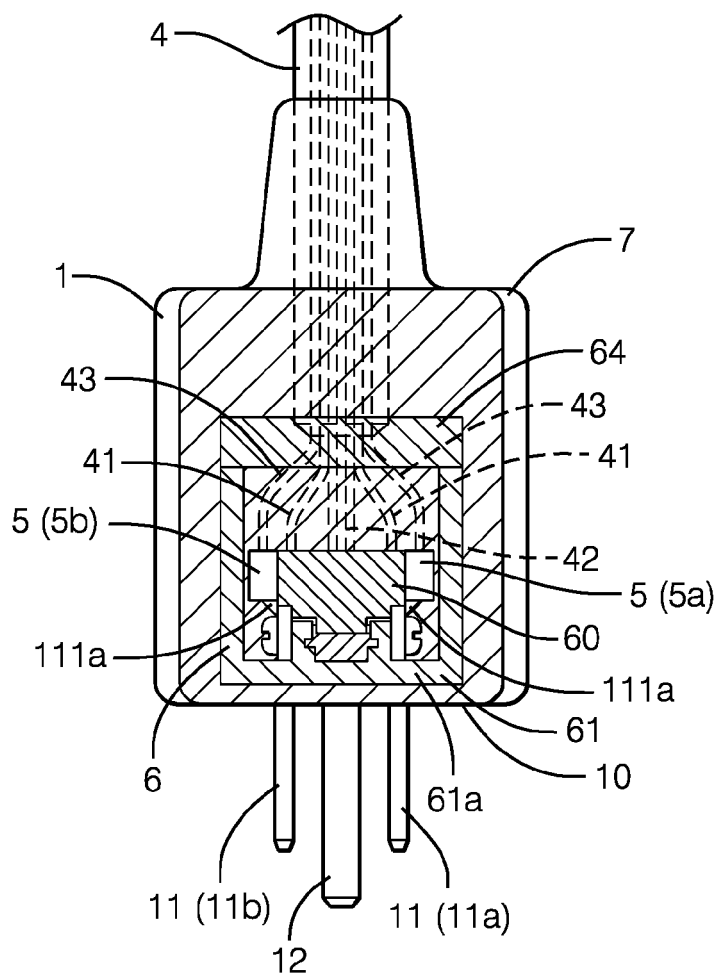
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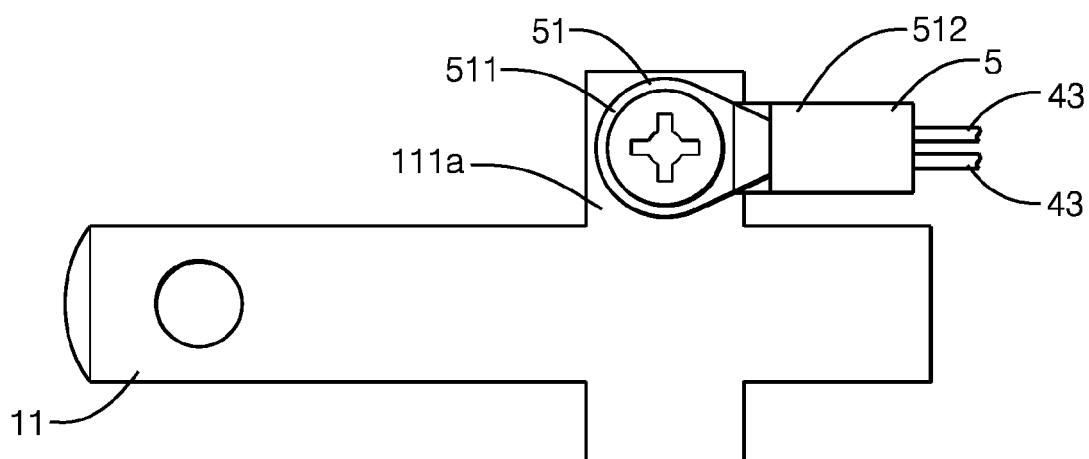
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PRIOR ART
FIG. 1a



PRIOR ART
