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— *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))*

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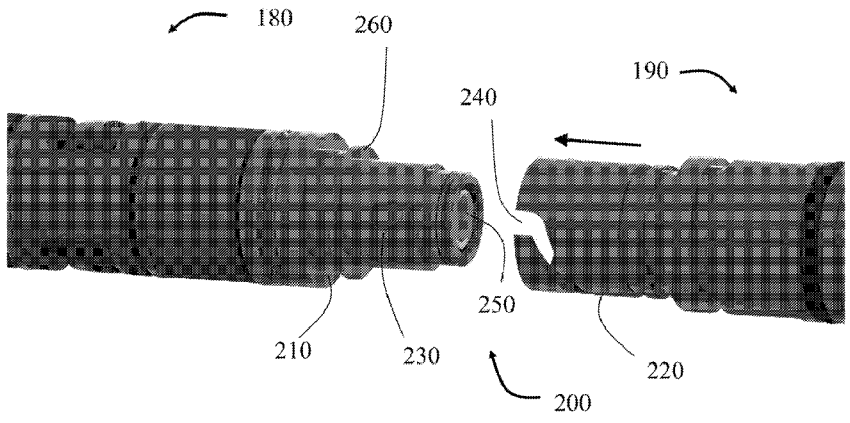

FIG. 2A

(57) Abstract: An apparatus for electrically connecting two downhole components configured to be disposed in a borehole. The apparatus includes two complementing tool connectors which each have a corresponding electrical connector. The tool connectors may mate using a bayonet and slot connection. The slot may be L-shaped or J-shaped. The slot may be configured for straight or rotational engagement of the tool connectors. The electrical connectors may mate using concentric contacts that share the same axis. The electrical connectors are configured to rotate without stressing the contacts during assembly, disassembly, and drilling operations. The electrical connectors may support two or more contacts.

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MATING CONNECTOR FOR DOWNHOLE TOOL

SPECIFICATION

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of Provisional U.S. Patent Application No. 61/988,282, filed May 4, 2014, which is hereby incorporated by reference for all purposes in its entirety.

BACKGROUND OF THE DISCLOSURE

1. Field of the Disclosure

[0002] This disclosure relates to the field of downhole tools associated with rotary drilling in earth formations, especially to reduction of damage to electrical connections during assembly, disassembly, and drilling operations.

2. Description of the Related Art

[0003] Rotary drilling in earth formations is used to form boreholes for obtaining materials in the formations, such as hydrocarbons. Rotary drilling involves a drill bit disposed on a drilling end of a drill string that extends from the surface. The drill string is made up of a series of tubulars that are configured to allow fluid to flow between the surface and earth formation. Above and proximate to the drill bit may be formation and/or borehole measurement tools for measurement-while-drilling. Multiple tools may be grouped together as a bottom hole assembly.

[0004] During rotation of the drill bit, downhole tools in the bottom hole assembly may be subjected to vibrations and mechanical shocks that can damage the measurement tools, communication along the drill string, or connections between downhole tools and other downhole components. Electrical connections of downhole tools often involve pins that may be damaged during drilling operations. Failure of an electrical connection may disable one or more

downhole tools requiring abandonment of the drilling run in order to diagnose and change out or repair the electrical connection.

[0005] Further, some electrical connections may be damaged during assembly or disassembly of the drill string. Tool breakage during set up and shutdown also contribute to cost and time delays for the current or future tool run.

[0006] There is a need for a tool connection that protects the electrical connectors during assembly, disassembly, and drilling operations. There is a need for a tool connector configured to allow assembly and disassembly without tools in the field. There is need for an electrical connection that can endure torsional forces without pin wear or breakage. Further, there is a need for a tool connection that augments the mechanical strength of the bottom hole assembly.

BRIEF SUMMARY OF THE DISCLOSURE

[0007] In aspects, the present disclosure is related downhole tools associated with rotary drilling in earth formations. Specifically, the present disclosure is related to reducing damage and wear due to mechanical shock and vibration.

[0008] One embodiment according to the present disclosure includes an apparatus for transmitting data across a tool joint connection configured to be disposed in a borehole, the apparatus comprising: a first data transmission element connected to a first downhole component having first tool connector with a bayonet plug disposed on an outer surface of the first tool connector; a second data transmission element connected to a second downhole component having a second tool connector with a slot configured to receive the bayonet plug of the first tool connector; wherein the first data transmission element comprises one of a male coaxial connector and a female coaxial connector, and the second data transmission element

comprises the other of the male coaxial connector and the female coaxial connector, and wherein an electrical connection between the female coaxial connector and the male coaxial connector is formed during the formation of the tool joint connection by the mating of the first tool connector and the second tool connector. In some aspects, the slot may be J-shaped. The apparatus may include a compression spring disposed with one of the data transmission elements and configured to maintain an electrical connection between the data transmission elements. In some aspects, the apparatus may include a second compression spring disposed on the other of the data transmission elements and configured to maintain the electrical connection between the data transmission elements. The first tool connector and the second tool connector may be configured to receive one or more cover plates when in a mated position. The electrical connection may include coaxial connectors with three or more concentric contacts. In some aspects, the coaxial connectors may have four or more concentric contacts.

[0009] Another embodiment according to the present disclosure may include a method for forming a joint tool connection configured to be disposed in a borehole, wherein the joint tool connection comprises: a first data transmission element connected to a first downhole component having first tool connector with a bayonet plug disposed on an outer surface of the first tool connector; and a second data transmission element connected to a second downhole component having a second tool connector with a slot configured to receive the bayonet plug of the first tool connector; wherein the first data transmission element comprises one of a male coaxial connector and a female coaxial connector, and the second data transmission element comprises the other of the male coaxial connector and the female coaxial connector, and wherein an electrical connection between the female coaxial connector and the male coaxial connector is formed during the formation of the tool joint connection by the mating of the first tool connector

and the second tool connector; the method comprising: moving the bayonet plug along a path formed by the slot from a first position to a second position while simultaneously moving two electrical connections into a mated position. The method may also include a step of moving the bayonet plug from a second position to a locked position using the first compression spring. And the step of moving the bayonet plug to the second position may include rotating the first tool connector and the second tool connector relative to one another.

