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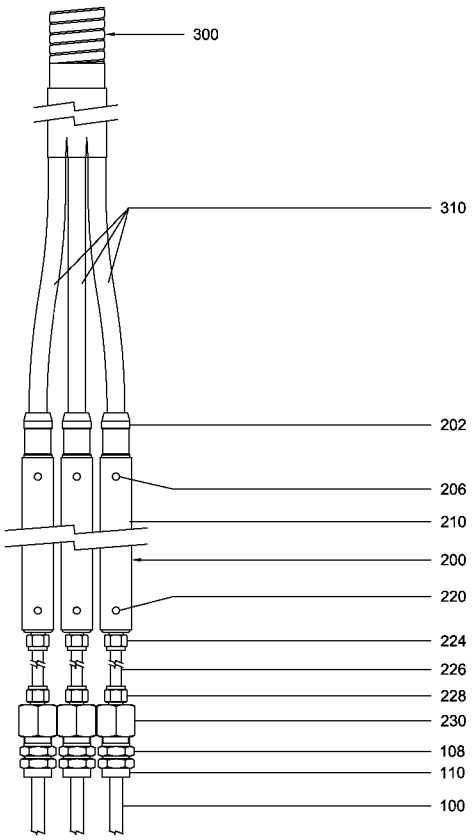


Fig. 1

(57) Abstract: A connector arrangement to attach an electrical submersible pump (ESP) cable to a resistance heater cable for use in oil and gas wells is accomplished by connecting a heater cable specially fabricated having a mineral insulation around an electrical conductor generating heat in a splice to a standard ESP cable. The splice section is formed from a low resistance conductor and terminated at a proximal end with a series of ferrule fittings to connect a tubing extending into an insulated sleeve and body to join an ESP cable conductor to a cold lead from the heater cable by crimping or other means of joinder. A method for performing this connection is described. The joinder sleeve is covered by an insulator sleeve and retained in a protective outer sleeve by stops at each end and epoxy plugs.

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HEATER CABLE TO PUMP CABLE CONNECTOR AND METHOD OF INSTALLATION

REFERENCE TO PRIOR APPLICATIONS

[0001] This application claims priority to United States Provisional Patent Application No. 61/035203, filed 10 Mar 2008, which is incorporated herein by reference.

BACKGROUND OF INVENTION

[0002] The present invention relates to a electrical connection for use with a heater cable in a well bore; more specifically, this invention claims an apparatus for connecting a electrical submersible pump cable to a heater cable to place the heater cable elements within a well bore distant from the source of electrical power for such heater cable.

[0003] There are many oilfield applications in which heating inside the well bore will enhance production. One type of down-hole heater consists of a single electrical conductor wire of high resistance (such as ni-chrome wire) which is placed concentrically inside a stainless steel, or other alloy metal tube (such as monel). To insulate the conductor from the outer tubing, an inert mineral insulation (MI) material (such as magnesium oxide) is often used. These down-hole resistance heaters are usually strapped to the production tubing, and power is supplied from the surface. In the case of oil wells, these heater cables are submerged in the oil-producing zone, and are used to raise the temperature of the oil, thereby lowering its viscosity to permit efficient flow of the oil to surface. In gas wells, these heaters can often be used to heat almost the entire length of the production tubing, to reduce the formation of scale, paraffin, and hydrates which can form in the production tubing and restrict or block flow.

[0004] Heaters of this type are usually powered by three-phase equipment at surface, so three individual heater tubes are typically strapped or banded to the production tubing. Close to surface, each of these tubes are connected to a "cold lead" section, or a section of tubing which is not meant to increase in temperature. Basically, the cold section consists of low resistance wires inside metal tubing. A cross-over type piece from the hot section to the cold section is assembled by the heater manufacturer, and installed prior to delivery.

[0005] The cold lead section typically passes through the surface wellhead, using metal ferrule type fittings. This arrangement works well for shallow well applications, in which the overall length of the hot and cold section is not more than 4,000 ft.

[0006] However, for deeper well applications, the manufacture of longer lengths of heater tubes is difficult, or impossible. At times, only a 300 foot section of pay zone in an oil well needs to be heated, but the pay zone is 7,500 feet below surface. It is not economical to manufacture a hot or cold section in these longer lengths.

[0007] The current patent application solves the above problem by providing a connector that will connect the three cold lead sections of a heater cable to the three individual wires from a typical Electrical Submersible Pump (ESP) cable, thereby providing a readily available solution to this problem of providing an electrical connection in high temperature, high pressure well bores.

[0008] ESP cable is much less expensive, easier to manufacture and procure than the MI Heater Cables. The connection of the present invention can allow for a short section of heater cable, a short section of cold lead cable, and a long length of ESP cable. ESP cable can be sealed off using several known means through the

surface wellhead, providing an economical and efficient solution to the problem of increasing oil and gas production.

SUMMARY OF INVENTION

[0009] This present invention claims a heater cable to a pump cable connector for joining a cold lead of a heater cable having a stripped terminal end and a lead from a pump cable having a stripped terminal end by using a conductive sleeve joining the heater cable cold lead and the pump cable lead; an insulating boot covering the conductive crimp sleeve disposed inside a protective outer sleeve; a covering for the cold lead of the heater cable extending through a ferrule fitting and an extrusion limiting top stop retaining said stainless covering at a first end of said protective sleeve; epoxy coating and an extrusion limiting bottom stop of a second end of said protective outer sleeve; and, a ferrule fitting joining said cold lead to said stainless steel covering exterior to said outer protective sleeve.

[0010] Joining of the pump cable conductor to the cold lead of the heater cable conductor can be made by crimping the connector, welding, soldering, compressively fitting or gluing each end into the connector without departing from the spirit of this invention. Crimping is the preferred method of joining in the present embodiments.

[0011] This heater cable to pump cable connector is installed by running a production tubing into a well bore with a heater cable and cold lead section of said cable clamped to the production tubing; spacing the cold lead ends at their proximal ends and stripping each cold lead uniformly; installing ferrule tube fittings at each end of a cold lead section of the heater cable; installing a silicone filled tubing over each cold lead into each ferrule tube fitting and tightening the ferrule tube fittings; inserting the tubing in a top stop and install cold lead in the compressive fit insulator;

stripping insulation extending from insulator to fit in a conductive sleeve; cleaning and inserting the cold lead into the sleeve; seating the sleeve against an edge of compressive fit insulator or standoff; positioning a top stop gage around silicone filled tubing and moving the top stop to seat adjacent the top stop gage and affixing to silicone filled tubing; removing the gage; inserting a butt plug into the opposing end of the crimp sleeve and lubricating the sleeve and cold lead with non-conductive silicone and sliding the female nonconductive boot over the assembly until the boot touches the top stop; and, removing the butt plug to enable completion of installation of pump cable stripped leads from triskelion tubes.

BRIEF DESCRIPTION OF DRAWINGS

[0012] Fig. 1 is a side perspective view of pump cable to heater cable connector apparatus.

[0013] Fig. 2 is a side cross-sectional view of the pump cable to heater cable connector apparatus made with a crimp splice connector.

[0014] Fig. 3 is a side cross-sectional view of the pump cable to heater cable connector apparatus made with a male to female splice connector.

[0015] Fig. 4A is detailed view of a wellhead penetrator and production tubing showing the details of an deployment of the ESP cable to the MI heater cable splice embodiment of the present invention.

[0016] Fig. 4B is a detailed view of the attachment of ESP cable/MI heater cable to the production tubing near the desired deployment of the heater cable in the well.

[0017] Fig. 5 is an exploded composite view of the cold lead ferrule attachment of the MI cable ready to be spliced to the ESP cable and lowered in the well bore.

[0018] Fig. 6A-6E are detailed views of a partially assembled cold lead ferrule attachment as it is prepared for connection to the bottom stop of the splice arrangement of one embodiment of this invention.

[0019] Fig. 7 is a cross sectional view of the insulator member or insulating standoff of the present embodiment.

[0020] Fig. 8 is a composite view of the manner of attachment of various components to the cold lead conductor of the heater cable and the installation of the insulator member in preparation for completion of the ESP/MI cable splice.

[0021] Fig. 9 is a composite view of the insulating standoff located on the stripped end of the cold lead of the MI heater cable ready for the installation of the splice cover.

[0022] Fig. 10 is a composite view of the manner of attachment of the crimp socket and the female boot to the cold lead of the heater cable.

[0023] Fig. 11 is a vise-grip spacer tool used for proper spacing the splice boots over the crimp splice and conductors.

[0024] Fig. 12A-E is a series of installation steps showing the use of the vise-grip spacer tool for the placement of the bottom stop on the crimp splice boot on the conductor line.

[0025] Fig. 13A is a side view of the completed assembly with the female insulating boot surrounding the cold lead from the heater cable and awaiting the installation of the ESP cable from the triskelion, including the protective cap which is installed temporarily to prevent contaminants from entering the upward facing female boot.

[0026] Fig. 13B is a side profile view of the installed female insulating boot surrounding the cold lead from the heater cable and awaiting the installation of the ESP cable form the triskelion.

