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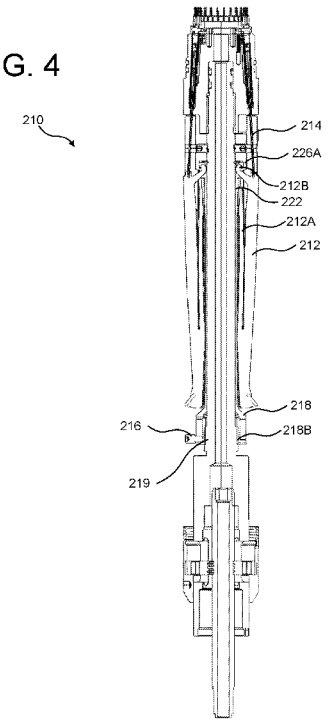
Declarations under Rule 4.17:
— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*
— *of inventorship (Rule 4.17(iv))*

(54) Title: CALIPER-ARM RETENTION SYSTEM

FIG. 4



(57) Abstract: A caliper-arm-retention mechanism for a caliper tool is disclosed. The retention mechanism includes a selectively movable retention sleeve and a pivot arm that cooperate to constrain relative translational motion between the pivot arm and a caliper arm pivotally engaged with the pivot arm while at the same time allowing relative rotational movement of the caliper arm and pivot arm. The retention sleeve may be selectively repositioned using a threaded nut configured to push the sleeve toward the pivot arm or pull the sleeve away from the pivot arm, depending on the direction of rotation of the nut.

WO 2020/172000 A1

[Continued on next page]

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TITLE OF INVENTION

CALIPER-ARM RETENTION SYSTEM

PRIORITY CLAIM

This application claims priority to U.S. Patent Application No. 62/807,657, filed on February 19, 2019.

TECHNICAL FIELD

This invention pertains generally to technology for caliper tools that may be used to measure geometric aspects of tubulars or a wellbore. More particularly, the invention pertains to technology to retain caliper arms (aka fingers) in a caliper tool while easing installation and replacement of the arms as part of the manufacture, maintenance, or repair of the tool.

BACKGROUND ART

Caliper tools are often used in the oil-and-gas industry to measure characteristics of the wellbore environment. For example, a multi-arm caliper logging tool may be positioned in a wellbore (e.g., via wireline) to measure the diameter of the wellbore at various depths in the wellbore. The diameter measurement may be taken at various axes to provide a diameter profile. When positioned in a tubular, such as casing in a wellbore, the caliper tool provides information about the condition of the inner wall of the tubular. An overview of caliper tools is provided in Applicant's U.S. Patent No. 10,087,740, the entirety of which patent is incorporated herein by reference.

Generally, the arms of a caliper tool are configured to pivotally attach to a tool body. One end of the arm is pivotally attached to the tool. The other end of the arm extends out from the body of the tool until it encounters a surface (e.g., the inside wall of casing disposed in a wellbore). With arms extended, the caliper tool is sequentially positioned within that being measured (e.g., wellbore, tubular). For example, for a caliper logging tool disposed within casing in a wellbore via a line (e.g., wireline or slickline), the tool is sequentially positioned by pulling on the line and dragging the arms along the surface. As such, caliper arms are exposed to wear and tear.

The circumferential resolution of a caliper tool may be increased by increasing the number of caliper arms. For example, a 60-arm caliper tool has a greater circumferential resolution than a 40-arm caliper tool which has a greater circumferential resolution than a 24-arm caliper tool. This increased circumferential resolution comes at a cost. Namely, more caliper arms need to be installed on the tool and more caliper arms need to be replaced due to the wear and tear on the tool. Installation and replacement of the caliper

arms can be a time-consuming and laborious process. Thus, increasing the number of caliper arms increases the labor costs associated with manufacturing and maintaining the caliper tool. Accordingly, there is a need for a pivotal caliper-mounting mechanism that eases the processes of installing and replacing caliper arms.

SUMMARY OF INVENTION

The present invention is directed to technology to satisfy the need for a caliper-arm-retention mechanism that secures pivotally-mounted caliper arms to a caliper tool during operation while easing replacement or installation of the caliper arms on the tool.

In one aspect of the invention, a caliper tool includes one or more caliper arms each having a pivot feature configured to pivotally engage a pivot arm mounted to the tool. The tool further includes a retention sleeve that may be selectively positioned relative to the pivot arm. In one position of the retention sleeve, a surface of the sleeve engages a surface of the pivot feature of the caliper arm to hold the caliper arm in translational position relative to the pivot arm while allowing rotational (pivotal) movement of the caliper arm relative to the pivot arm. In another position of the retention sleeve, the pivot-feature-engaging surface is sufficiently distant from the pivot arm that the caliper arm may be disengaged from the pivot arm to allow removal (or installation) of the caliper arm. In one aspect of the invention, the retention sleeve may be selectively positioned by a threaded nut that when rotated in one direction moves the sleeve toward the pivot arm and that when rotated in the another direction moves the sleeve away from the pivot arm.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other features, aspects, and advantages of the present invention will be better understood with reference to the following description, appended claims, and accompanying drawings where:

Figure **1** depicts an exemplary caliper tool disposed in a wellbore via wireline.

Figure **2** is a perspective view of a portion of an exemplary caliper tool implementing an aspect of the invention.

Figure **3** is a perspective view of a portion of an exemplary caliper tool implementing an aspect of the invention.

Figure **4** is a sectional view of the exemplary caliper tool depicted in Figure **3**.

Figure **5** is a perspective view of a portion of an exemplary caliper tool and depicts an exemplary caliper retention mechanism according to an aspect of the invention.

Figure **6** is a partially-exploded perspective view of a portion of an exemplary caliper tool and depicts an exemplary caliper retention mechanism according to an aspect of the invention.

Figure **7** is a side view of a portion of an exemplary caliper tool and depicts an exemplary caliper retention mechanism according to an aspect of the invention.

Figure **8** is a side view of a portion of an exemplary caliper tool and depicts an exemplary caliper retention mechanism according to an aspect of the invention.

Figure **9** is a section view of a portion of an exemplary caliper tool and depicts an exemplary caliper retention mechanism according to an aspect of the invention.

Figure **10** is substantially the section view of Figure **9** but also depicting caliper arms as installed.

Figure **11** is a section view of a portion of an exemplary caliper tool and depicts a caliper arm being installed into an exemplary caliper retention mechanism according to an aspect of the invention.