[0010] Examples of the more important features of the disclosure have been summarized rather broadly in order that the detailed description thereof that follows may be better understood and in order that the contributions they represent to the art may be appreciated. There are, of course, additional features of the disclosure that will be described hereinafter and which will form the subject of the claims appended hereto.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] A better understanding of the present disclosure can be obtained with the following detailed descriptions of the various disclosed embodiments in the drawings, which are given by way of illustration only, and thus are not limiting the present disclosure, and wherein:

FIG. 1 is a diagram of a drilling system with a bottom hole assembly configured for use in a borehole that includes a connection according to one embodiment of the present disclosure;

FIG. 2A is a 3-D view of a downhole component with a bayonet tool connector and second downhole component with a corresponding slot for mating with the bayonet tool connector according to one embodiment of the present disclosure.

FIG. 2B is a 3-D view of the components from **FIG. 2A** beginning to form a connection;

FIG. 2C is a 3-D view of the components from **FIG. 2A** with the bayonet plug in an intermediate position in the slot;

FIG. 2D is a 3-D view of the components from **FIG. 2A** with the bayonet plug at the end of the slot while the components are fully pressed together;

FIG. 2E is a 3-D view of the components from **FIG. 2A** with the bayonet plug at the end of the slot after release of the pressure on the components;

FIG. 3 is a picture of the electrical connectors for each of the components of **FIG. 2A** according to one embodiment of the present disclosure;

FIG. 4A is a 3-D view of the connection prior to closure of the half-shell according to one embodiment of the present disclosure;

FIG. 4B is a 3-D view of the connection of **FIG. 4A** with one of the half-shells applied;

FIG. 4C is a 3-D view of the connection of **FIG. 4A** with both of the half-shells applied;

FIG. 4D is a cross-sectional view along the length of connection of **FIG. 4C** according to one embodiment of the present disclosure;

FIG. 5 is a flow chart of a method of forming an electrical connection between two downhole tools according to one embodiment of the present disclosure.

DETAILED DESCRIPTION OF THE DISCLOSURE

[0012] In aspects, the present disclosure is related to downhole drilling operations. Specifically, the present disclosure is related to maintaining and protecting electrical continuity between downhole components during assembly and drilling operations. The present invention is susceptible to embodiments of different forms. There are shown in the drawings, and herein will be described in detail, specific embodiments with the understanding that the present

invention is to be considered an exemplification of the principles and is not intended to limit the present invention to that illustrated and described herein.

[0013] **FIG. 1** shows a diagram of a drilling system **100** that includes a drilling rig **110** disposed on a surface **120** and above a borehole **130** in an earth formation **140**. Disposed in the borehole **130** is drill string **150** with a drill bit **160** at the bottom of the borehole **130**. Above the drill bit **160** is a bottom hole assembly **170** that includes downhole components **180**, **190**. The downhole components **180**, **190** may be configured for measurement, communication, and other operations during drilling. The downhole components **180**, **190** are configured for an electrical connection to be made between the downhole components. The electrical connection may be suitable to communicate data, power, or both.

[0014] **FIGs. 2A-2E** show 3-D views of a connection **200** of the first downhole component **180** and the second downhole component **190**. **FIG. 2A** shows the first component **180** with a first tool connector **210** disposed on one end, and the second component **190** with a second tool connector **220** disposed on one end. The first tool connector **210** includes a generally cylindrical outer surface with a bayonet plug **230** on its outer surface and a stop ring **260** with a larger diameter than the adjacent portions of the outer surface. The stop ring **260** is a raised portion of the first tool connector **210**. The second tool connector **220** is also generally cylindrical and includes a slot **240** configured to mate with the bayonet plug **230**. The second tool connector **220** has an interior diameter that is larger than the exterior diameter of the end of the first tool connector **210** but smaller than the exterior diameter of the stop ring **260**. The first tool connector **210** and the second tool connector **220** are configured to house a female electrical connector **250** and a male electrical connector **255** (**FIG. 3**). While shown with the female electrical connector **250** disposed on the first tool connector **210** and the male electrical

connector **255** disposed on the second tool connector **220**, it is contemplated that the connectors **250**, **255** may be switched.

[0015] **FIG. 2B** shows the connection **200** being formed. The end of the second connector **210** is configured to slidingly engage the end of the first connector **220** when the bayonet plug **230** is aligned with the slot **240**. The slot **240** may be L-shaped or J-shaped. When using a J-shaped slot, the slot **240** may define a first position where the bayonet plug **230** enters the slot **240** and a second position where the bayonet plug **230** must change its path to move further down the length of the slot **240** (usually the maximum position that may be achieved through rotation). The slot **240** will also have a locked position, beyond the second position, which, when reached, prevents rotation of the tool connectors **210**, **220**. The final movement from the second position to the locked position in the slot **240** may be performed through the action of the biasing element **470 (FIG. 4D)**. As shown, the slot **240** defines a path that requires the connectors **210**, **220** to rotate 90 degrees relative to one another during engagement; however, this is exemplary and illustrative only. The defined path may require any degree of rotation during the engagement, including 0 degrees (straight path), 360 degrees, and variations in between as would be understood by a person of ordinary skill in the art. With the bayonet plug **230** and its corresponding slot **240** provided, the two connectors **210**, **220** may be engaged in the field without tools.

[0016] **FIG. 2C** shows the connection **200** proceeding, and the bayonet plug **230** in an intermediate position within the slot **240**. In order for the connection formation to continue, one or both of the tool connectors **210**, **220** must rotate relative to the other while moving closer together, as guided by the slot **240**.

[0017] **FIG. 2D** shows the bayonet plug **230** at the end of intermediate section of the slot **240**. If the slot were L-shaped, this would be the final position of the bayonet plug **230**; however, since a J-shaped slot is shown, the slot **240** is configured to allow the tool connectors **210**, **220** to "lock" in position by moving outward.