DETAILED DESCRIPTION OF EMBODIMENT

[0027] As may be readily appreciated from Fig. 1, pump cable **300** is split into the triskelion tubes **310** for each of the three conductors contained within the pump cable **300**. These are joined in the connector **200** mating the two differing types of cables. The cold lead from the MI heater cable **100** is disposed in the well bore clamped on the production tubing (not shown). The cold lead connects through cable ferrule fittings **108** and **110** to Swagelok™ fitting **230**, through stainless steel tubing **226** through ferrule fitting **224** connected to the top stop held in the outer sleeve by stop screws **220**. Similarly, triskelion tubing **310** is inserted into the bottom stop **202** and into the outer sleeve **210** where it is retained by stop screws **206**. The details of the interior of the connector are more clearly shown in Fig. 2.

[0028] Fig. 2 is a cross-sectional side view of the connector **200**. One leg of a triskelion tubing **310** from the ESP cable leads is inserted into the bottom stop **202** and a triskelion bushing **204** which are compressively retained in outer sleeve **210** by stop screws **206**. The lead jacket **312** from the pump cable and the insulation **314** are stripped in a uniform manner leaving a bare pump cable conductor **316** which is inserted into a one-piece conductive crimp sleeve **212**.

[0029] Similarly, as shown in Fig. 2, the MI heater cable conductor cold lead portion is inserted in the outer sleeve, stripped at its proximal end to expose a bare conductor **102** and inserted into the opposing end of the conductive crimp sleeve **212**. The cold lead portion of the heater cable's insulation **104** is stripped to a measured position and a compressive fit insulating standoff **214**, which has been

previously filed with silicone holds the exposed end of the lead in spaced relationship with the crimp sleeve **212**. The crimp sleeve **212**, pump cable conductors **314** and heater cable cold lead conductor **104** are slipped inside a non-conductive rubber boot fabricated from ethylene propylene diene monomer (EPDM) rubber. The EPDM rubber used can be Centrilift compound #CL177E or Eagle Elastomer, Inc. compound #EE66465A. It is believed that a medium viscosity fluoroelastomer obtained from Solvay Solexis named Tecnoflon® BR 9151 can also be substituted for the EPDM rubber described above. A non-extrusion washer **218** surrounds the tubing than encloses the MI cable insulation and conductor and is retained within the outer sleeve **210** by stop screws **220** and a top stop **222**. The top stop connects another ferrule fitting to retain the stainless steel tubing **226** within the body to provide a protective sleeve for the MI cable lead from the termination of the MI cable **106**. Epoxy **208** is inserted in the proximal end of the outer sleeve **210**.

[0030] Alternatively, as shown in Fig. 3, the cold lead of the MI cable can be joined to the ESP cable leg of the triskelion tube using a male pin **317** which is attached to the stripped end **316** of the ESP cable, which is thereafter mated to the female connector **315** and joined to the stripped end of the cold lead **102**. The female plug is covered with an insulating cover or boot **319** and the male plug is covered by a mating insulating cover **313**, both of which are joined and covered by the outer protective sleeve **210**, in the same manner describing the first embodiment above.

[0031] The manner of inserting the ESP cable in the well bore to attach by the connector to a MI heater cable can best be visualized by reviewing Figs. 4A-4B. A surface cable **30** supplies electrical service to a bracketed **50** wellhead penetrator with each of the electrical conductors inserted through a tubing adaptor **40** in said

well head. Each conductor is guided by penetrator **20** into the ESP cable supplying power to the well bore. The wellhead supports a casing string **10** that has inserted therein a production tubing **12** to which the ESP cable has been previously clamped **15**. The ESP cable **300** in this view has been previously attached to the heater cable connectors **200**, all as previously described and shown in Fig 4A.

[0032] Directing our attention to Fig. 4B, the entire heater cable assembly **200** is connected with the Swagelok™ ferrule fittings **230** previously described, clamped to the production tubing **12** and lowered to the desired heater activation point as the production tubing was lowered into the casing string **10**.

[0033] Having viewed the completed assembly of Figs. 4A-4B, one may commence understanding of the method of assembly by directing one's attention to Fig. 5 which shows the production tubing **12** held by conventional means not shown in this view in the well bore. As the MI heater cable is clamped to the production tubing **12**, the tubing is lowered into the well bore. After the MI heater cable hot portion is disposed, the heater cable attaches to low resistance "cold" conductors for some length. The production tubing **12** is lowered into the well bore with the MI heater cable and the cold lead section clamped to the tubing. The ends of the cold lead **104** are spaced approximately 1-1/2" apart and stripped of their insulation as evenly as possible to reveal the conductor **102**, which can be either strands (as shown) or solid conductor.

[0034] Fig. 6A-6E describe the steps in installing the tube fittings **108**, **110**, **230** and **228** on the cold lead portion **100** of the heater cable in preparation for installation. It is believed that the end termination consists of a thermal gradient section butt-connected to a 19-strand THWN cold leads. The cold leads are crimped and soldered to the thermal gradient section, insulated with a high-dielectric tape,

and epoxy potted in a brass sleeve. The epoxy pot is shown at **106**. An installer would slide on the tube fittings **108** to the end of the cold lead tube section **106** then tighten the nut **110**. The installer would cover the threads of the ferrule body **108** with Teflon™ tape then slide the Swagelok™ fitting **230** over the wire and tighten it against the fitting body **108** as shown in Figs. 6B and 6C to join the cold lead section of the MI cable **100** and provide the means for connection to the ESP cable.

[0035] Next, as shown in Fig. 6D, a short section of stainless steel tubing **226** filled with silicone is run over the end of the cold lead section into tubing nut **228** which is then tightened to hold the tubing **226** in Swagelok™ assembly **228**, **230** on the cold lead of the heater cable. This process is repeated for each leg of the three electrical cold leads leading to the heater cable. As shown in Fig. 6E, the top stop **222** and nut **224** are installed over the tubing **226** in preparation for the joinder of the cold lead cable to the ESP cable.

[0036] Fig. 7 details the insulating standoff, an insulator positioned at the proximal end of the stainless steel tubing **226**, which seats on an internal shoulder **215**. An alternative embodiment for this insulating standoff could be formed from an insulator, a stainless steel counter-bored washer accepting the end of the protective tubing and a stainless steel washer on the opposing side of the insulating standoff without departing from the spirit of this invention. The insulating material can be fabricated from any heat resistant insulating material having appropriate mechanical properties and the preferred material is an alumina ceramic material consisting of nominally 99.5% Al_2O_3 commercially available from Coorstek™ as AD-995. As suggested in Figs. 8 and 9, the installer would clean the protective tubing **226** with contact cleaner and dry. After installation of the top stop **222** and nut **224**, the insulating standoff **214** is twisted onto the end of the insulated conductor **104**, and

the insulation on the conductor is cut back to be flush with the upper surface of the insulating standoff **214**, which is trimmed to leave approximately 1-1/4" exposed conductor **102** to fit the crimp splice connector **212** of Fig. 2 or the female conductor connector **315** of Fig. 3.

[0037] Fig. 10 details the steps next following the insertion of the insulating standoff **214**. The conductor **102** is cleaned to remove any residual silicone left on the conductor after installation of the insulating standoff **214** and inserted into the female conductor connector **315** and crimped. If the crimp socket shown in Fig. 2 is to be used, the crimp socket **212** is pushed over the end of the conductor **102** until the end of the crimp socket **212** seats against the upper edge of the insulating standoff **214**. The socket is crimped twice to affix the crimp socket to the conductor. Whether using the crimp socket of Fig. 2 or the female connector of Fig. 3, this step is performed on each of the two remaining cold lead conductors until all are complete.

[0038] The spacing of the connector in both embodiments is important in establishing the integrity of the connection between the ESP cable and the MI cable. If the male/female conductive sleeve assembly is to be used, the female conductor **315** is joined to the stripped end of the cold lead **102**, after the insulating standoff is placed over the cold lead jacket. Similarly, if the crimp sleeve **212** is used as described in Fig. 2, it is installed after the insulating standoff **214** is placed on the conductor **104**.

[0039] Fig. 11 describes the process to locate the top stop in spaced relation with the insulating standoff and crimp socket to enable the EPDM sleeve to cover the assembly properly illustrating the female connector conductor. A top stop gage **90** is inserted in a specially prepared vise-grip wrench **91** and placed immediately

adjacent the insulating standoff **214** as shown in Fig. 12A. The gage allows the top stop **222** and nut **224** to be moved up to the proper location where they are joined and tightened to fix the stainless steel tube **226** in the position to accept the location of either the insulating boot **216** of Fig. 2 or the bottom female insulation boot **319** of Fig. 3. The gage **90** is then removed from the stainless steel tubing **226**. Figs. 12A-12C show the progression of the placement of the gage on the stainless steel tubing; the top stop **222** is then moved to seat between the insulating standoff **214** and the connector **315** and set with set-screws **220**. The method of installation for the crimp sleeve **212** shown in Fig. 2 proceeds similarly.