DESCRIPTION OF EMBODIMENTS

In the summary above, and in the description below, reference is made to particular features of the invention in the context of exemplary embodiments of the invention. The features are described in the context of the exemplary embodiments to facilitate understanding. But the invention is not limited to the exemplary embodiments. And the features are not limited to the embodiments by which they are described. The invention provides a number of inventive features which can be combined in many ways, and the invention can be embodied in a wide variety of contexts. Unless expressly set forth as an essential feature of the invention, a feature of a particular embodiment should not be read into the claims unless expressly recited in a claim.

Except as explicitly defined otherwise, the words and phrases used herein, including terms used in the claims, carry the same meaning they carry to one of ordinary skill in the art as ordinarily used in the art.

Because one of ordinary skill in the art may best understand the structure of the invention by the function of various structural features of the invention, certain structural features may be explained or claimed with reference to the function of a feature. Unless used in the context of describing or claiming a particular inventive function (e.g., a process), reference to the function of a structural feature refers to the capability of the structural feature, not to an instance of use of the invention.

Except as otherwise stated herein or as is otherwise clear from context, the inventive methods comprising or consisting of more than one step may be carried out without concern for the order of the steps.

The terms "comprising," "comprises," "including," "includes," "having," "haves," and their grammatical equivalents are used herein to mean that other components or steps are optionally present. For example, an article comprising A, B, and C includes an article having only A, B, and C as well as articles having A, B, C, and other components. And a method comprising the steps A, B, and C includes methods having only the steps A, B, and C as well as methods having the steps A, B, C, and other steps.

Terms of degree, such as "substantially," "about," and "roughly" are used herein to denote features that satisfy their technological purpose equivalently to a feature that is "exact." For example, a component A is "substantially" perpendicular to a second component B if A and B are at an angle such as to equivalently satisfy the technological purpose of A being perpendicular to B.

Except as otherwise stated herein, or as is otherwise clear from context, the term "or" is used herein in its inclusive sense. For example, "A or B" means "A or B, or both A and B."

An exemplary caliper tool is depicted in Figure **1**. The caliper tool **110** is shown disposed in casing **102** via a wireline **106**. The wireline **106** mechanically attaches the caliper tool **110** to a surface system, as is well known in the art. The caliper tool **110** includes a number of caliper arms **112**. The caliper arms **112** are pivotally connected to the body of the tool **110** through a pivot collar **126** on the tool **110** and a corresponding pivot feature **112B** on the caliper arms **112**. A spring feature **112A** of the caliper arms **112** pushes the caliper arms **112** away from the body of the tool **110**. A sensor section **114** is connected to the caliper arms **112** to convert the radial positions of the tips **112C** of the caliper arms **112** into electronic or magnetic signals that are collected and processed to provide geometric information regarding the inside surface of the casing **102**.

A portion of an exemplary caliper tool **210** is depicted in Figures **2** and **3**. In Figure **2**, an actuator sleeve **220** is disposed over a number of retained caliper arms **212**. For sake of clarity, the actuator sleeve **220** is not shown in Figure **3**. The tool **210** includes a threaded adjustment nut **218** that is configured to selectively trap or release the caliper arms **212** at a pivot mount on the tool **210** (as is described below). The actuator sleeve **220** includes a slot **220A** to allow access to the adjustment nut **218** when the sleeve **220** is installed on the tool **210**.

A section view of the caliper tool **210** is depicted in Figure **4**. Caliper arms **212** are shown pivotally mounted to the tool **210** at a pivot arm **226A** of the tool **210** via pivot features **212B** of the caliper arms **212**. Here, the caliper springs **212A** are shown compressed. The caliper arms **212** are connected to a sensor(s) (not shown) via an actuator rod **214**. The caliper arms **212** are held in position relative to the pivot arm **226A** using a longitudinally movable caliper-arm-retaining sleeve **222**. The caliper-arm retaining sleeve **222** is mechanically linked to the adjustment nut **218**. The adjustment nut **218** engages a threaded feature **219** of the tool **210** via nut threads **218B**. Threaded rotation of the nut **218** causes the nut **218** to move toward or away from the pivot arm **226A**, depending on the direction of the rotation. Thus, the nut **218** can be used to position the retaining sleeve **222** to hold the caliper arms **212** on the pivot arm **226A** and it can be used to position the retaining sleeve **222** to release the caliper arms **212** from the pivot arm **226A**. A set screw **216** is used to lock the adjustment nut **218** in place to hold the caliper arms **212** to the pivot arm **226A** for operation of the tool **210**.

A portion of the caliper-retention mechanism of the caliper tool **210** is shown in Figure **5**. The pivot collar **226**, the caliper-arm-retaining sleeve **222**, the adjustment nut **218**, and the screw **216** cooperate to selectively retain or release the caliper arms **212**. The pivot arm **226A** is a feature of the pivot collar **226**. The adjustment nut **218** is linked to the retaining sleeve **222** via complementary features **218A**, **222B** on the nut **218** and sleeve **222**. The mechanism depicted in Figure **5** is further depicted in the partially-exploded view of Figure **6** which further shows a caliper-arm guide **224.** Figures **7** and **8** are side views of the caliper-retention mechanism. As shown in Figure **8**, the retaining sleeve **222** includes a retention-ramp surface **222A** configured to engage a surface of the caliper arm **212** when installed.

Figure **9** is a section view of the caliper-retention mechanism with retaining sleeve **222** shown in position to hold caliper arms (not shown) on pivot arm **226A**. Figure **10** is a section view depicting the caliper arms **212** retained by the retaining sleeve **222** and pivot arm **226A**. The retaining sleeve **222** is positioned via the adjustment nut **218** such that the retention-ramp surface **222A** engages a corresponding surface of the pivot feature **212B** of the caliper arm **212** sufficiently to hold the pivot feature **212B** on the pivot arm **226A** and yet allow the caliper arm **212** to pivot at the pivot arm **226A**.

Figure **11** is a section view depicting the retaining sleeve **222** positioned to release the caliper arms **212** from engagement with the pivot arm **226A**. The springs **212A** of the caliper arms **212** are shown compressed (this could be accomplished, e.g., using a wrench during installation or removal of the caliper arms **212**). To install or remove a

caliper arm **212**, the retaining sleeve **222** is moved longitudinally away from the pivot arm **226A** (via adjustment nut **218**) to create a gap between the pivot arm **226A** and the retention-ramp surface **222A**. The caliper arm may be moved radially in on the tool (left, in the figure) in the gap between the pivot feature **212B** and the pivot arm **226A**. This then allows longitudinal movement of the caliper arm **212** to engage the pivot arm **226A** (installing the caliper arm **212**) or to disengage the pivot arm **226A** (removing the caliper arm). Once the caliper arms **212** are installed on the pivot arm **226A**, the retaining sleeve **222** may be repositioned (via adjustment nut **218**) so as to lessen the gap between the retention-ramp surface **222A** and the pivot arm **226A** and thereby hold the caliper arm **212** on the pivot arm **226A** (as shown, e.g., in Figure **10**).