[0018] **FIG. 2E** shows the connection **200** after the tool connectors **210**, **220** have moved outward until the bayonet plug **230** is restrained by the longitudinal limit of the slot **240**. In some embodiments, the bayonet plug **230** may be maintained in this position by compression force from a biasing element, such as, but not limited to, spring **470** (**FIG. 4D**). The tool connectors **210**, **220** can be disengaged by overcoming the compression force and then rotating to move the bayonet plug **230** out of the slot **240** along the path defined by the slot **240**. Typically, the tools **180**, **190** will be enclosed in a tubular component that will provide some degree of protection against disconnection due to mechanical shock and vibration; however, the use of the bayonet plug **230** and the slot **240** may provide additional resistance against disconnection when the bottom hole assembly **170** is subjected to mechanical forces that could potentially sever or separate the electrical connectors **250**, **255**. The material structure and composition of the tool connectors **210**, **220** may be selected to ensure a robust tool connection for the borehole environment.

[0019] **FIG. 3** shows a view of the electrical connectors **250**, **255** facing their contacts. The electrical connectors **250**, **255** are configured to rotate relative to one another without stressing the electrical connections. During assembly and operations, torsional forces may rotate electrical connector pairs relative to one another resulting in stressed, damaged, or broken pins; however, electrical connectors **250**, **255** may rotate relative to each other while maintaining an electrical connection. Electrical connectors **250**, **255** may be coaxial connectors. The female electrical

connector **250** may include a plurality of concentric contacts **310**. Correspondingly, the male electrical connector **255** may include a plurality of concentric contacts **320** configured to mate with the contacts **310**. The connectors **250**, **255** may be configured to operate in a borehole environment, including a temperature range of about -55 degrees C to about 225 degrees C. In other aspects, the connectors **250**, **255** may be configured to operate in a temperature range of about -50 degrees C to about 205 degrees C. In still other aspects, the connectors **250**, **255** may be configured to operating in a temperature range of about 0 degrees C to about 175 degrees C. The connectors **250**, **255** may have two or more concentric contacts. In some embodiments, the connectors **250**, **255** may have three or more concentric contacts. Further, in some embodiments, the connectors **250**, **255** may have four or more concentric contacts.

[0020] **FIG. 4A** shows a 3-D view of the connection **200** separate from the downhole components **180**, **190**. Each of the tool connectors **210**, **220** has a circular recessed area **410**, **420** configured to receive an O-ring, which is designed to protect the interior of the connection **220** from contamination by borehole fluids and debris. The tool connectors **210**, **220** also include circular recessed areas **430**, **440** configured to receive cover shells **450** (**FIG. 4B**).

[0021] **FIG. 4B** shows a 3-D view of the connection **200** with one of the cover shells **450** in place. The cover shell **450** may be a half-shell.

[0022] **FIG. 4C** shows a 3-D view of the connection **200** with both of the cover shells **450** in place. Once the cover shells **450** are attached, the mated tool components **180**, **190** may be sleeved in a tubular housing (not shown). Contact between the interior of the tubular and the O-rings in the recessed areas **410**, **420** will form a protective seal between the connection **200** and the fluids and debris of the borehole **130**.

[0023] **FIG. 4D** shows a cross-sectional view along the length of the connection **200**. A spring adapter **460** may be disposed between the female electrical connector **250** and the spring **470**. While a spring **470** is shown, other suitable biasing elements may be contemplated, including, but not limited to an elastomeric element with a hollow allowing passage of wires through its interior. Another adapter **465** may be disposed between the male electrical connector **255** and a spacer **480**. The spacer **480** may be configured to maintain the position of the male electrical connector **255** in the second connector **220**, especially when force is applied by the spring **470**. Thus, the spacer **480** may preload spring **470** during the connection **200**. The spacer **480** may include a shaft **485** configured to allow passage of wires from the male electrical connector **255** to an exit port **490** in the second tool connector **210**. Similarly, an exit port in the first tool connector **495** may aligned so that wires may pass from the female electrical connector **250** through the spring adapter **460** and the center of the spring **470**.

[0024] In some embodiments, a second spring (not shown) may be used in place of spacer **480**. As would be understood by a person of ordinary skill in the art with the benefit of the present disclosure, the spring **470**/spring adapter **460** and the spacer **480** may be reversed such that the spring **470**/spring adapter **460** are disposed in the first connector **210**. Thus, all 8 combinations of the complementing components are contemplated so that the male/female electrical connectors **250**, **255**, the bayonet plug **230**/slot **240**, and the spring **470**/spacer **480** combinations may be implemented in any variety as long as the component complementary relationships are maintained.

[0025] **FIG. 5** shows a method **500** of forming the joint tool connection **200**. In step **510**, the first downhole tool connector **210** is aligned with the second downhole tool connector **220** such that the bayonet plug **230** is in the same clock position as an opening of the slot **240**. In step **520**,

the tool connectors **210**, **220** are moved relative to one another so that the bayonet plug is moved along the path of the slot to a second position. In step **530**, which may take place during step **520**, the electrical connectors **250**, **255** move closer until they form an electrical connection. In step **540**, the compression spring **470** moves the bayonet plug **230** form the second position of the slot to its locked position. In embodiments where the slot does not have a second position, the tool connection **200** may be formed without step **540**. Steps **510-540** may be reversed to safely severe the connection **200**.

[0026] While embodiments in the present disclosure have been described in some detail, according to the preferred embodiments illustrated above, it is not meant to be limiting to modifications such as would be obvious to those skilled in the art.

[0027] The foregoing disclosure and description of the disclosure are illustrative and explanatory thereof, and various changes in the details of the illustrated apparatus and system, and the construction and the method of operation may be made without departing from the spirit of the disclosure.