[0040] Fig. 12D shows the last assembly step of slipping a non-extrusion washer **218** over the connector and insulating standoff to the top stop **222**. A butt plug **92** is inserted into the ESP cable end of the crimp socket **315** to facilitate enclosure within the insulating sleeve **319**. A non-extrusion washer **218** is placed over the butt plug **92** and moved to seat on the upper edge of the top stop **222** now fixed in position. The entire assembly is then lubricated with silicone compound and a female boot **216** is run over the butt plug **92** by rotating the boot until it seats against the non-extrusion washer **218**. The silicone assists in the installation of the insulating boot. The boot should be checked to determine whether it is uniformly round and straight without bulges that would reflect that it has not properly seated itself on the washer. The insulating standoff **214** should not be bent or moved by this step. The butt plug **92** is then removed.

[0041] Installation of the crimp splice **212** proceeds in a similar manner. All of the exterior covers are deployed on the cold lead in preparation for being moved up over the crimp splice **212** and insulating boot or sleeve **216**, after the insulating standoff **214** is placed over the exposed portion of the cold lead **102** and the

protective tubing **226** seats on the insulating standoff shoulder **215**. This installation requires each of the pieces of the splice connection be installed over the cold lead portion **226** of the MI cable so that the last connective step of crimping the splice **212** joins all together. Once the crimps are made, the boot is moved over the splice connector and insulating standoff and the end caps and epoxy installed and protective outer cover moved into place and sealed.

[0042] As shown in Figs. 13A-B, a small plastic cap **93** can be inserted over each end of the female insulating boots **216** to prevent junk from entering the crimping socket as installation proceeds. Additional clamps **15** are installed to hold the heater cable to ESP cable connector in proper position. The female boots are now ready for the installation of the ESP cable. As shown in Fig. 3, the male connector **317** is covered with insulating boot **313** and slid into engagement with the female receptacle **315** now covered by boot **319**. The outer cover **210** is slid into place, epoxy **208** added to seal and allowed to cure.

[0043] The particular embodiments disclosed above are illustrative only, as the invention may be modified and practiced in different but equivalent manners apparent to those skilled in the art having the benefit of the teachings herein. Furthermore, no limitations are intended to the details of construction or design herein shown, other than as described in the claims below. It is therefore evident that the particular embodiments disclosed above may be altered or modified and all such variations are considered within the scope and spirit of the invention. Accordingly, the protection sought herein is as set forth in the claims below.

CLAIMS

What is claimed is:

1. A heater cable to pump cable connector comprising:

a conductive sleeve assembly adapted to join a stripped terminal end of a heater cable cold lead and a stripped terminal end of a pump cable lead;

an insulating boot covering the conductive sleeve assembly disposed inside a protective outer sleeve;

a covering for the cold lead of the heater cable and the conductor having an extrusion limiting top stop retaining said covering at a first end of said protective sleeve; and,

epoxy coating and an extrusion limiting bottom stop of a second end of said protective outer sleeve.

2. The heater cable to pump cable connector of claim 1 wherein the conductive sleeve assembly is composed of a single splice sleeve into which the stripped cold lead and the stripped pump cable conductor are both inserted and joined.

3. The heater cable to pump cable connector of claim 1 wherein the conductive sleeve assembly is composed of a male plug joined to the stripped pump cable and covered in an insulating sleeve, then inserted in a female conductive receptacle, covered in a mating insulating sleeve, joined to the stripped cold lead end.

4, The heater cable to pump cable connector of claim 2 wherein the stripped ends are joined in the single splice sleeve by a method selected from the following: crimping, welding, soldering, compressive fitting, or gluing.

5. The heater cable to pump cable connector of claim 3 wherein the male plug is joined to the stripped pump cable lead and the female conductive receptacle is jointed to the stripped cold lead end by a method selected from the following: crimping, welding, soldering, compressive fitting, or gluing.

6. A method of installing a heater cable to a pump cable connector comprising:

joining a cold lead trimmed terminal end of a heater cable and a trimmed end of one leg of a pump cable in a conductive connector;

insulating the conductive connector in an insulating sleeve; and,

affixing a protective cover over said insulating cover by connecting a metal tubing over the cold lead of the heater cable and a metal sheath covering the pump cable to the protective cover to seal and maintain the terminal ends of each heater cable and pump cable within said protective cover.

7. A method of installing a heater cable to pump cable connector comprising:

running a production tubing into a well bore with a heater cable and cold lead section of said cable clamped to the production tubing;

spacing the cold lead ends at their proximal ends and strip each cold lead uniformly;

installing ferrule tube fittings at each end of a cold lead section of the heater cable;

installing a silicone filled tubing over each cold lead into each ferrule tube fitting and tightening the ferrule tube fittings;

inserting the tubing in a top stop and installing the cold lead in the compressive fit insulator;

stripping insulation extending from insulator to fit in a crimp sleeve;

cleaning and inserting the cold lead into the crimp sleeve and seating the crimp sleeve against the edge of compressive fit insulator;

positioning a top stop gage around silicone filled tubing and moving the top stop to seat adjacent the top stop gage and affixing the top stop to the tubing;

removing the gage;

inserting a butt plug into the opposing end of the crimp sleeve and lubricating the crimp sleeve and cold lead with non-conductive silicone and sliding the female nonconductive boot over the assembly until the boot touches the top stop; and,

removing butt plug to enable completion of installation of pump cable stripped leads from triskelion tubes.