While the foregoing description is directed to the preferred embodiments of the invention, other and further embodiments of the invention will be apparent to those skilled in the art and may be made without departing from the basic scope of the invention. And features described with reference to one embodiment may be combined with other embodiments, even if not explicitly stated above, without departing from the scope of the invention. The scope of the invention is defined by the claims which follow.

CLAIM OR CLAIMS

The invention claimed is:

1. A caliper tool comprising:
   (a) at least one caliper arm having two ends and a pivot feature at one end;
   (b) a pivot arm to pivotally engage the pivot feature;
   (c) a retention sleeve configured on one end to engage the pivot feature and hold the pivot feature in pivotal engagement with the pivot arm;
   (d) a means for selectively positioning the retention sleeve to engage the pivot feature.
2. The caliper tool of claim 1 wherein the pivot feature includes a hook.
3. The caliper tool of claim 1 wherein the means for selectively positioning the retention sleeve includes a threaded nut.
4. A caliper tool comprising:
   (a) a cylindrical chassis having a longitudinal axis;
   (b) at least one caliper arm having a first end and a second end, wherein the first end includes a hooked portion and a sloped portion;
   (c) a pivot collar disposed on the cylindrical chassis, wherein the pivot collar includes a pivot arm having a hooked portion shaped to engage the hooked portion of the caliper arm;
   (d) a retention sleeve disposed on the cylindrical chassis, wherein the retention sleeve has a first end and a second end and wherein the first end of the retention sleeve includes a sloped portion configured to engage the sloped portion of the caliper arm;
   (e) a positioning collar disposed on the cylindrical chassis, wherein the positioning collar has a first end and a second end and wherein the first end of the positioning collar is configured to abut the second end of the retention sleeve.
5. The caliper tool of claim 4 wherein the positioning collar is selectively translocatable along the longitudinal axis.
6. The caliper tool of claim 5 wherein:
   (a) the positioning collar includes a threaded portion; and
   (b) the cylindrical chassis includes a threaded portion complementary to the threaded portion of the positioning collar.

7. The caliper tool of claim 5 wherein the positioning collar may be placed at a first position along the longitudinal axis to force the retention sleeve to engage the caliper arm and may be placed at a second position along the longitudinal axis to allow the retention sleeve to disengage the caliper arm.

8. The caliper tool of claim 5 further comprising a means for disabling selective translocation of the positioning collar along the longitudinal axis.

9. The caliper tool of claim 4 wherein:

(a) the first end of the positioning collar includes a hooked portion; and

(b) the second end of the retention sleeve includes a hooked portion complementary to the hooked portion of the positioning collar.