CLAIMS

What is claimed is

1. An apparatus for transmitting data across a tool joint connection configured to be disposed in a borehole, the apparatus comprising:

a first data transmission element connected to a first downhole component having first tool connector with a bayonet plug disposed on an outer surface of the first tool connector;

a second data transmission element connected to a second downhole component having a second tool connector with a slot configured to receive the bayonet plug of the first tool connector;

wherein the first data transmission element comprises one of a male coaxial connector and a female coaxial connector, and the second data transmission element comprises the other of the male coaxial connector and the female coaxial connector, and wherein an electrical connection between the female coaxial connector and the male coaxial connector is formed during the formation of the tool joint connection by the mating of the first tool connector and the second tool connector.

2. The apparatus of claim 1, wherein the slot is J-shaped.

3. The apparatus of claim 1, wherein the slot is L-shaped.

4. The apparatus of claim 1, further comprising

a compression spring disposed with one of the data transmission elements and configured to maintain an electrical connection between the data transmission elements.

5. The apparatus of claim 4, further comprising:

a second compression spring disposed on the other of the data transmission elements and configured to maintain the electrical connection between the data transmission elements.

6. The apparatus of claim 1, wherein the first tool connector and the second tool connector are configured to receive one or more cover plates when in a mated position.

7. The apparatus of claim 1, wherein the coaxial connectors comprise three or more concentric contacts.

8. The apparatus of claim 7, wherein the coaxial connectors comprise four or more concentric contacts.

9. A method for forming a joint tool connection configured to be disposed in a borehole, wherein the joint tool connection comprises:

a first data transmission element connected to a first downhole component having first tool connector with a bayonet plug disposed on an outer surface of the first tool connector; and

a second data transmission element connected to a second downhole component having a second tool connector with a slot configured to receive the bayonet plug of the first tool connector;

wherein the first data transmission element comprises one of a male coaxial connector and a female coaxial connector, and the second data transmission element comprises the other of the male coaxial connector and the female coaxial connector, and wherein an electrical connection between the female coaxial connector and the male coaxial connector is formed during the formation of the

tool joint connection by the mating of the first tool connector and the second tool connector;

the method comprising:

moving the bayonet plug along a path formed by the slot from a first position to a second position while simultaneously moving two electrical connections into a mated position.

10. The method of claim 9, further comprising:

moving the bayonet plug from a second position to a locked position using the first compression spring.

11. The method of claim 9, wherein the step of moving the bayonet plug to the second position comprises rotating the first tool connector and the second tool connector relative to one another.