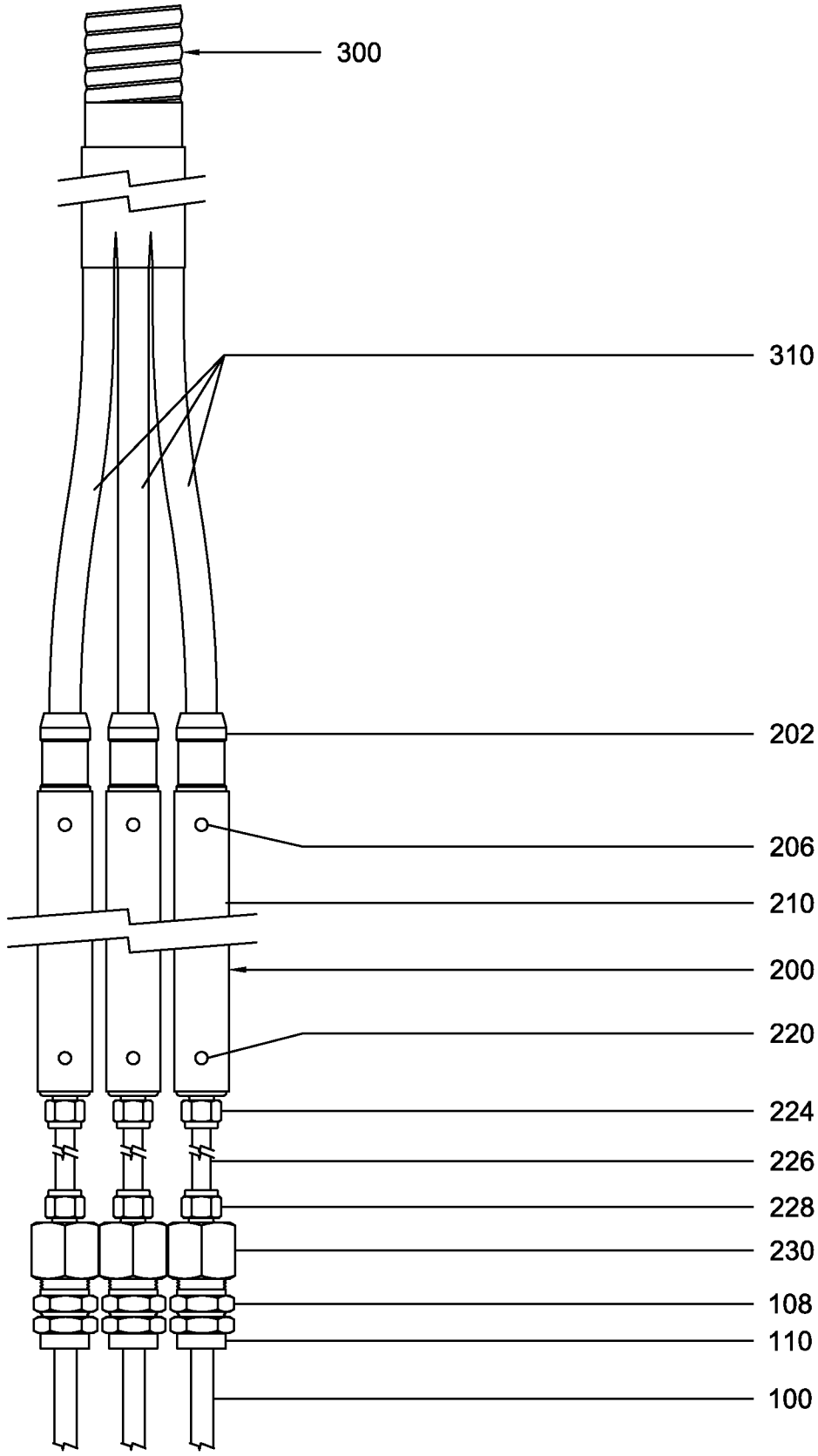


Fig. 1

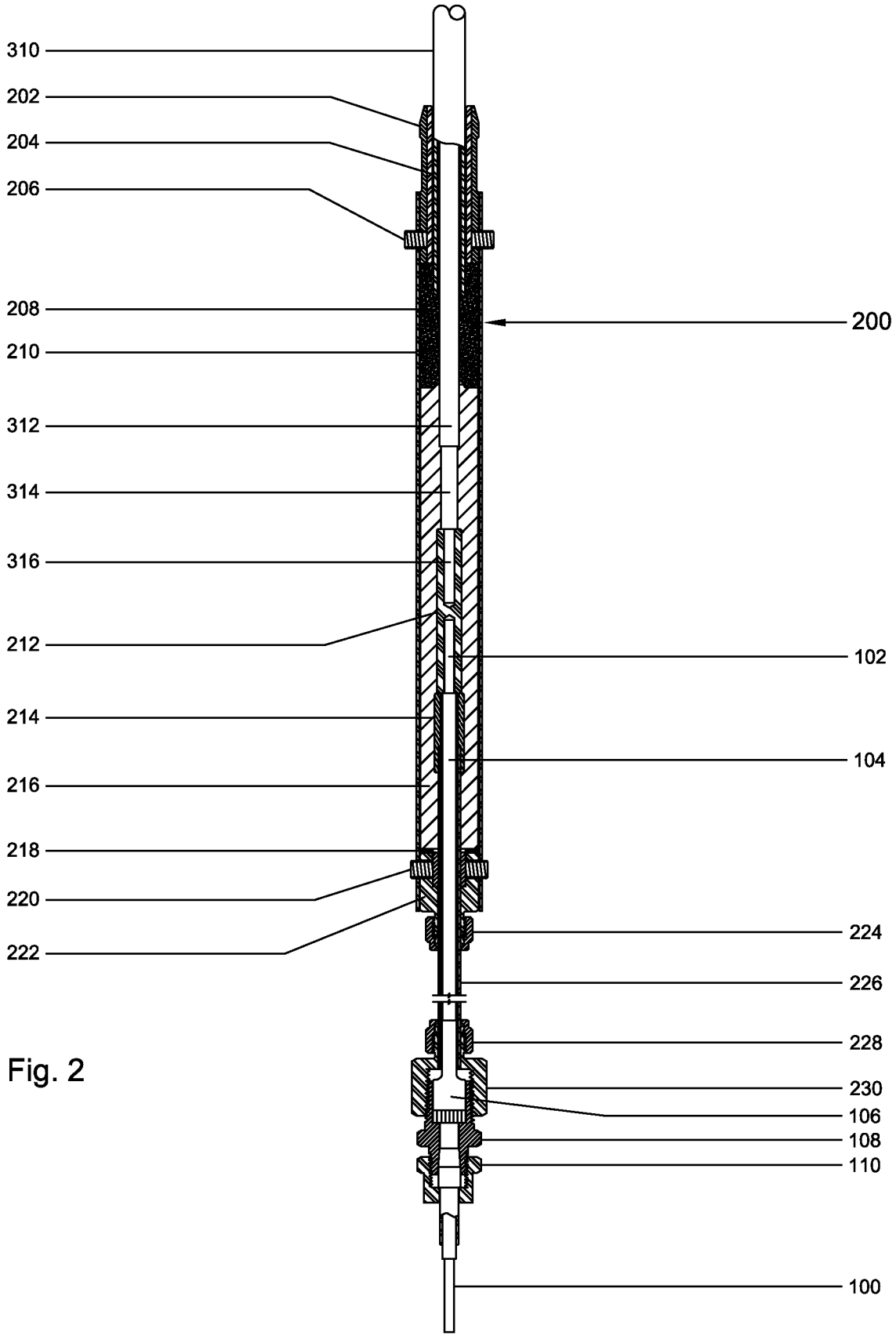

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Fig. 2

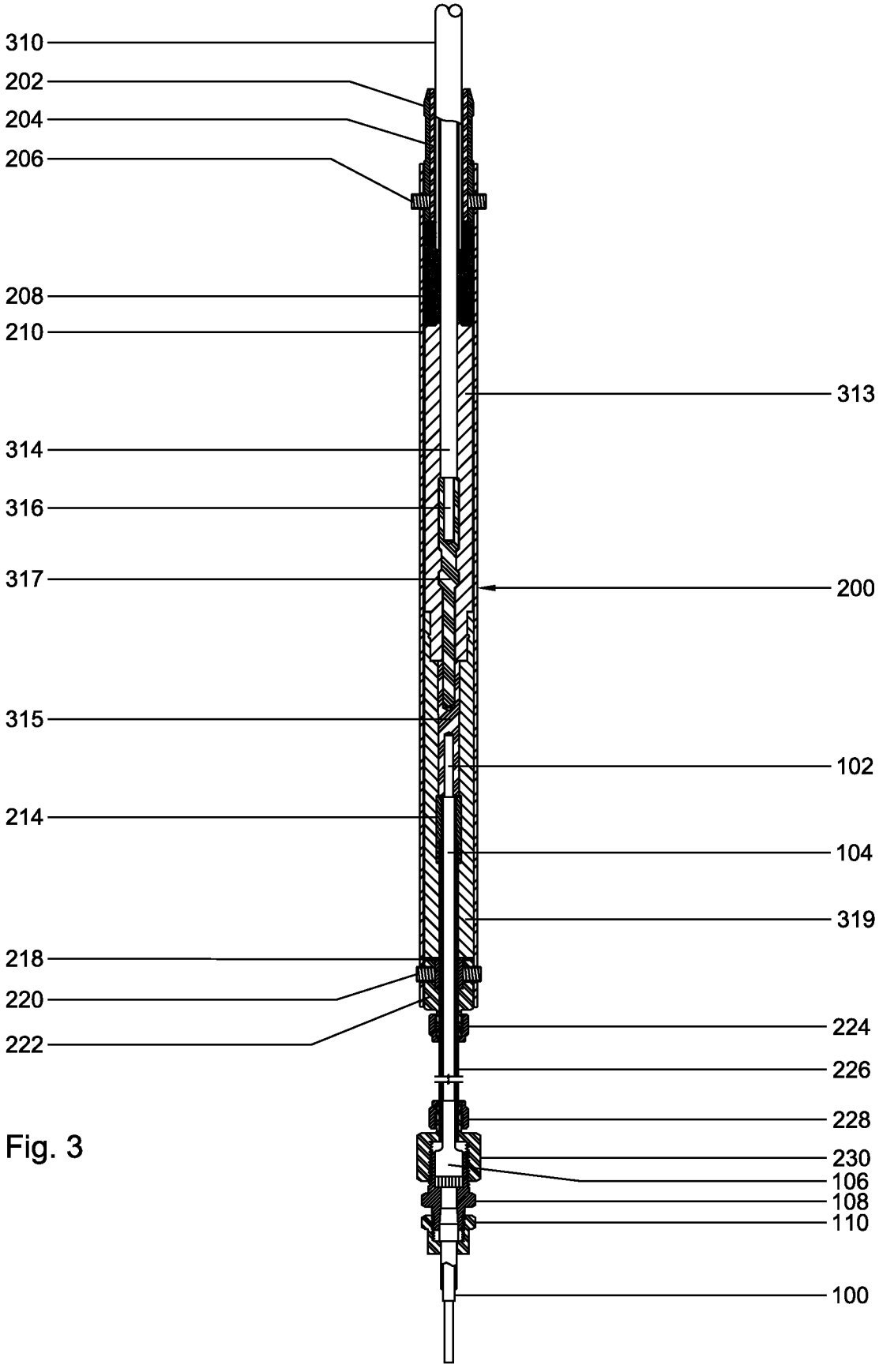

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Fig. 3