FIG. 1

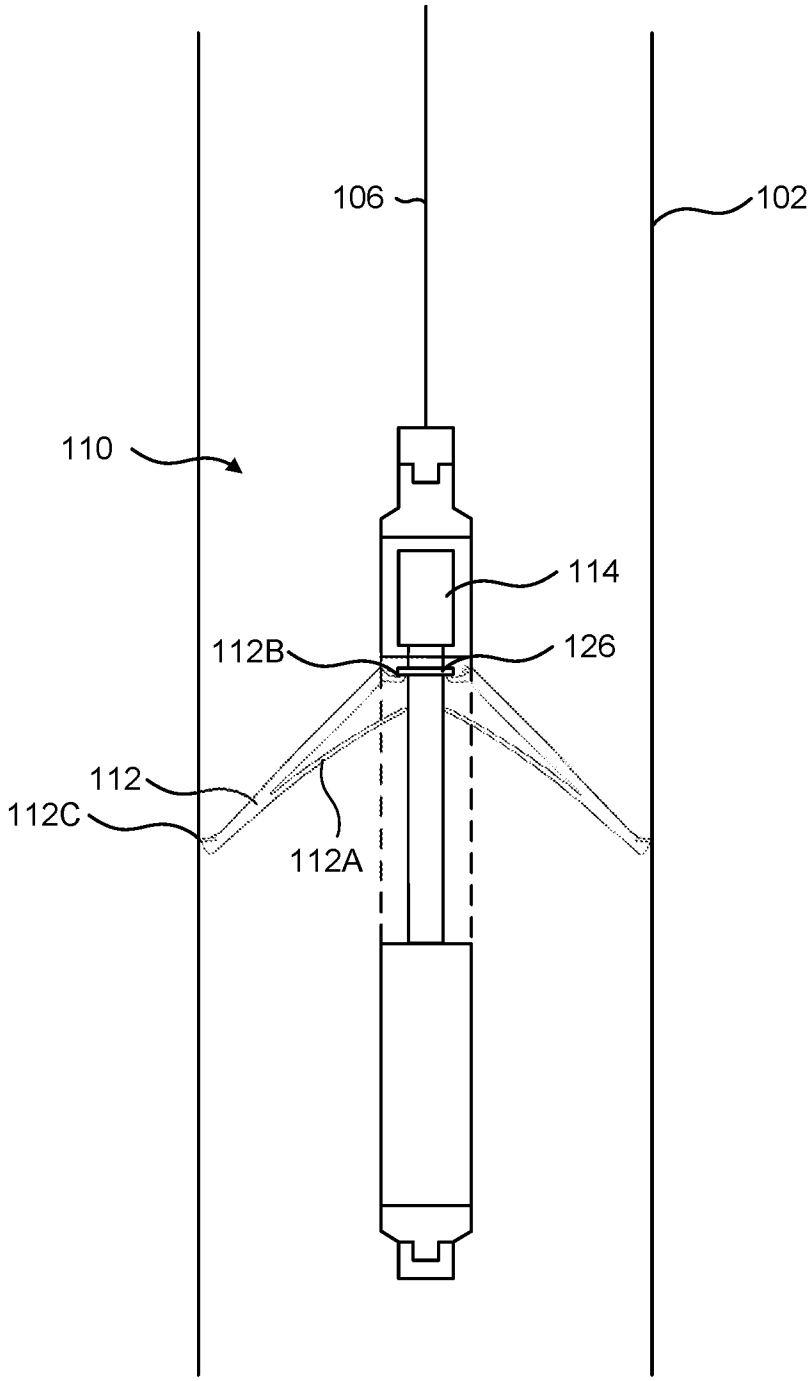


FIG. 2

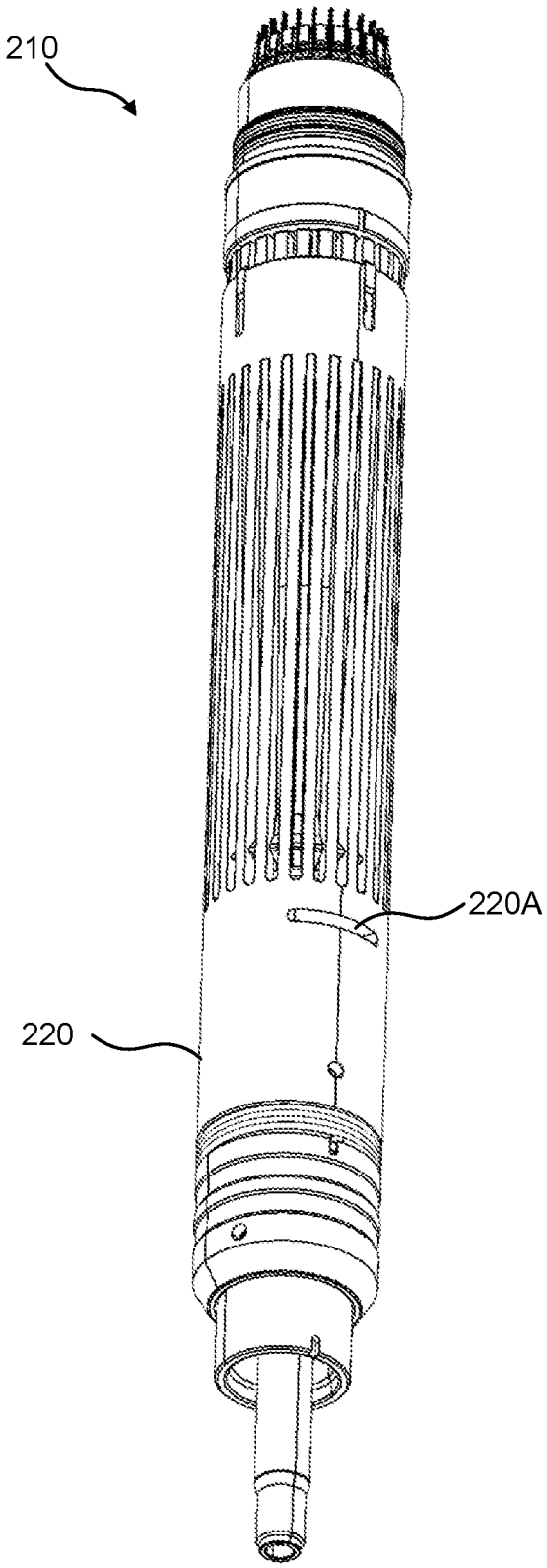


FIG. 3

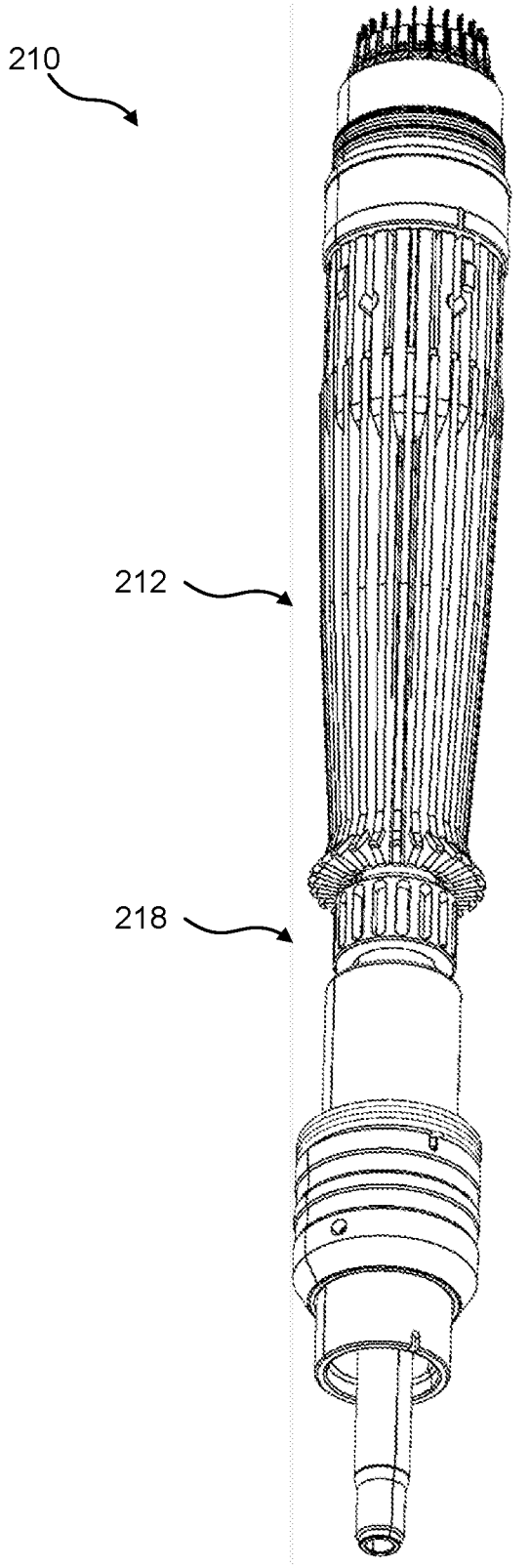


FIG. 4

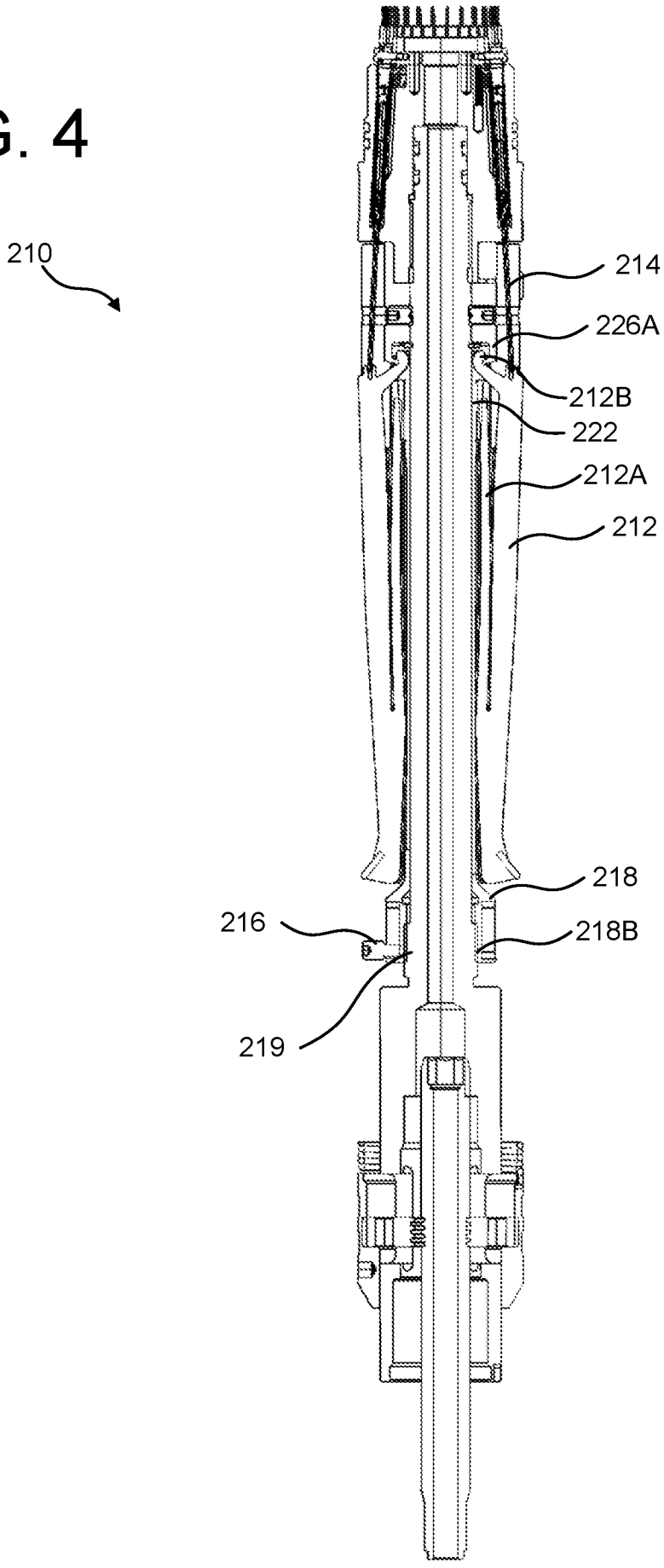


FIG. 5

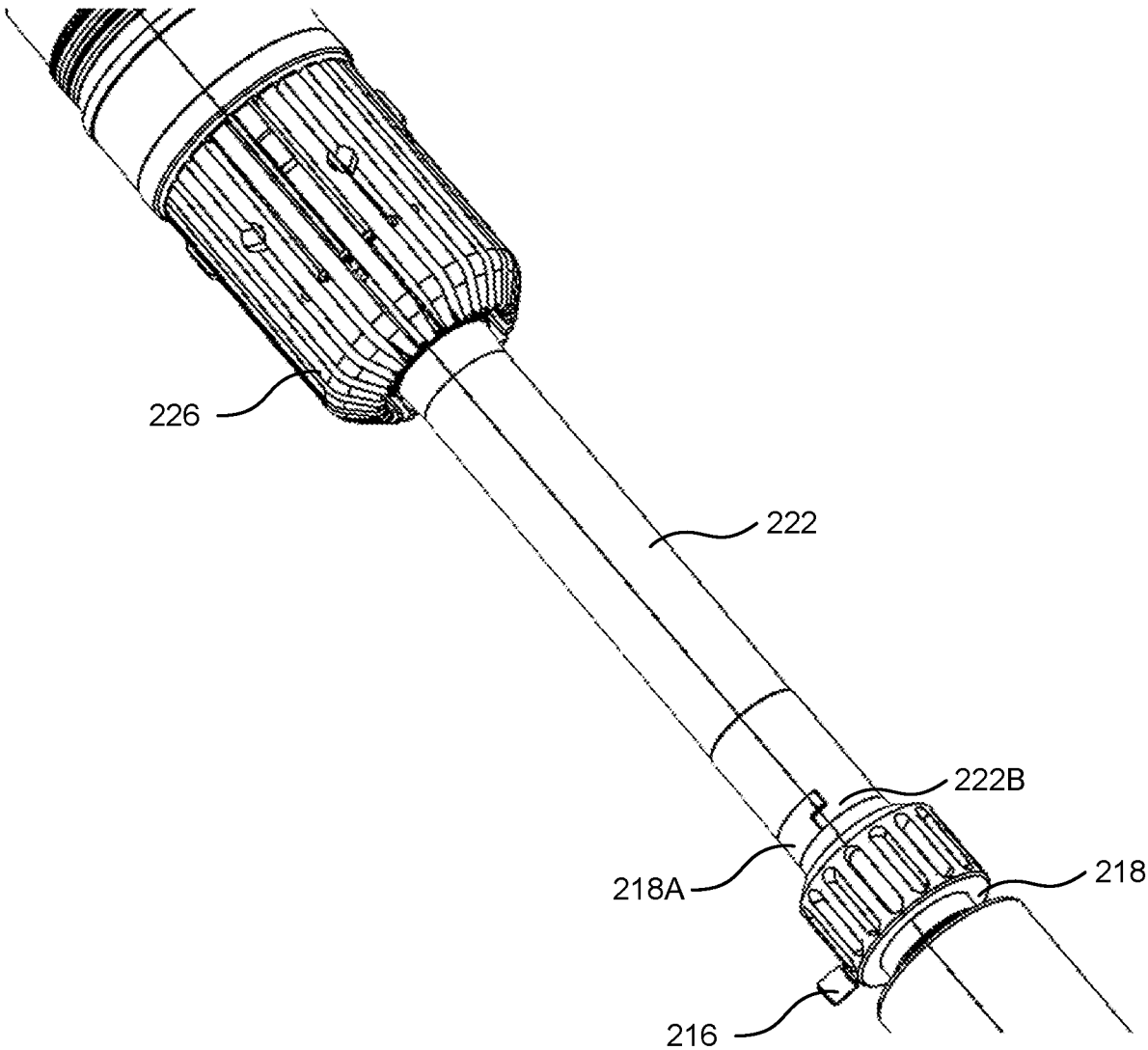


FIG. 6

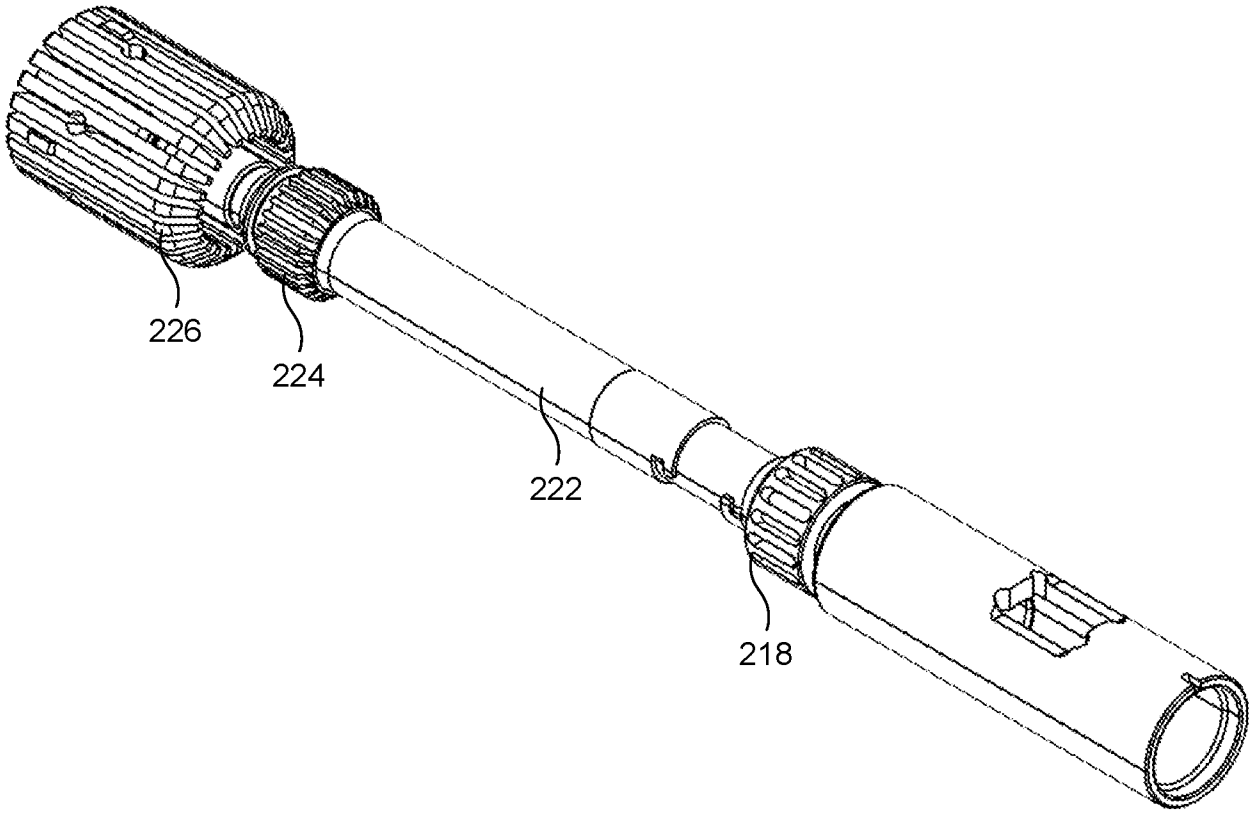


FIG. 7

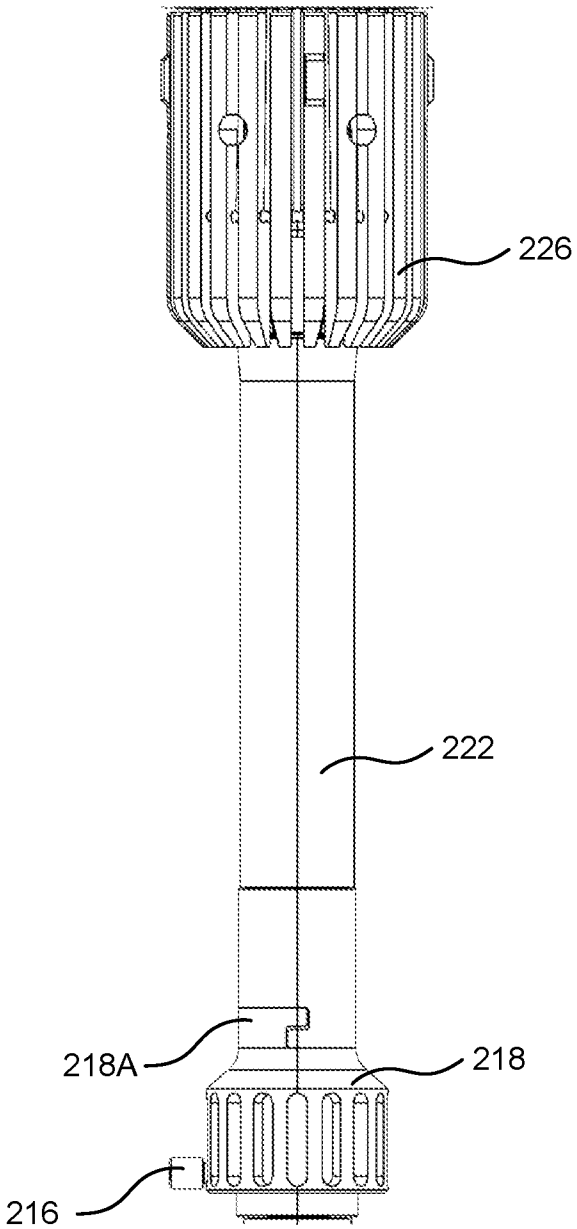


FIG. 8