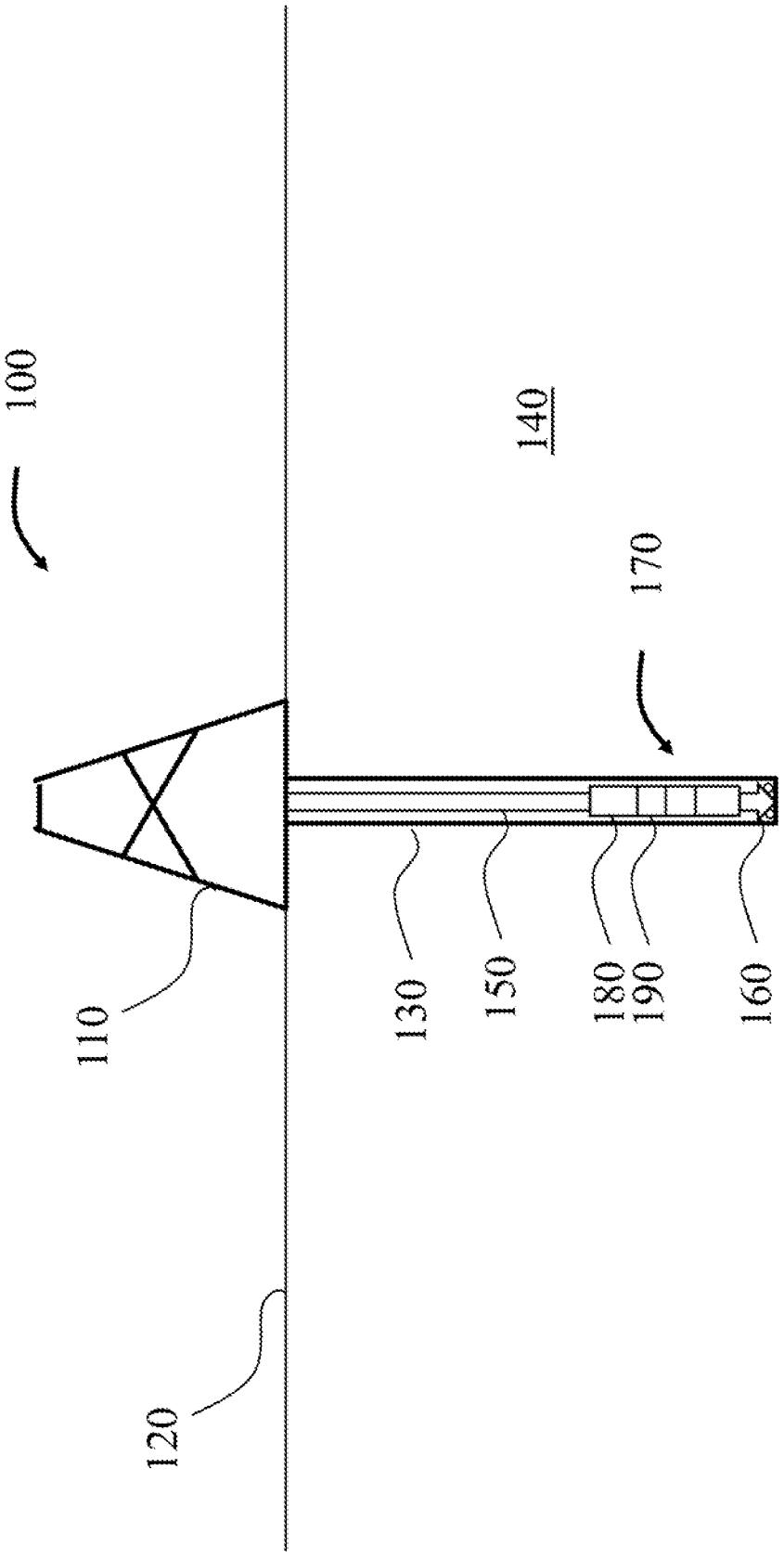


FIG. 1

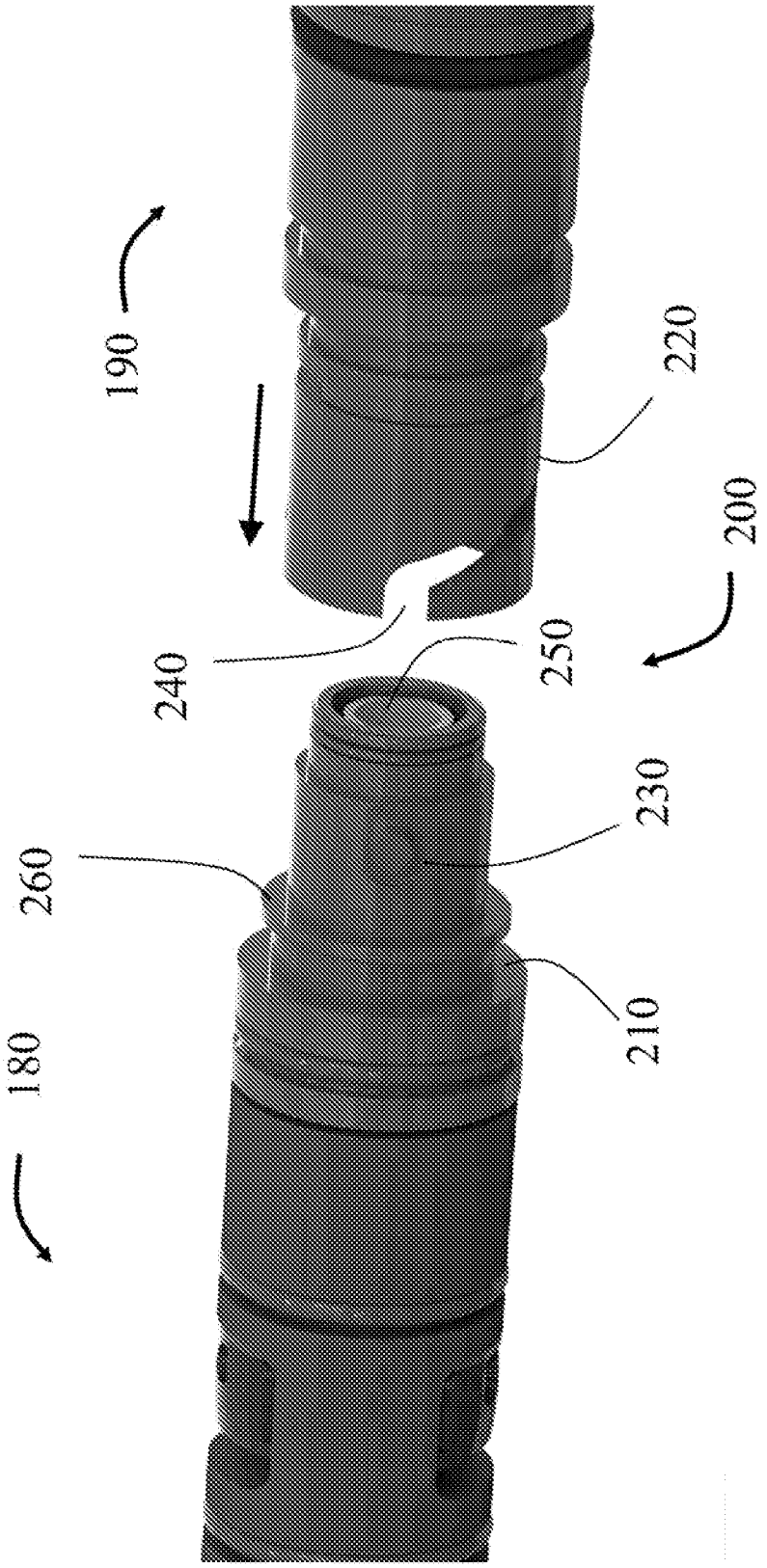