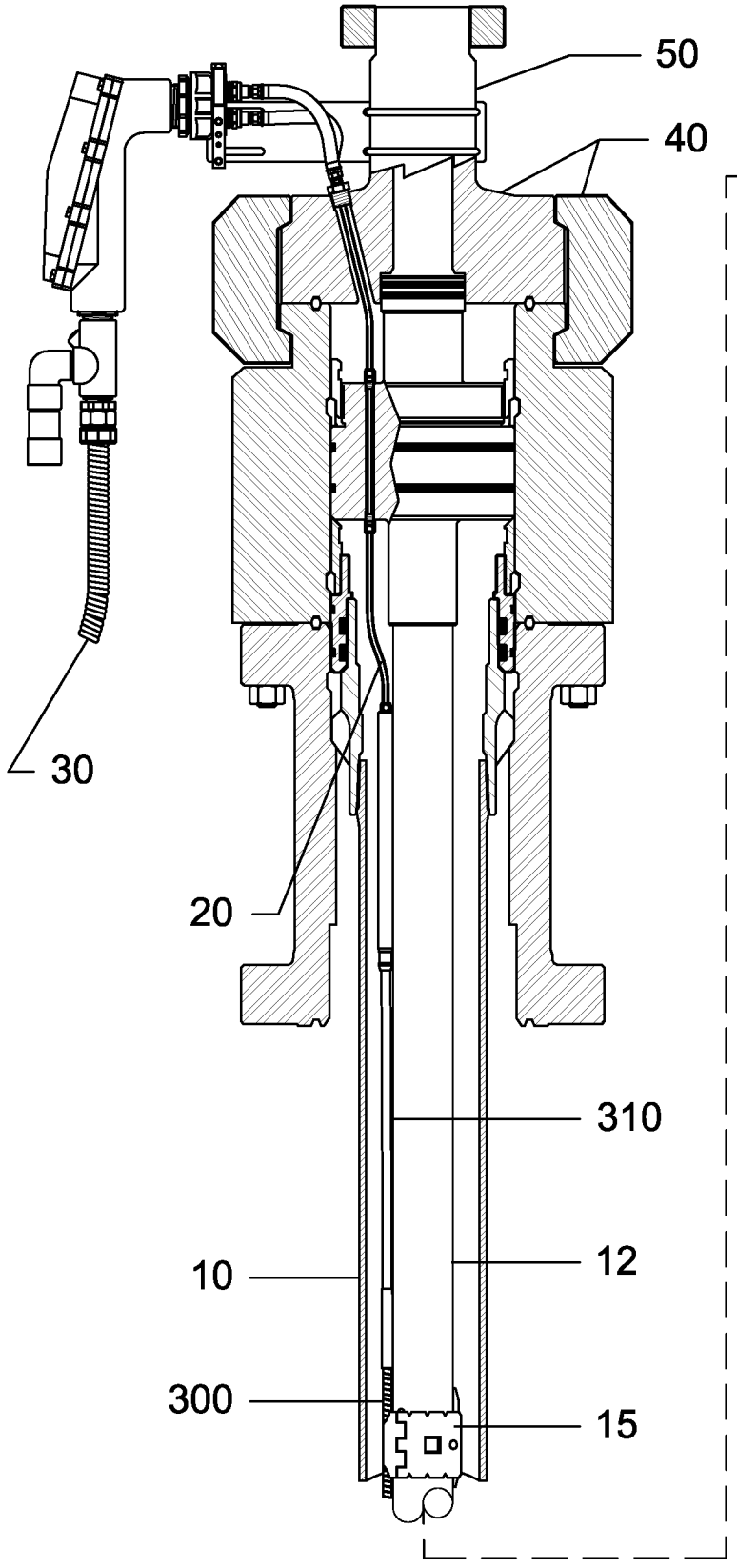


Fig. 4A

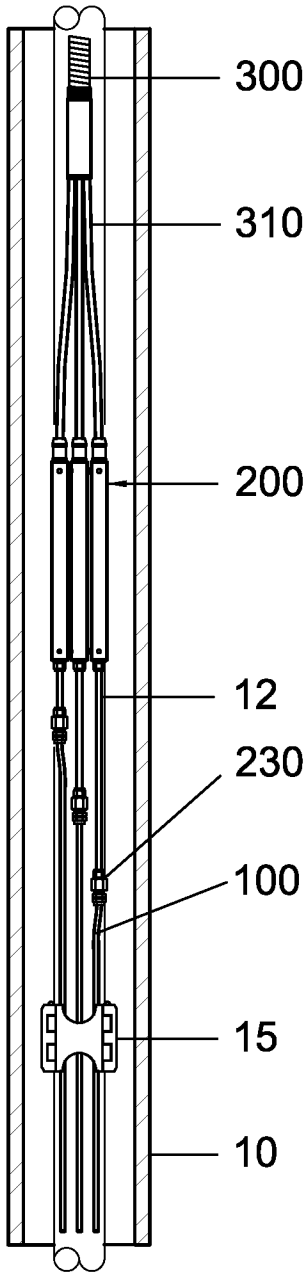


Fig. 4B

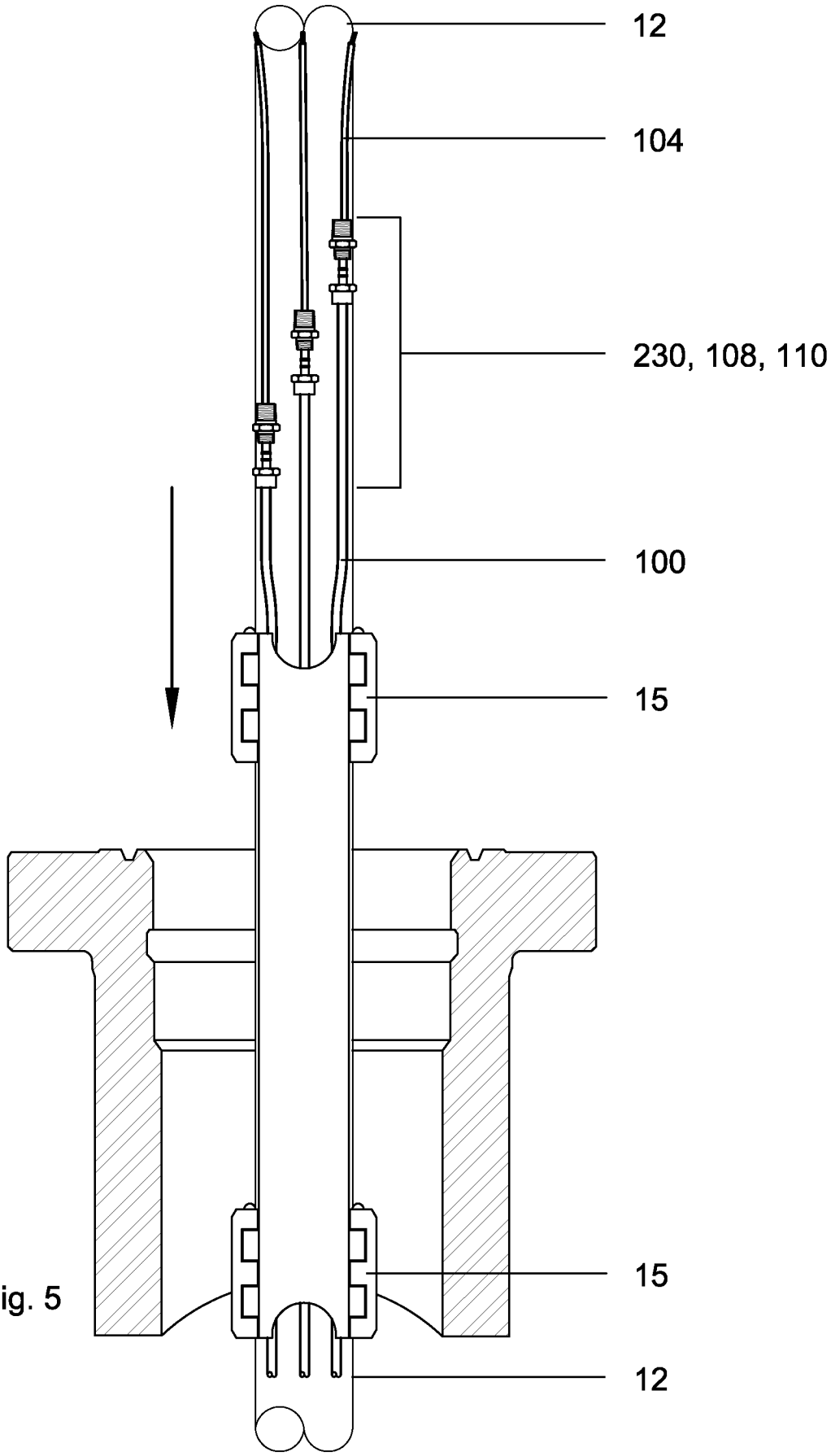


Fig. 5

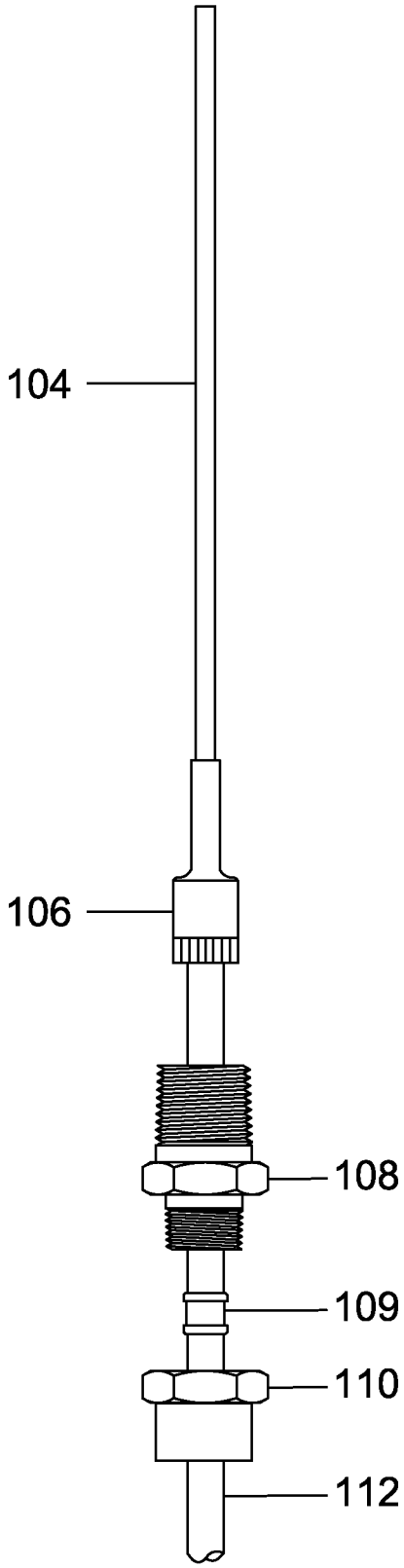


Fig. 6A

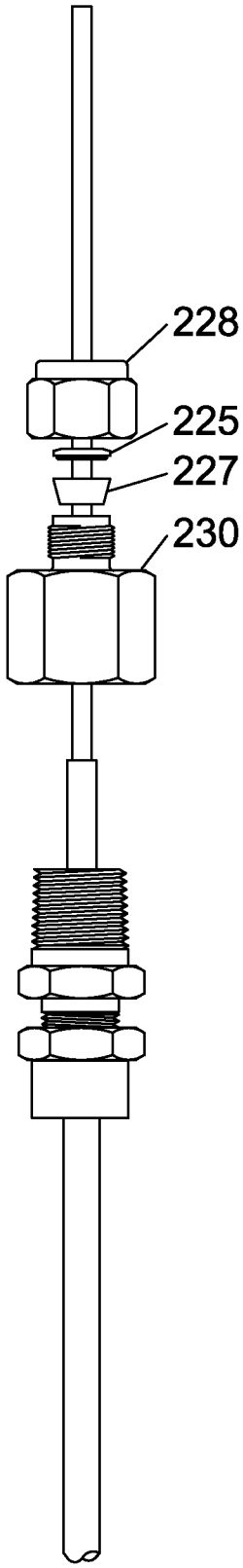


Fig. 6B

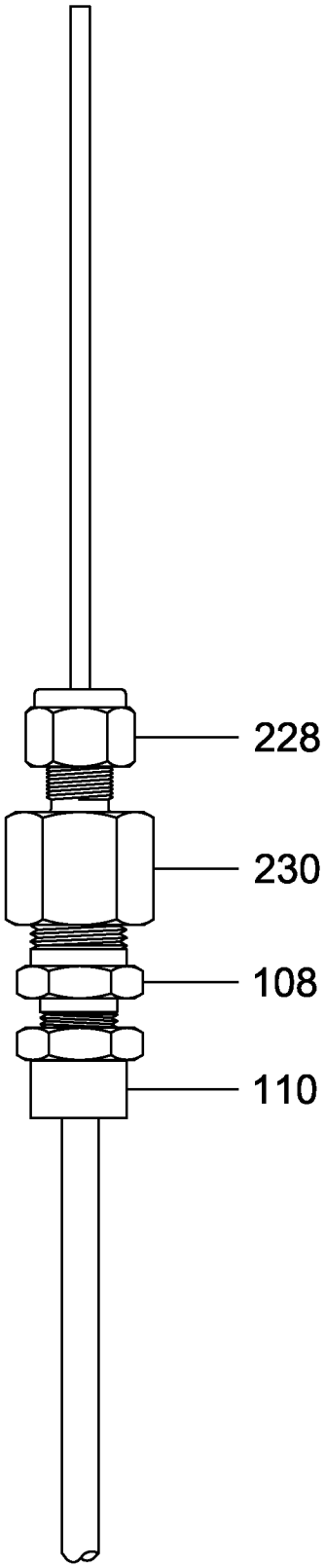