FIG. 1b

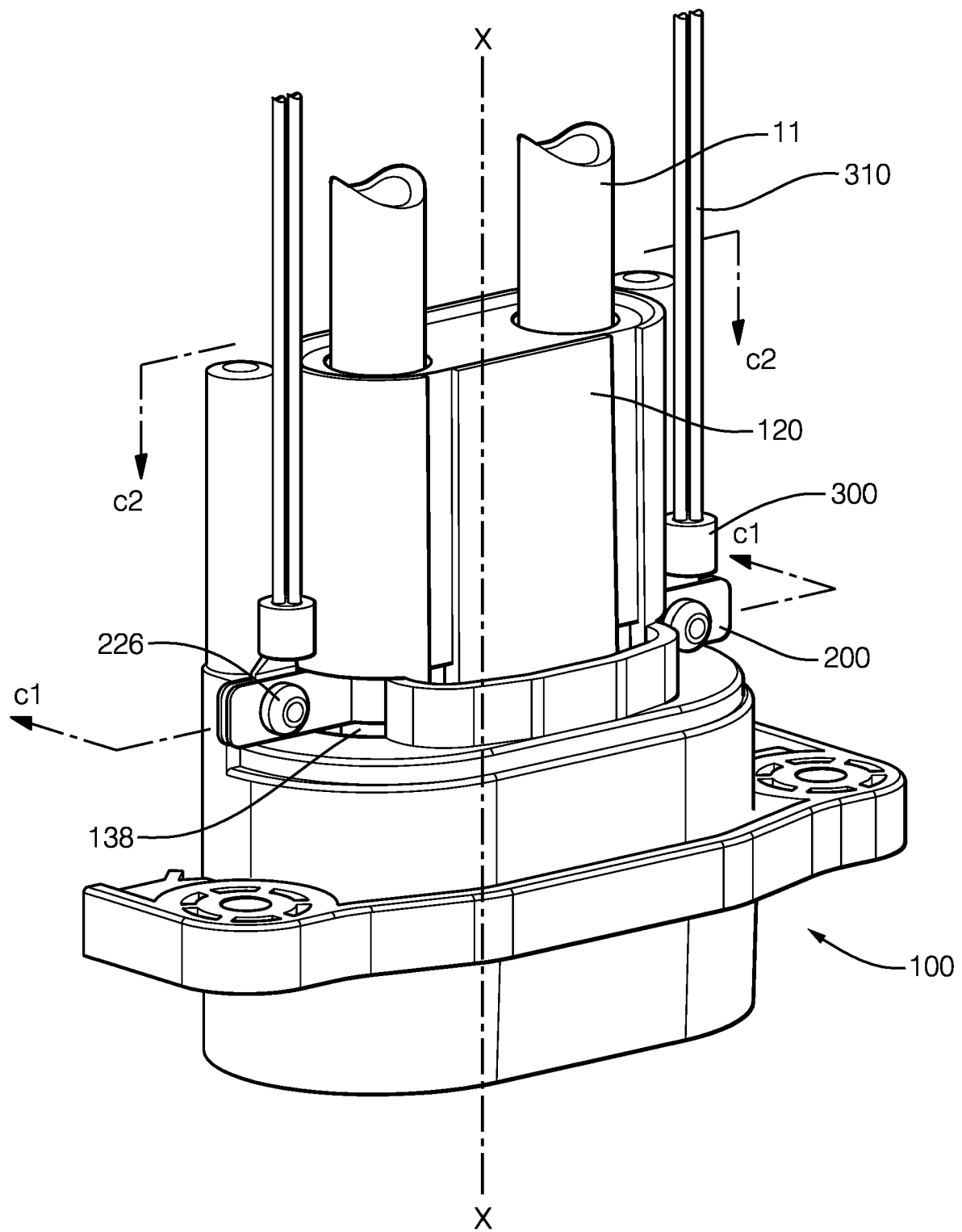


FIG. 2

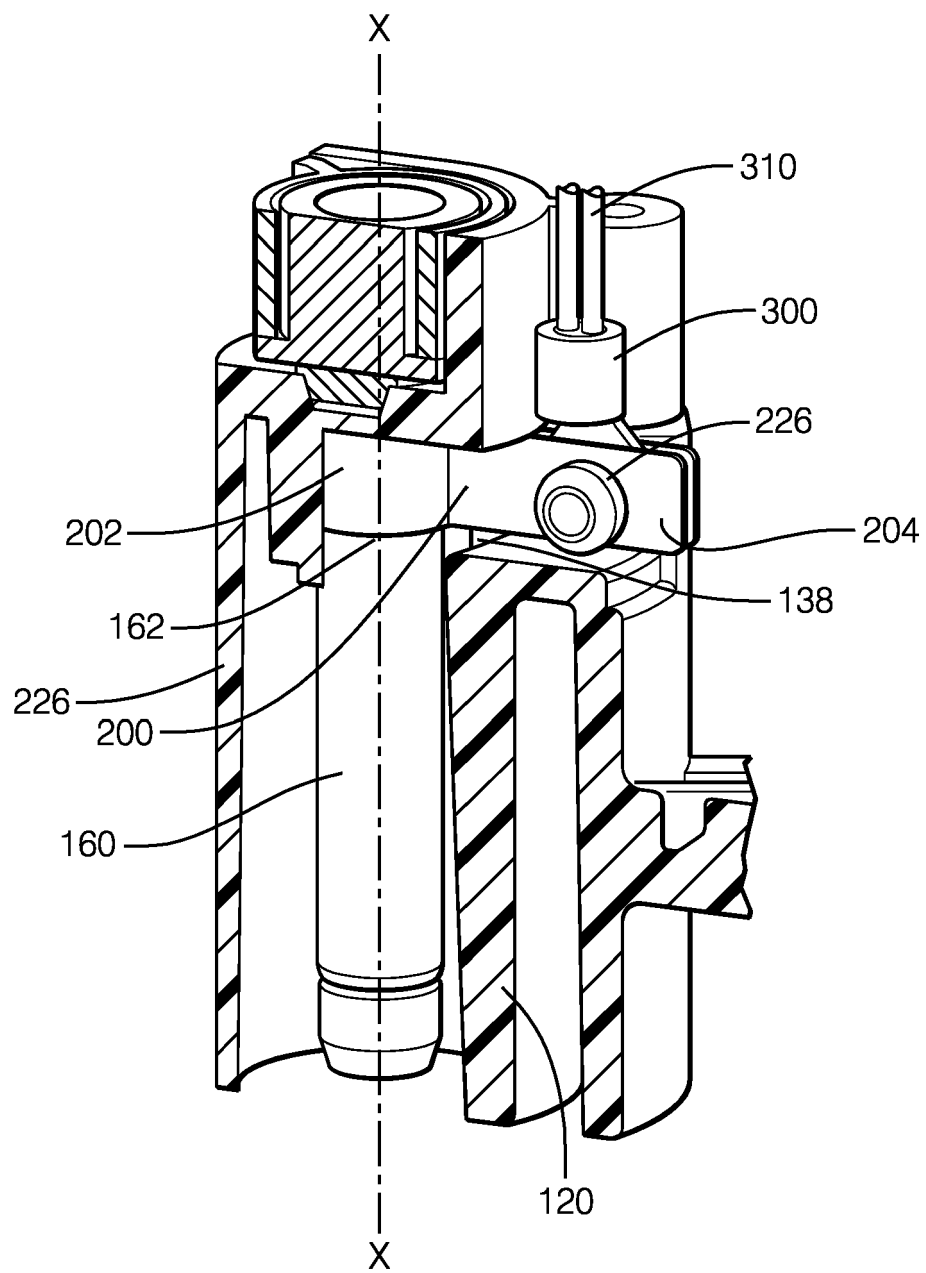
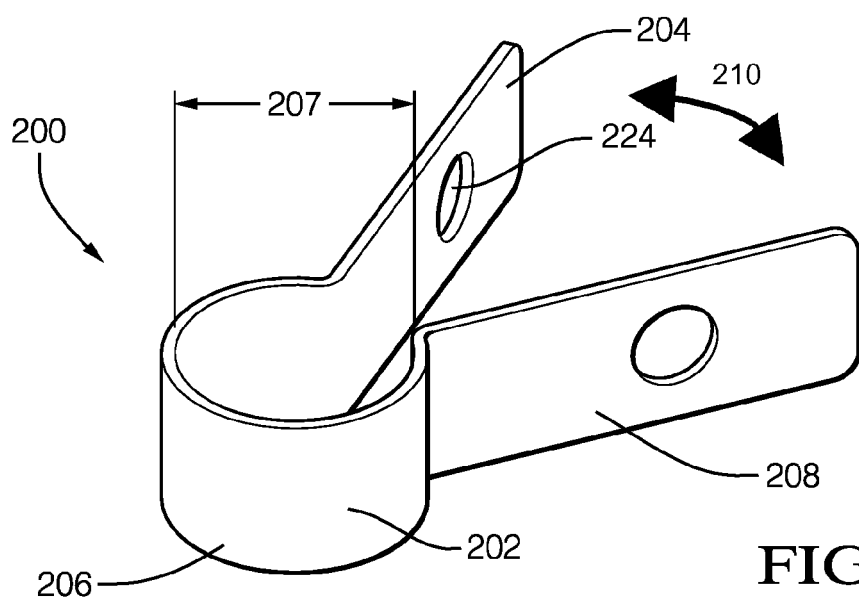
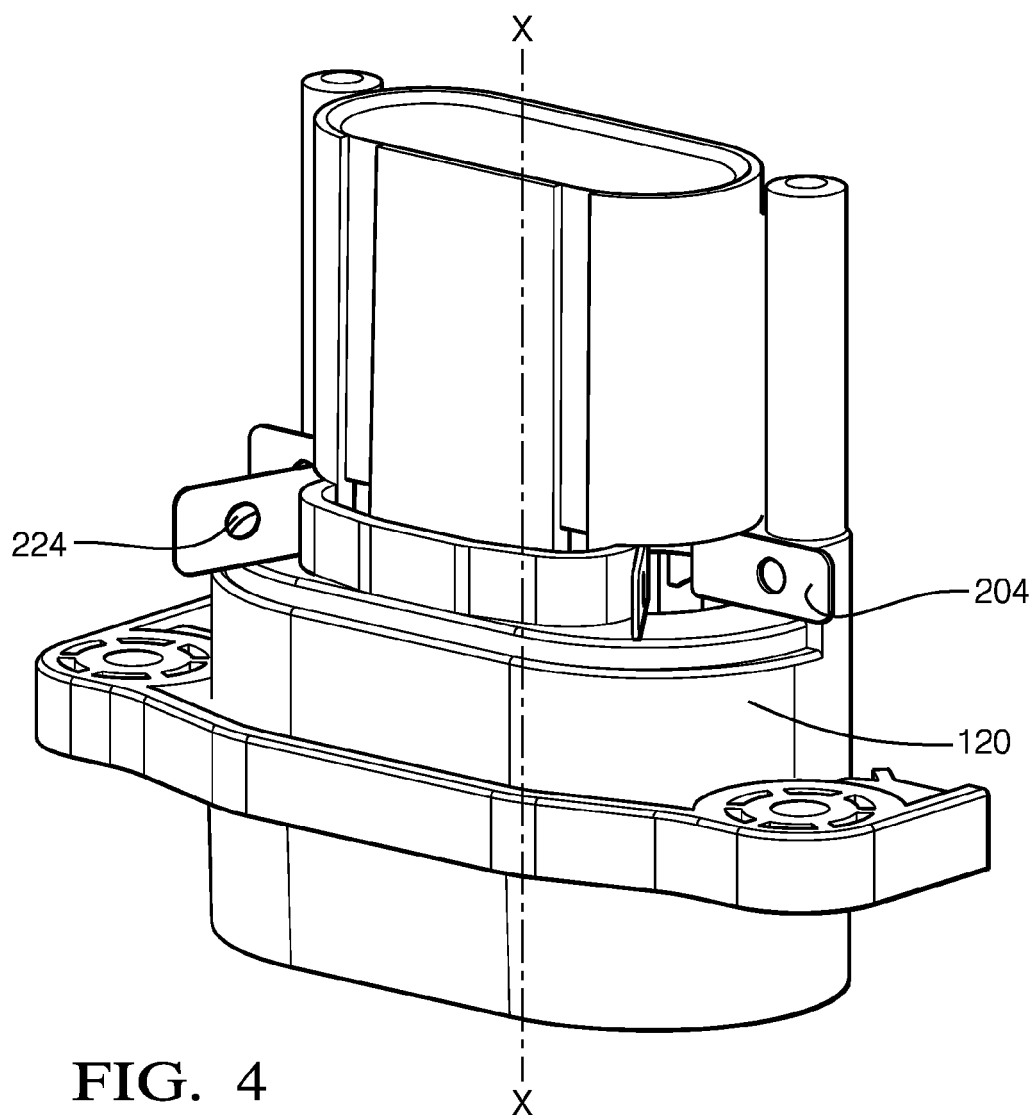
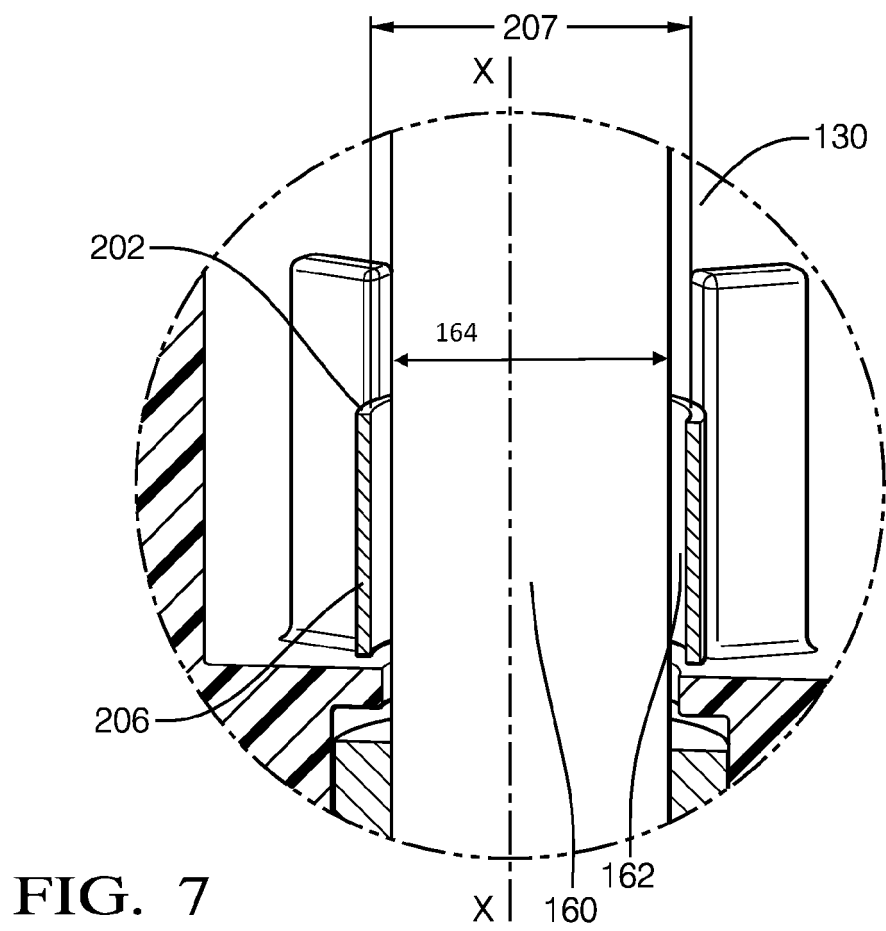