FIG. 2A

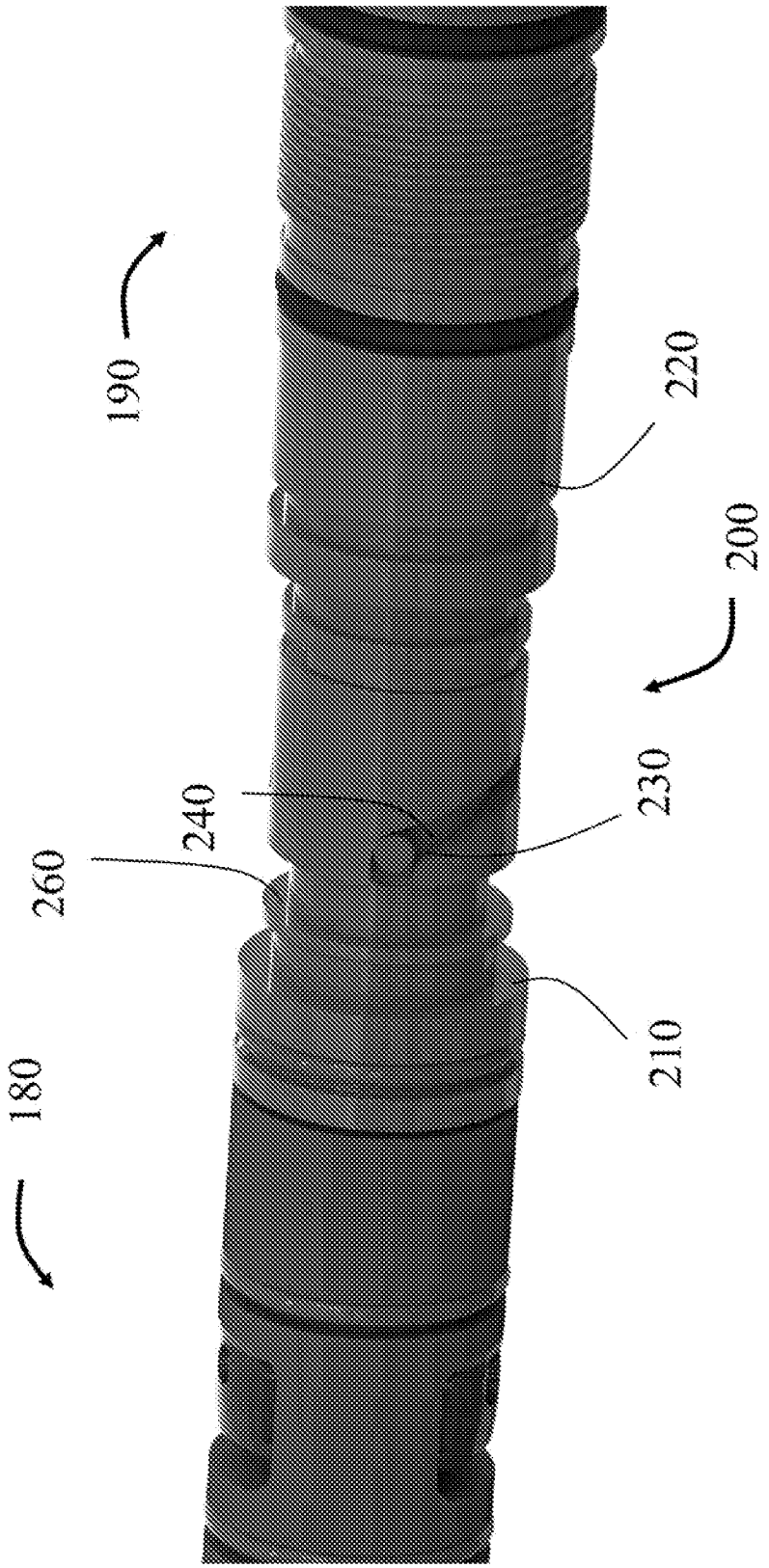


FIG. 2B

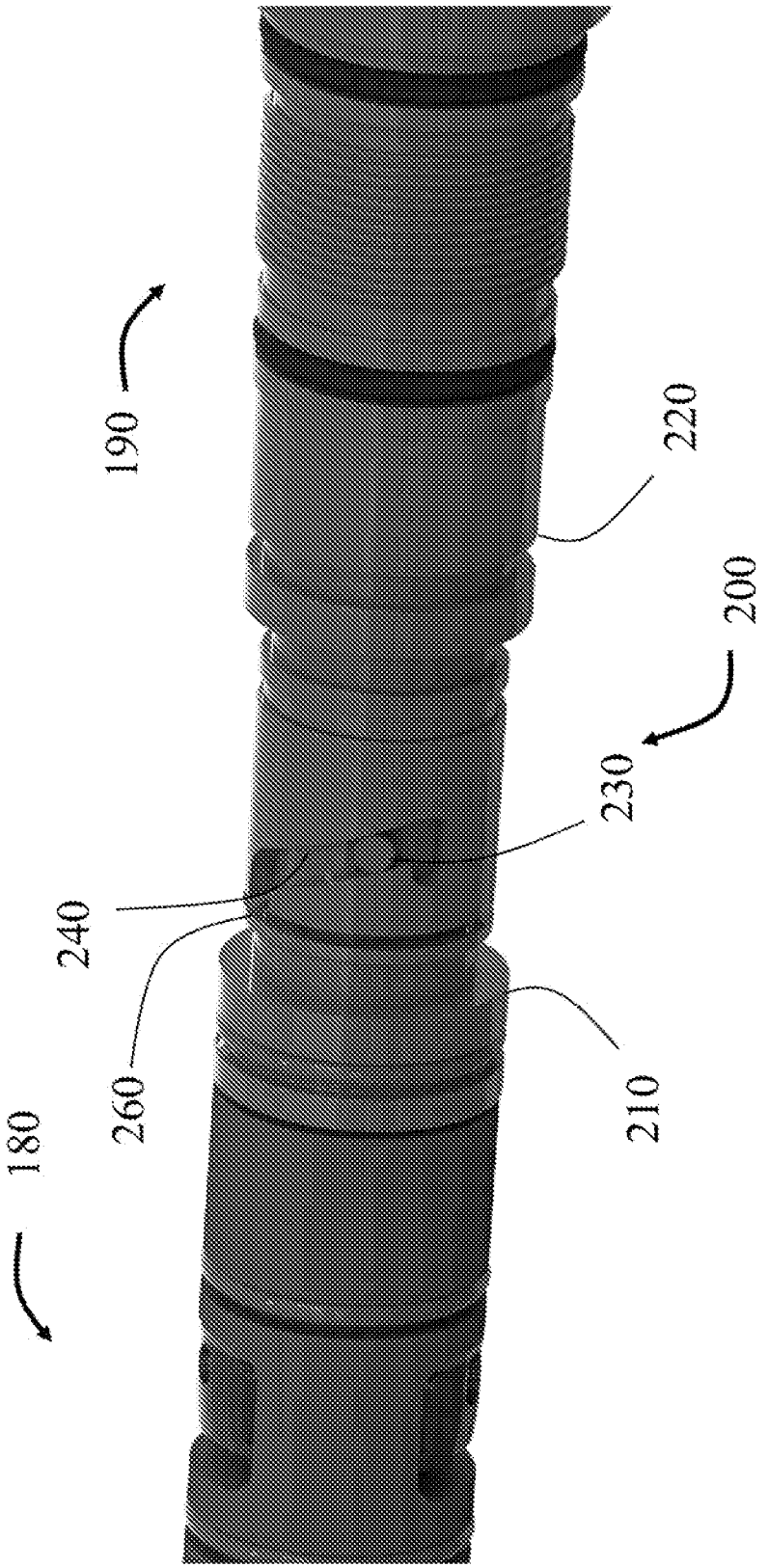