Fig. 6C

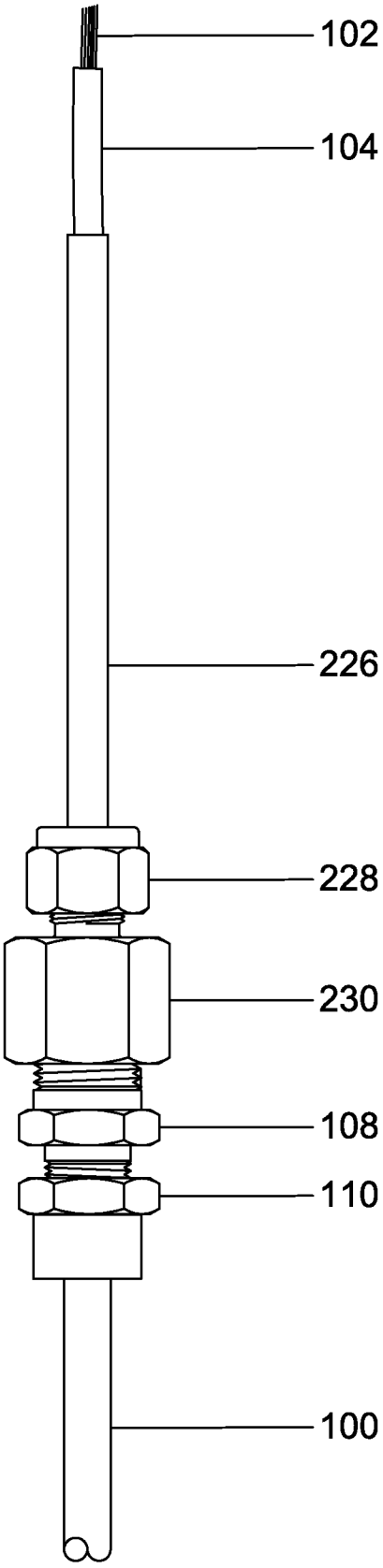

102
104
226
228
230
108
110
100

Fig. 6D

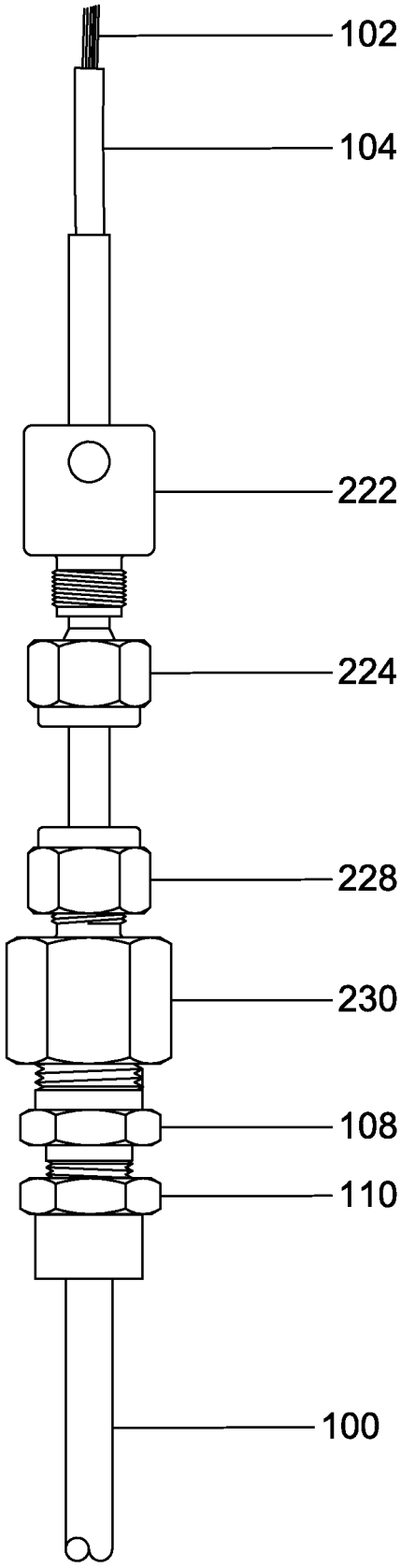

102
104
222
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108
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100