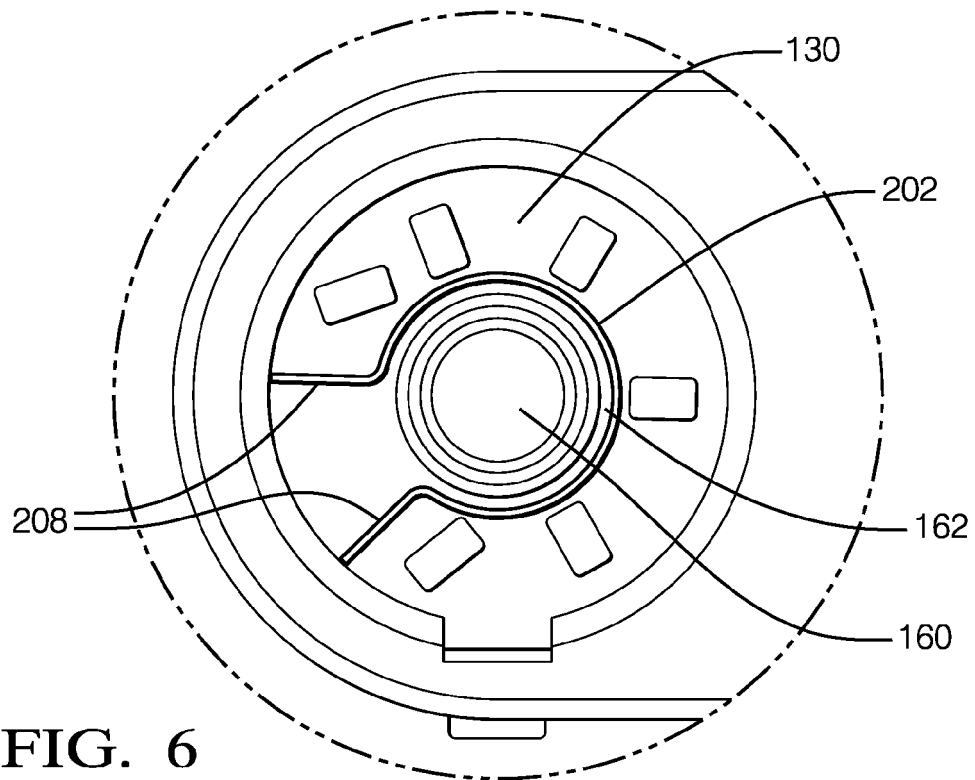


FIG. 3





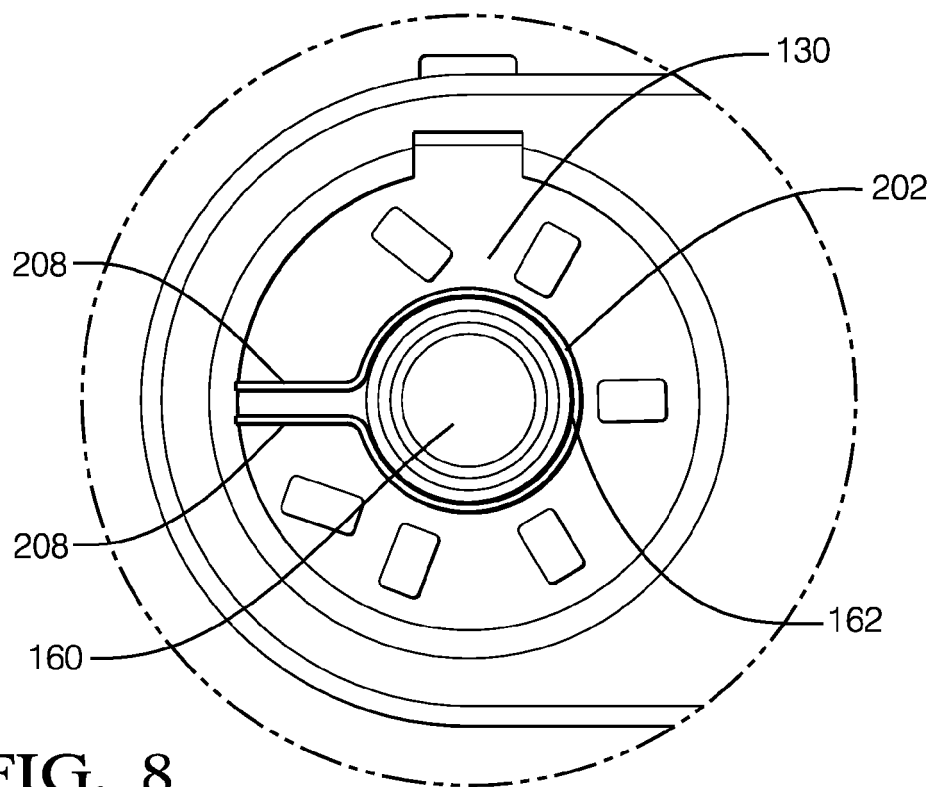


FIG. 8

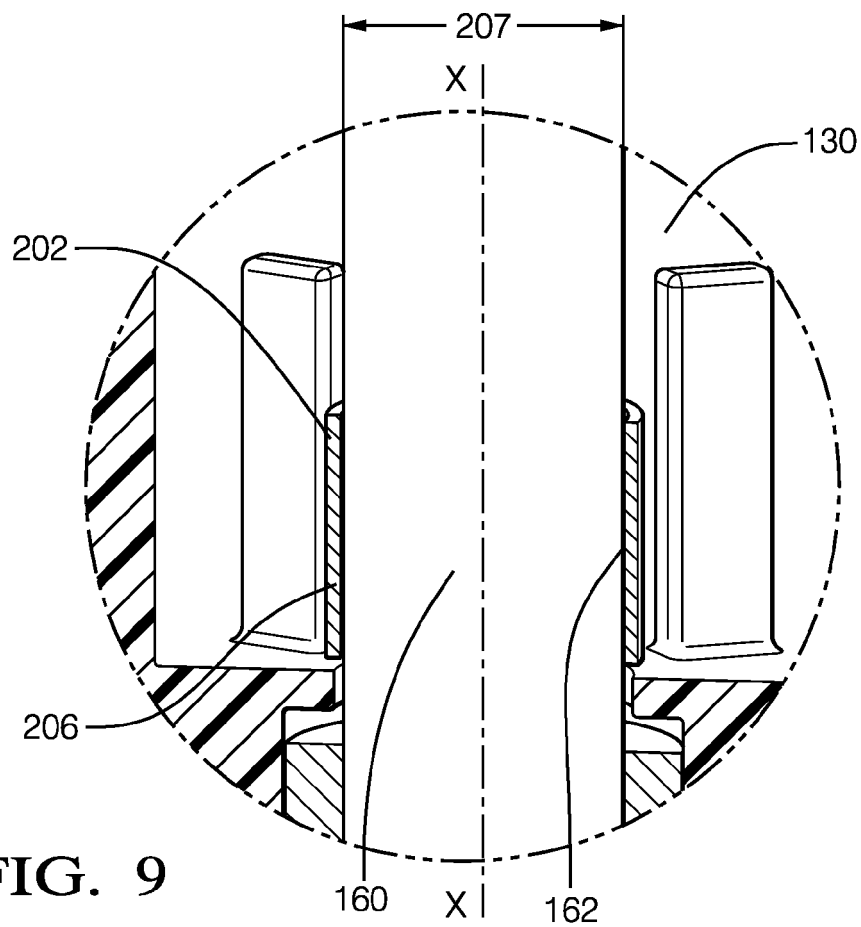
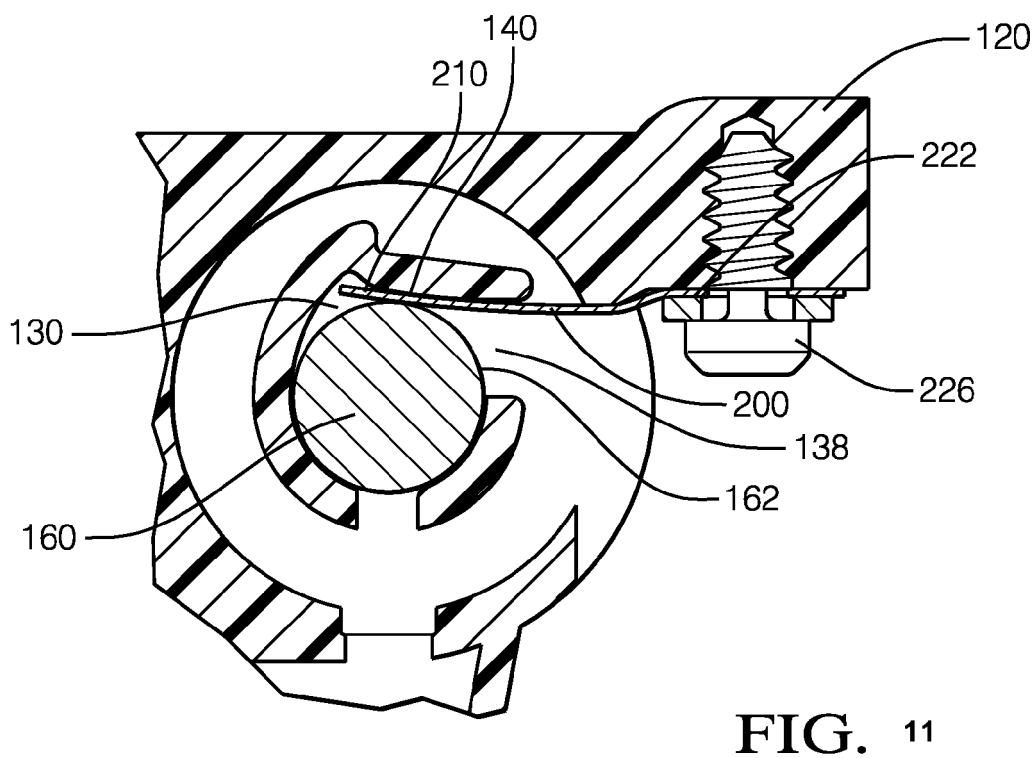