FIG. 2C

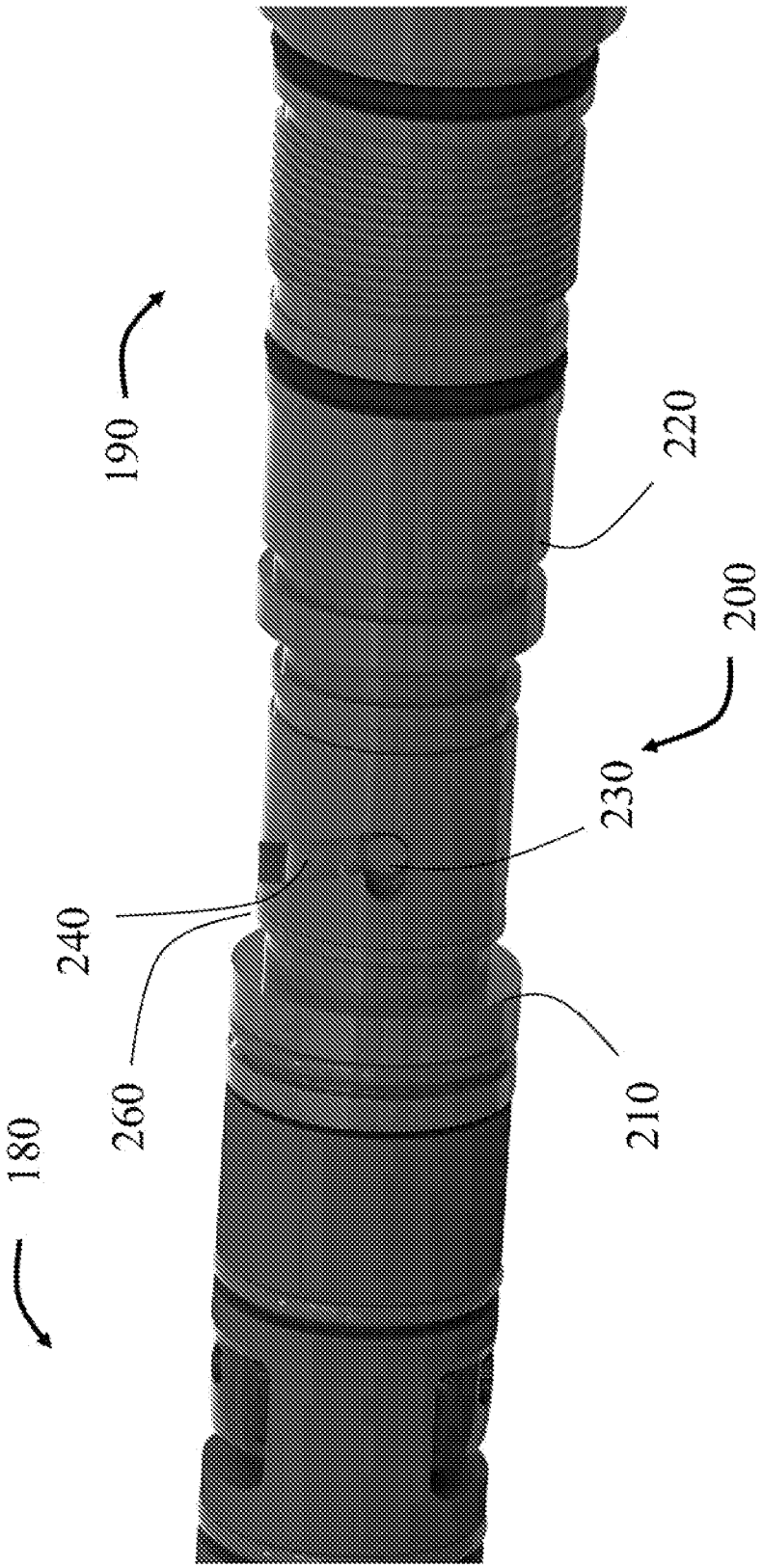


FIG. 2D