Fig. 6E

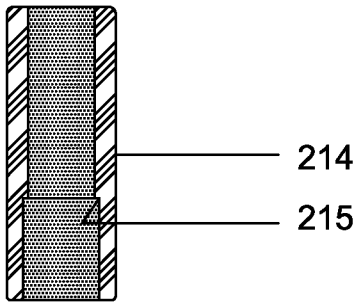


Fig. 7

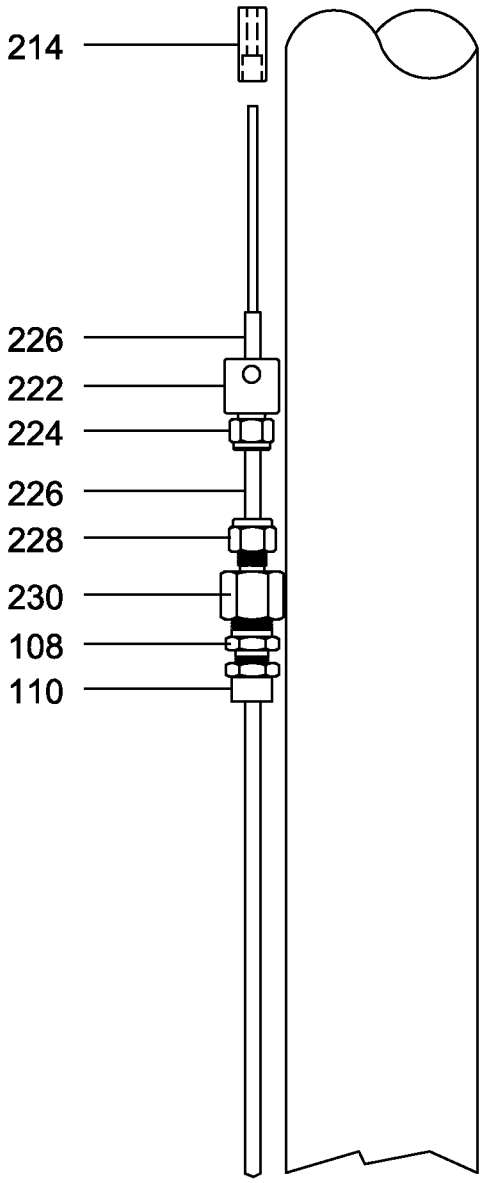


Fig. 8

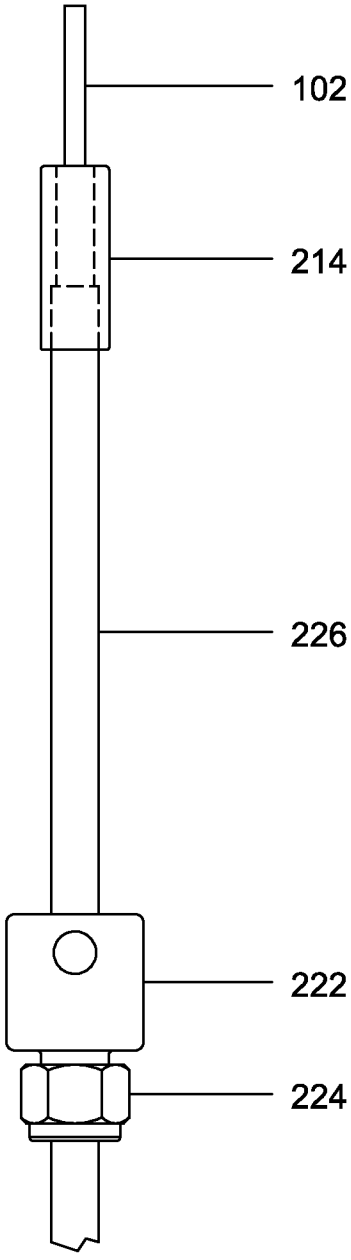


Fig. 9

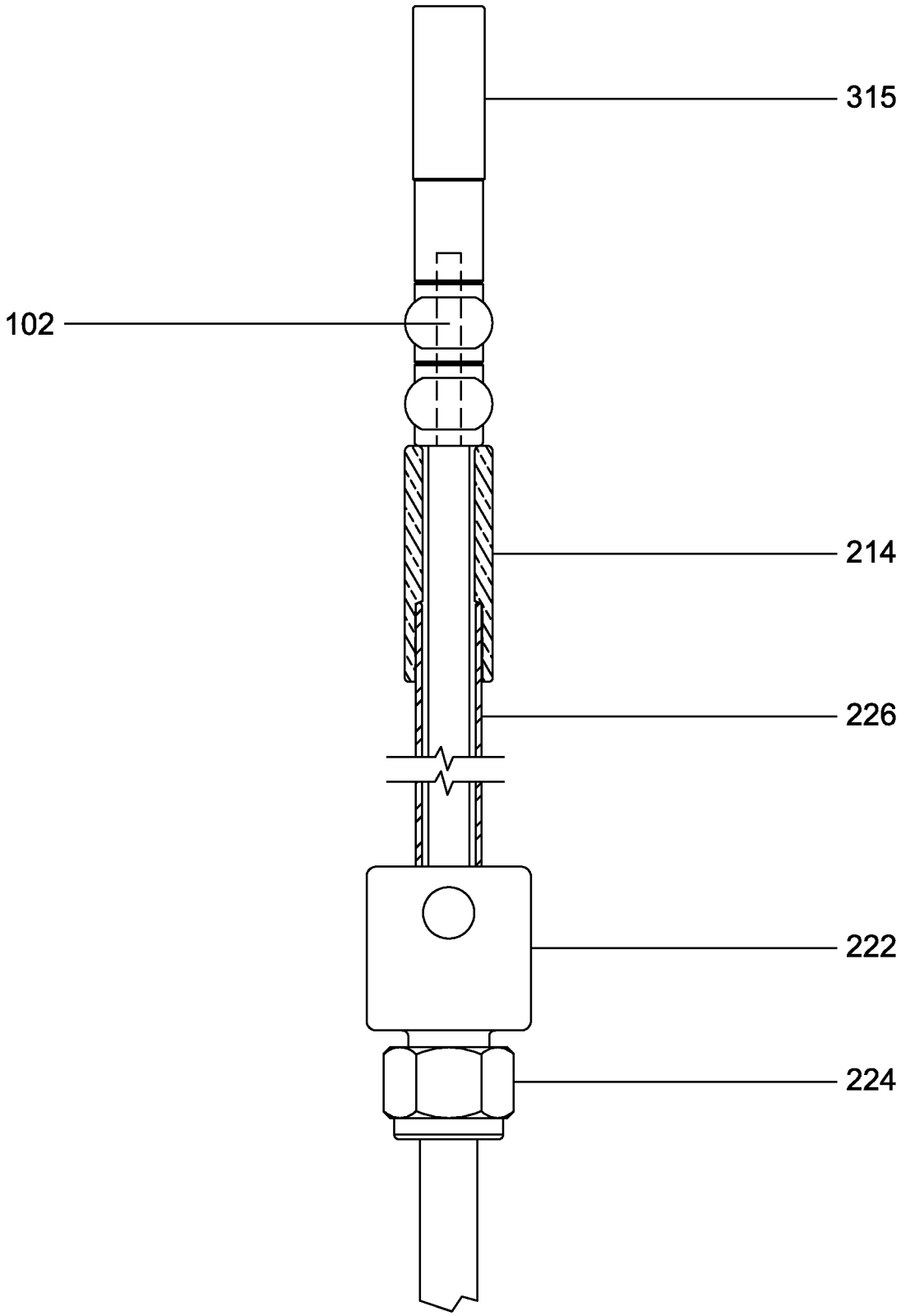


Fig. 10

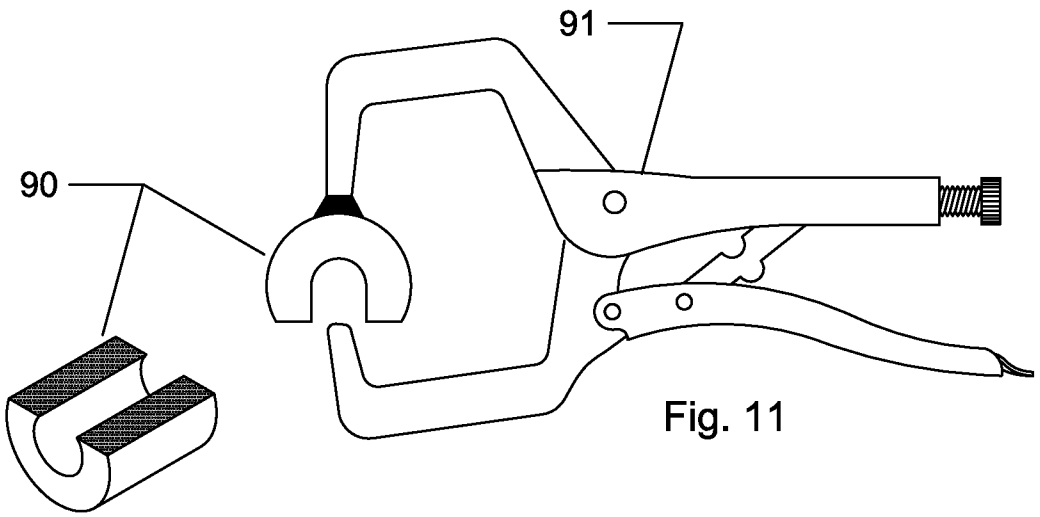


Fig. 11

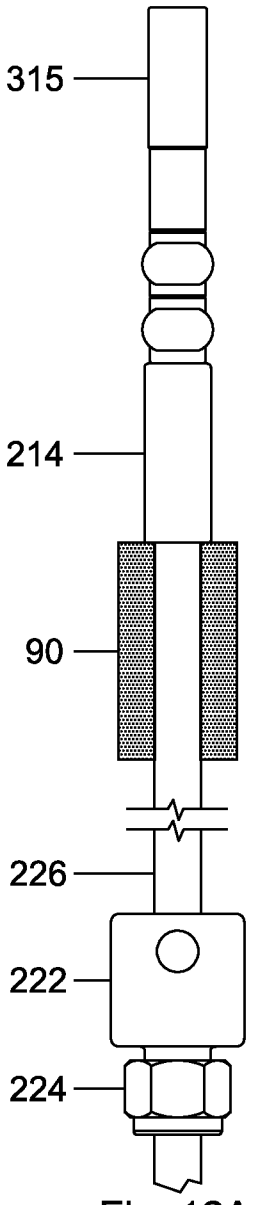


Fig. 12A