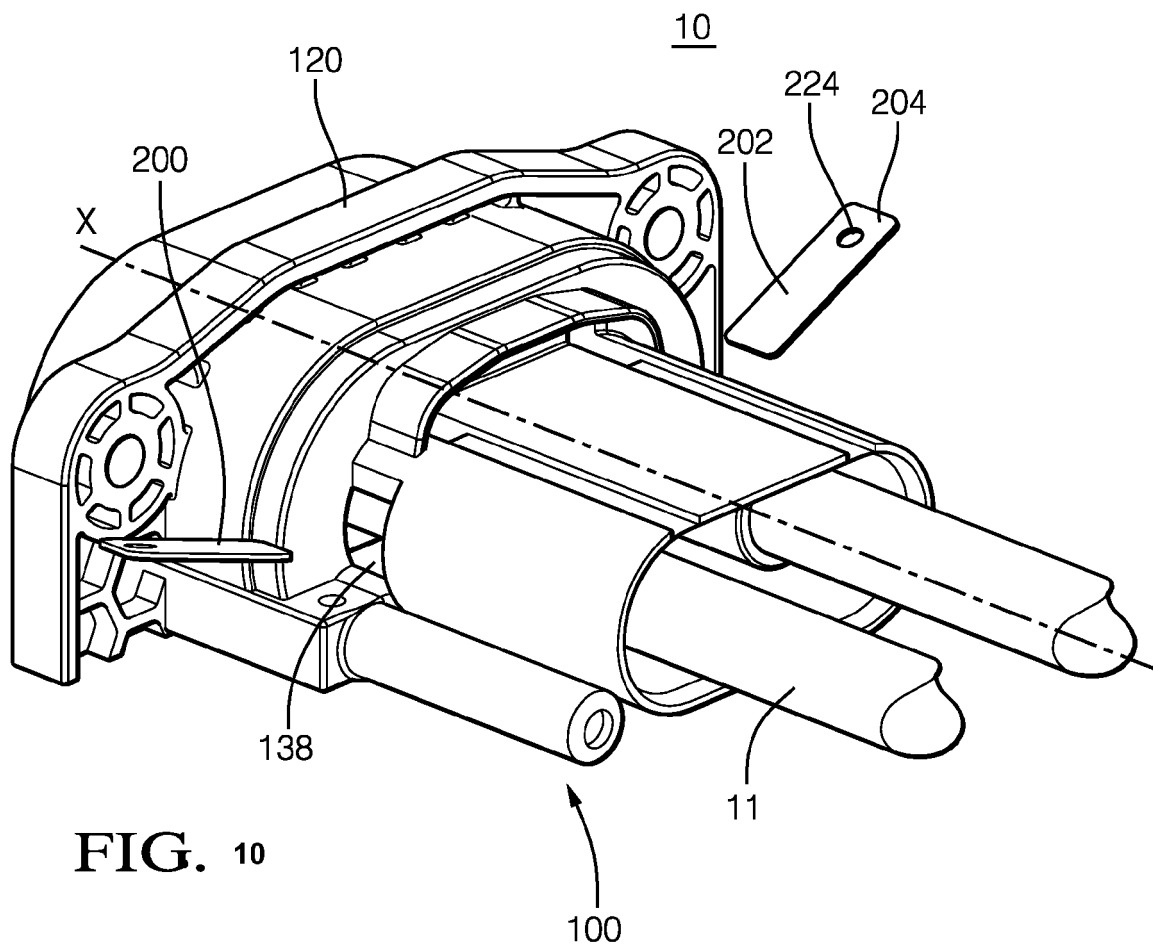
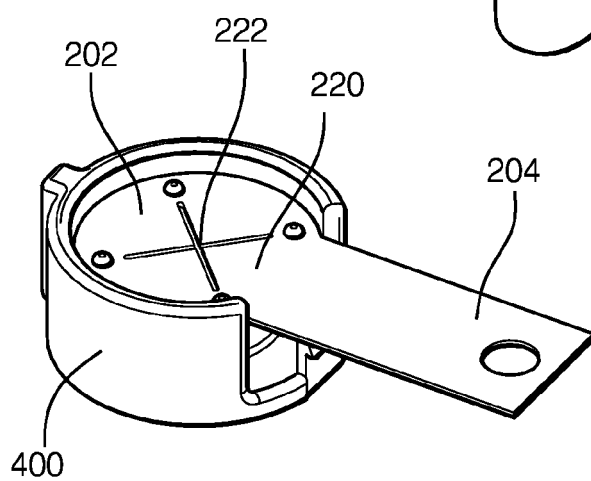
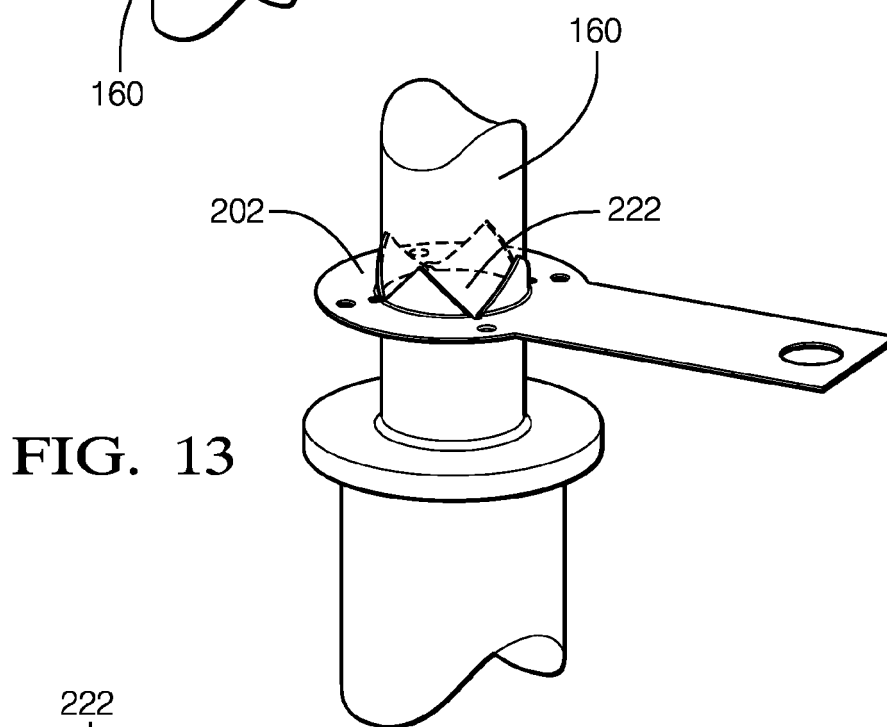
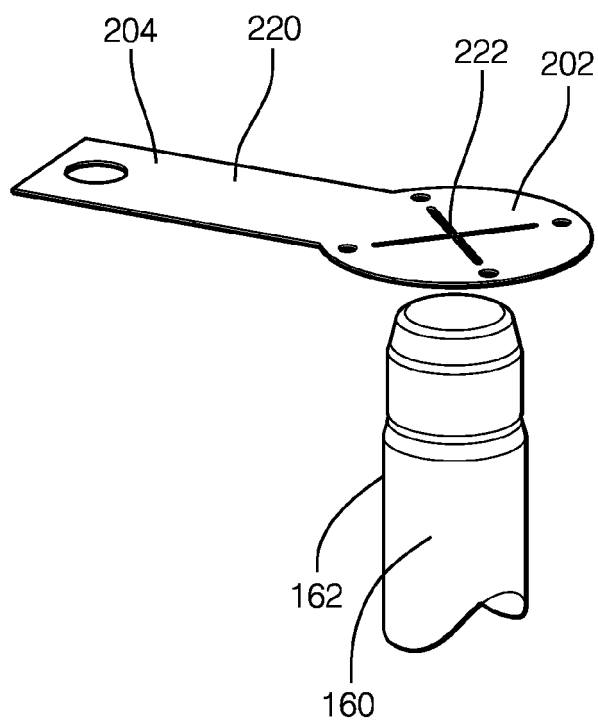


FIG. 9





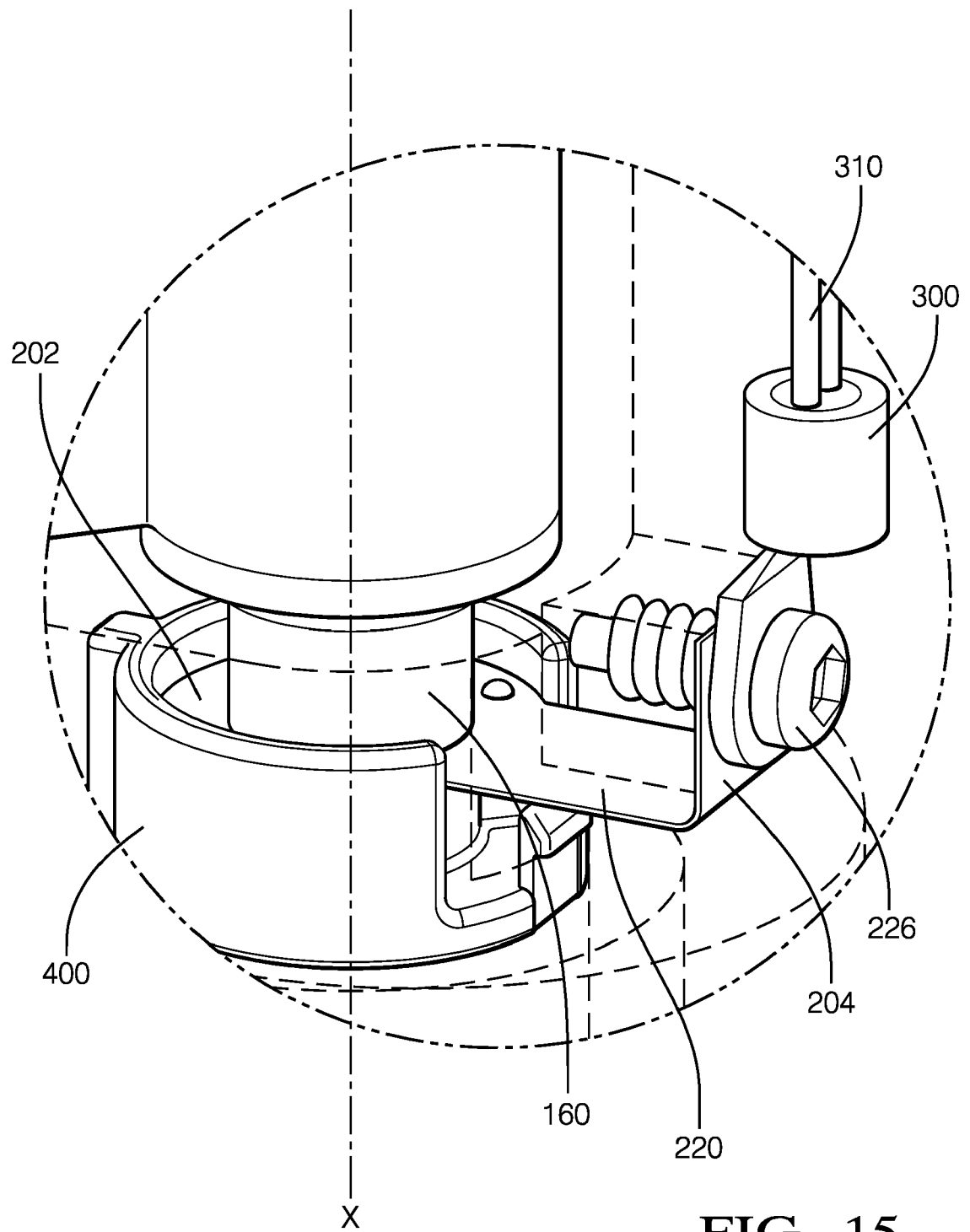


FIG. 15



EUROPEAN SEARCH REPORT

Application Number
EP 18 15 6945

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DOCUMENTS CONSIDERED TO BE RELEVANT			
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A	US 2016/344144 A1 (WU JERRY [US] ET AL) 24 November 2016 (2016-11-24) * abstract; figures 1-5 *	1,2	
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			TECHNICAL FIELDS SEARCHED (IPC)
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The present search report has been drawn up for all claims			
Place of search The Hague		Date of completion of the search 17 August 2018	Examiner Corrales, Daniel
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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EPO FORM 1503 03.82 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report.
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