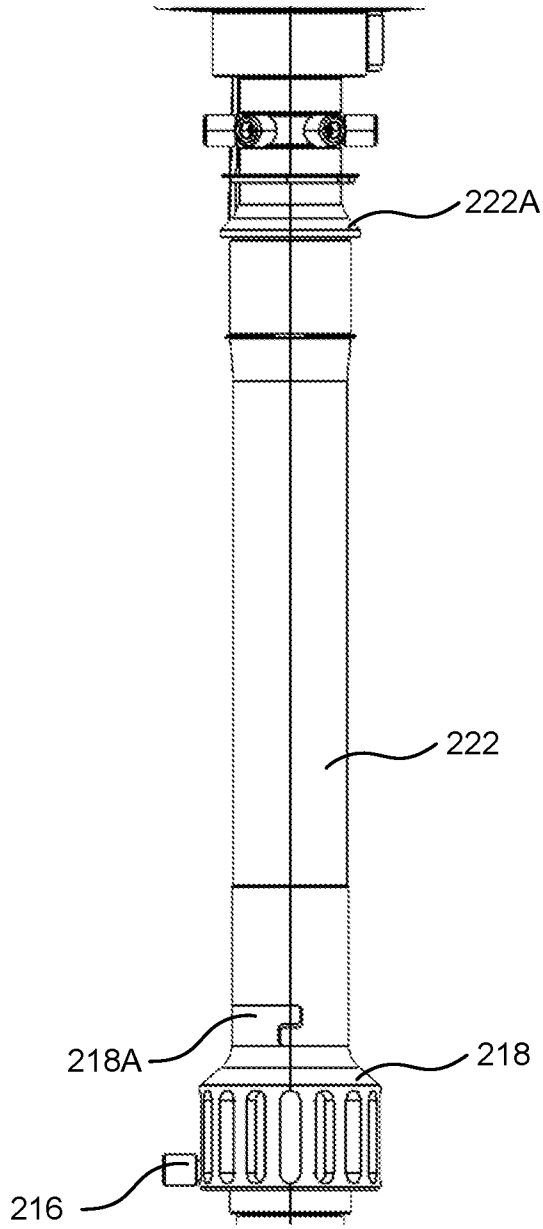


FIG. 9

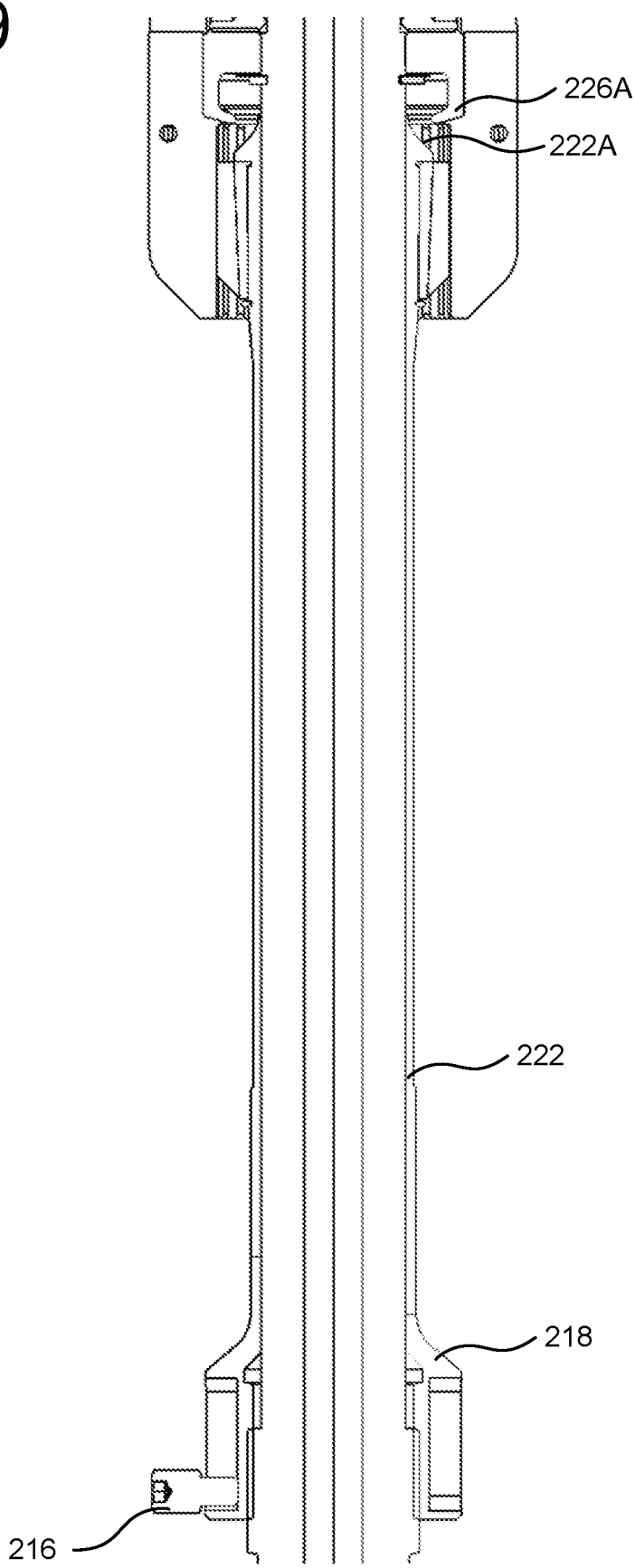


FIG. 10

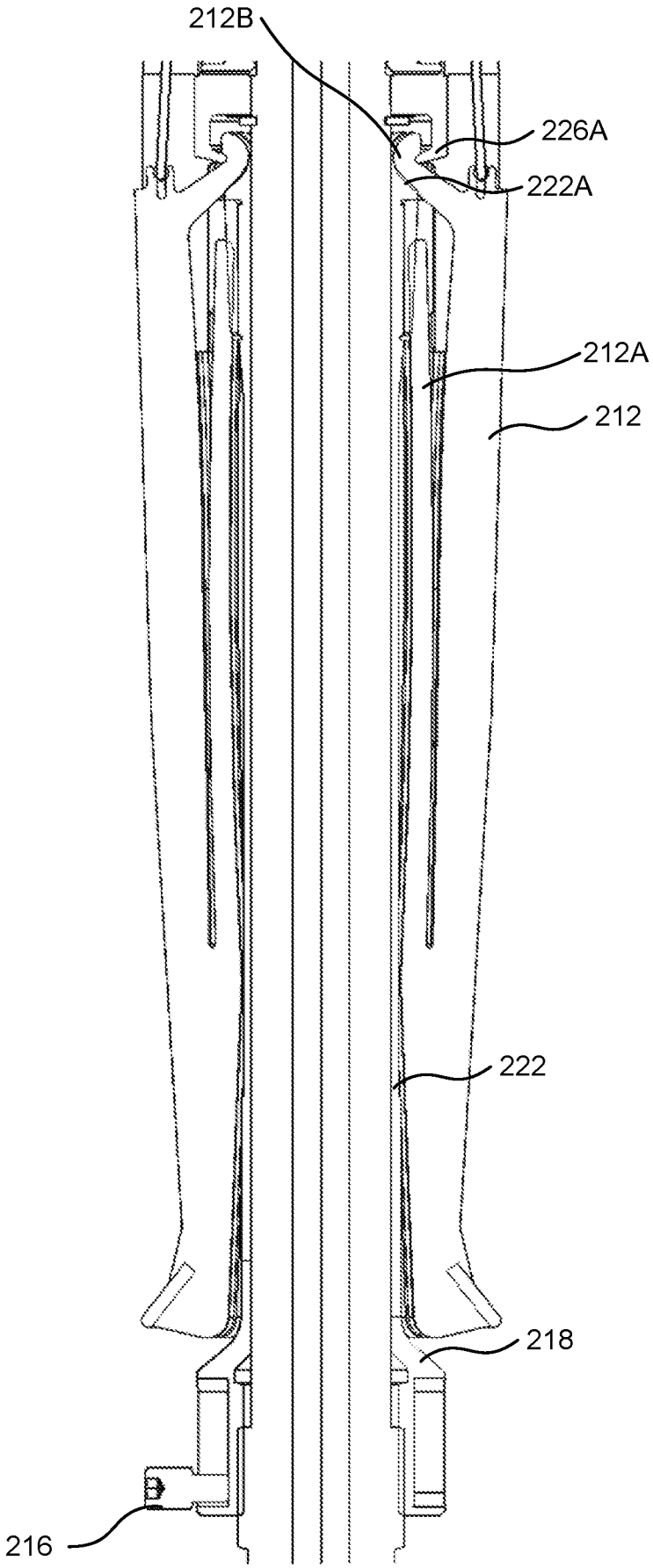
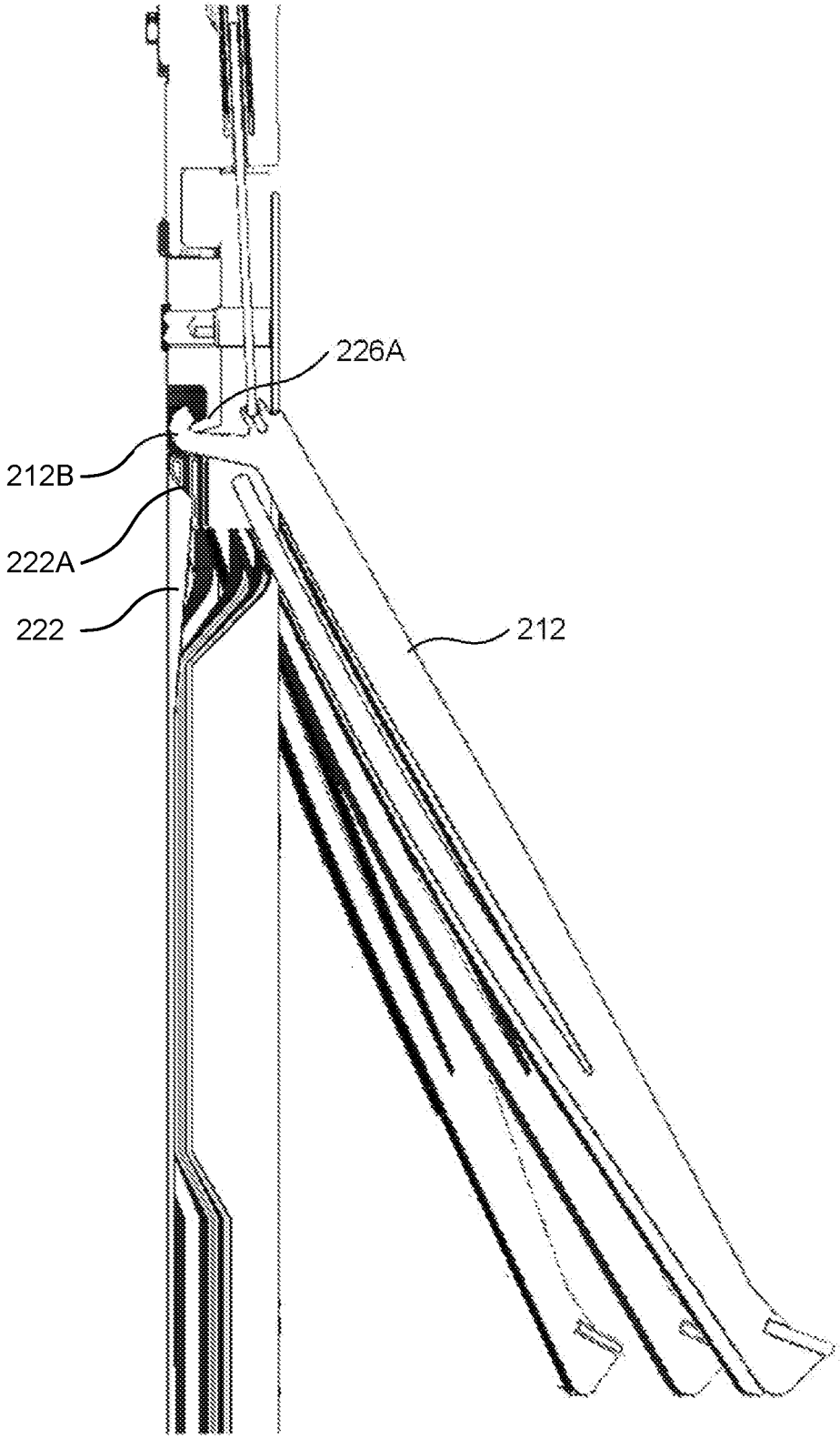


FIG. 11



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US20/17589

A. CLASSIFICATION OF SUBJECT MATTER

IPC - E21B 47/08; G01B 3/24; E21B 17/10 (2020.01)

CPC - E21B 47/08; G01B 3/24; E21B 17/1021

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
See Search History document

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2,680,913 A (JOHNSTON et al.) 10 August 1951; figures 1-4, column 2, lines 25-55, column 3, lines 1-13	1-3
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A		4-9
A	US 2018/0172418 A1 (PROBE HOLDINGS, INC) 21 June 2018; figures 1-11, paragraphs [0030], [0033], [0040]	4-9
A	US 2,853,788 A (KINLEY, J C) 30 September 1958; figures 1-2C, column 4, lines 30-35	4-9

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* *Special categories of cited documents:*
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"T" *later document published after the international filing date or priority* date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 April 2020 (07.04.2020)	24 APR 2020
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US, Commissioner for Patents P.O. Box 1450, Alexandria, Virginia 22313-1450 Facsimile No. 571-273-8300	Authorized officer Shane Thomas Telephone No. PCT Helpdesk: 571-272-4300