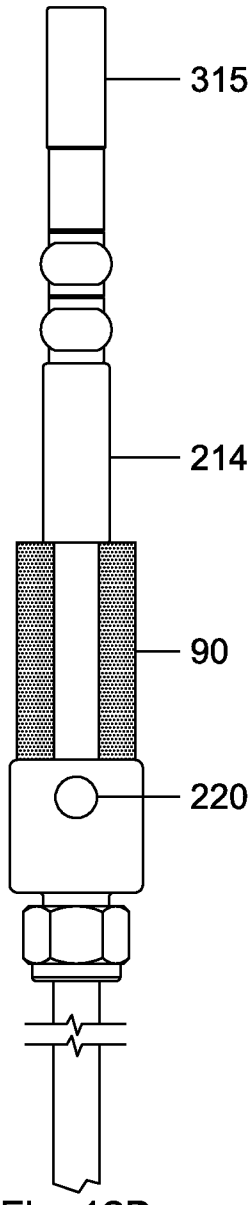


Fig. 12B

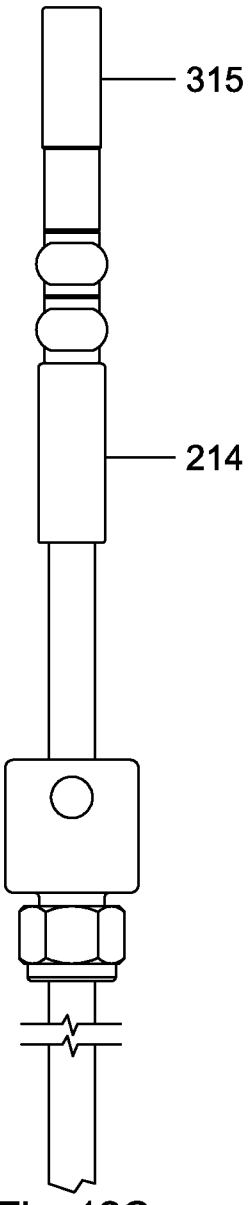


Fig. 12C

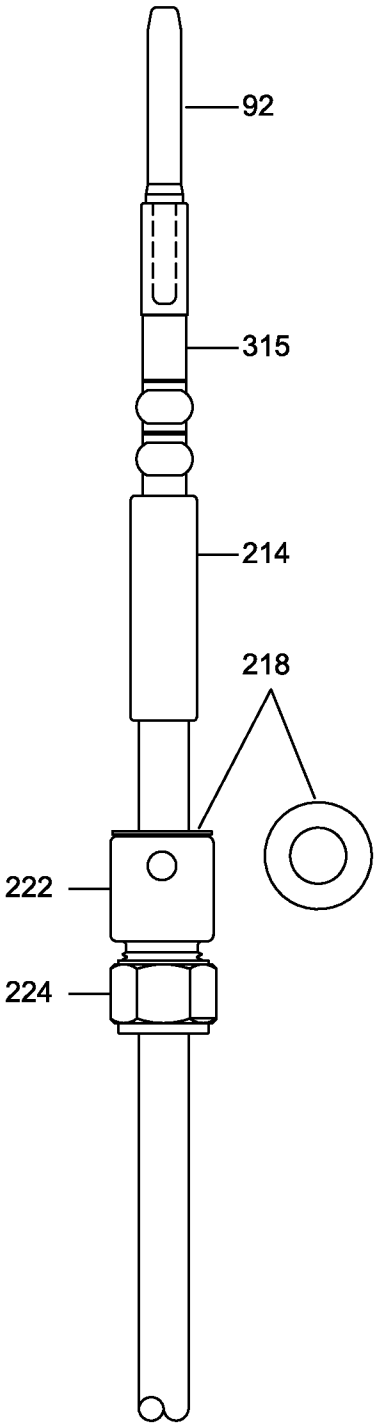


Fig. 12D

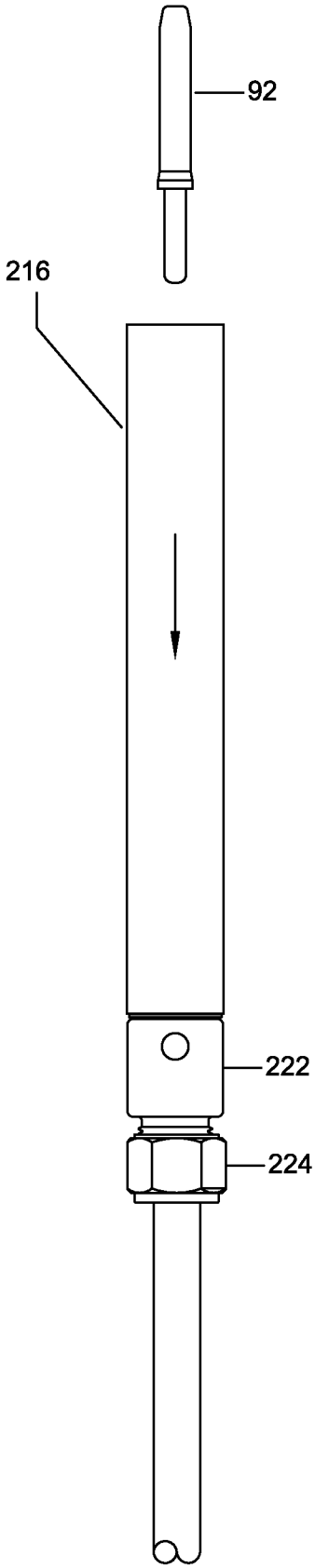


Fig. 12E

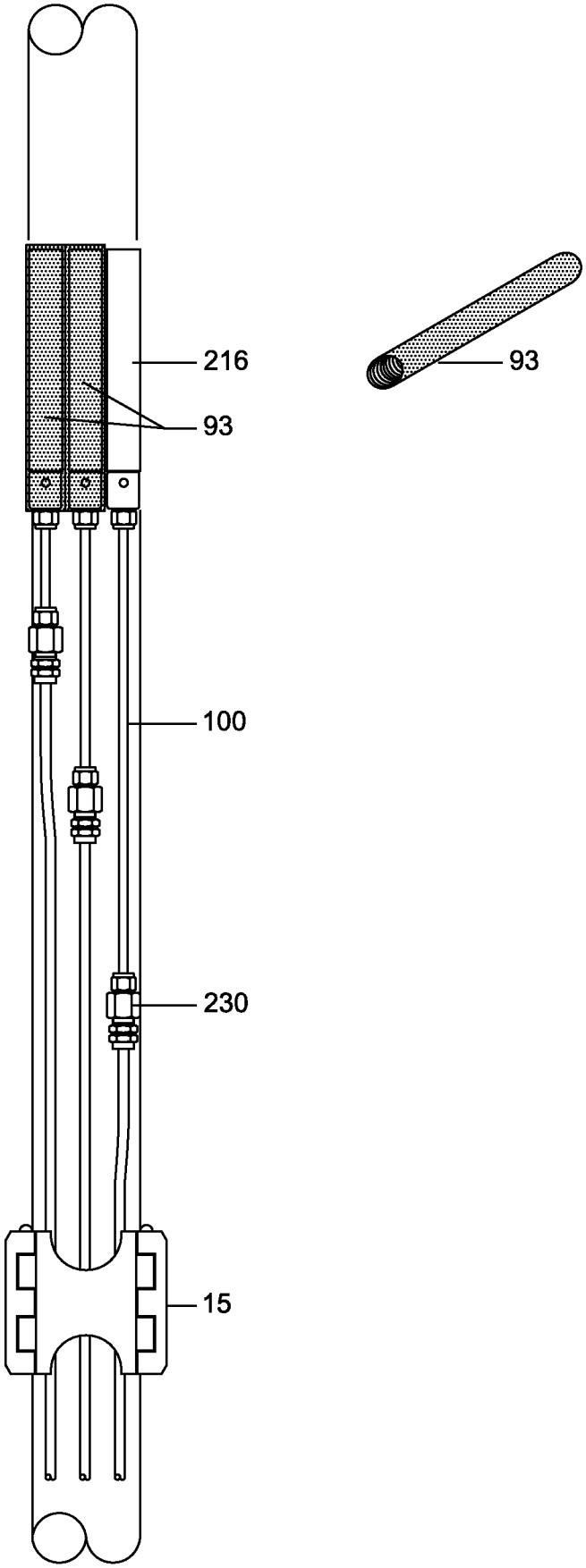


Fig. 13A

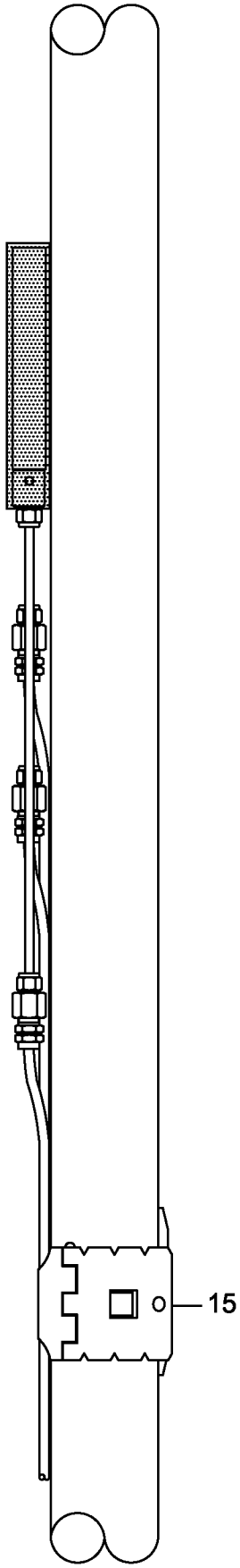


Fig. 13B