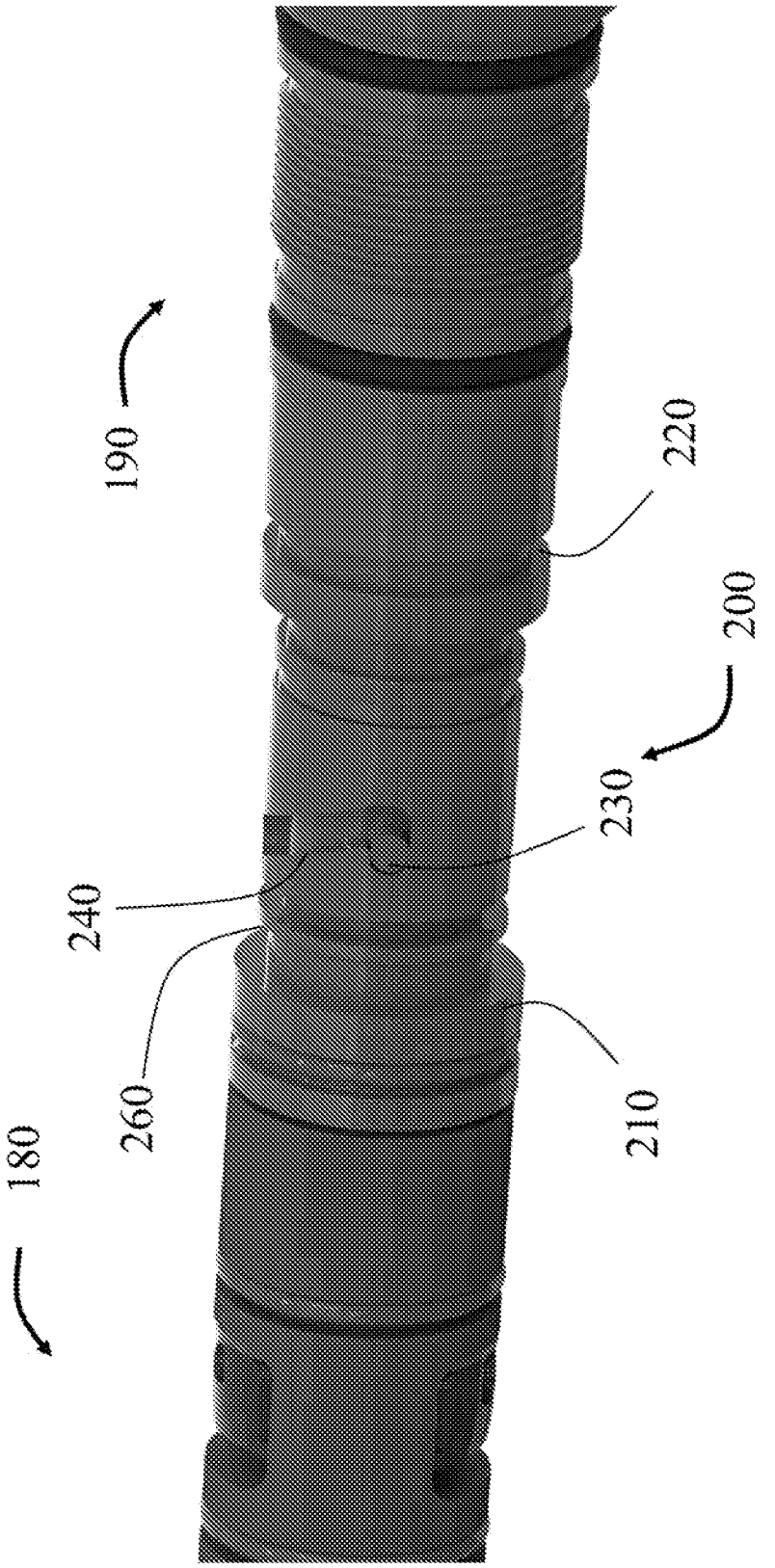
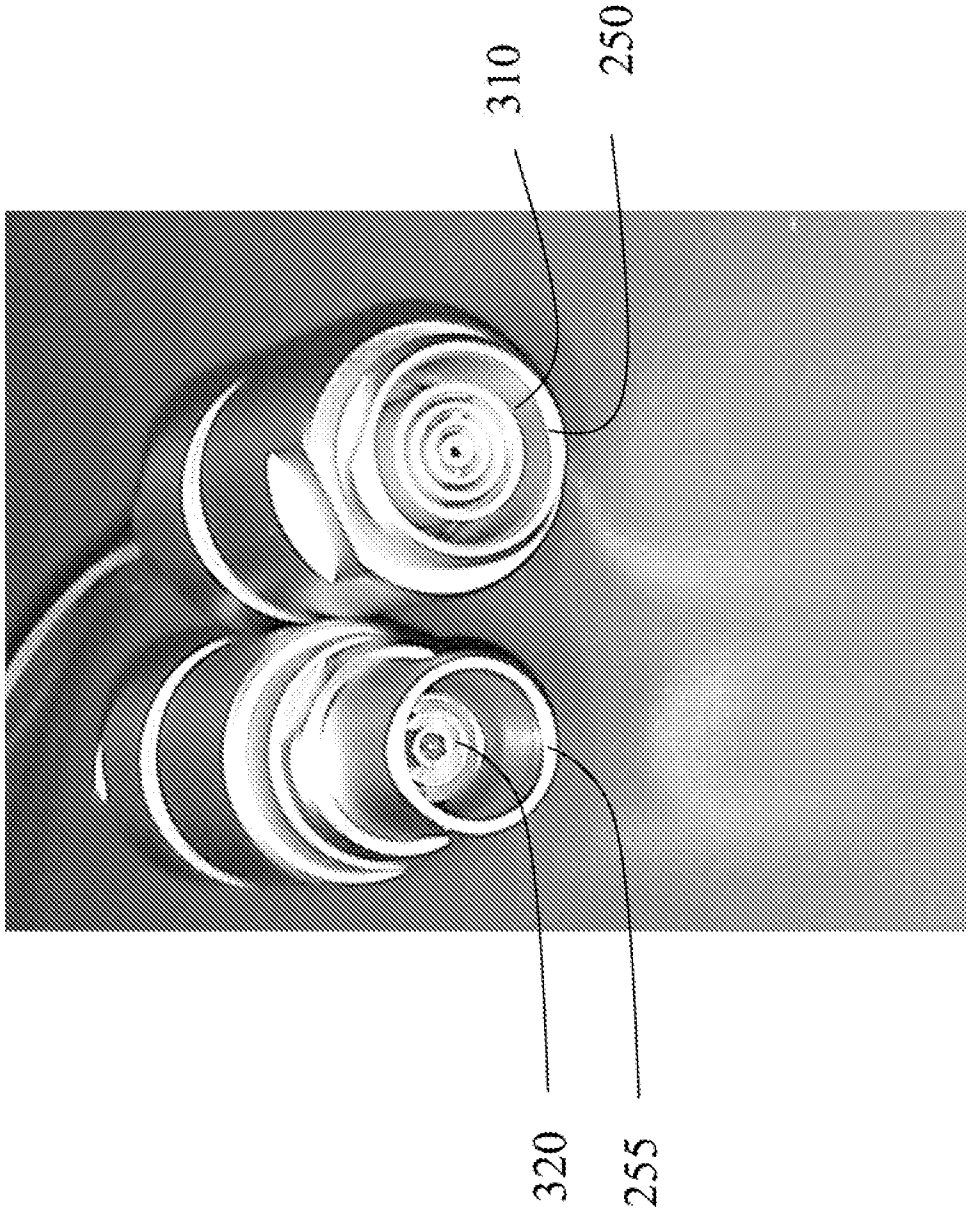


FIG. 2E

FIG. 3



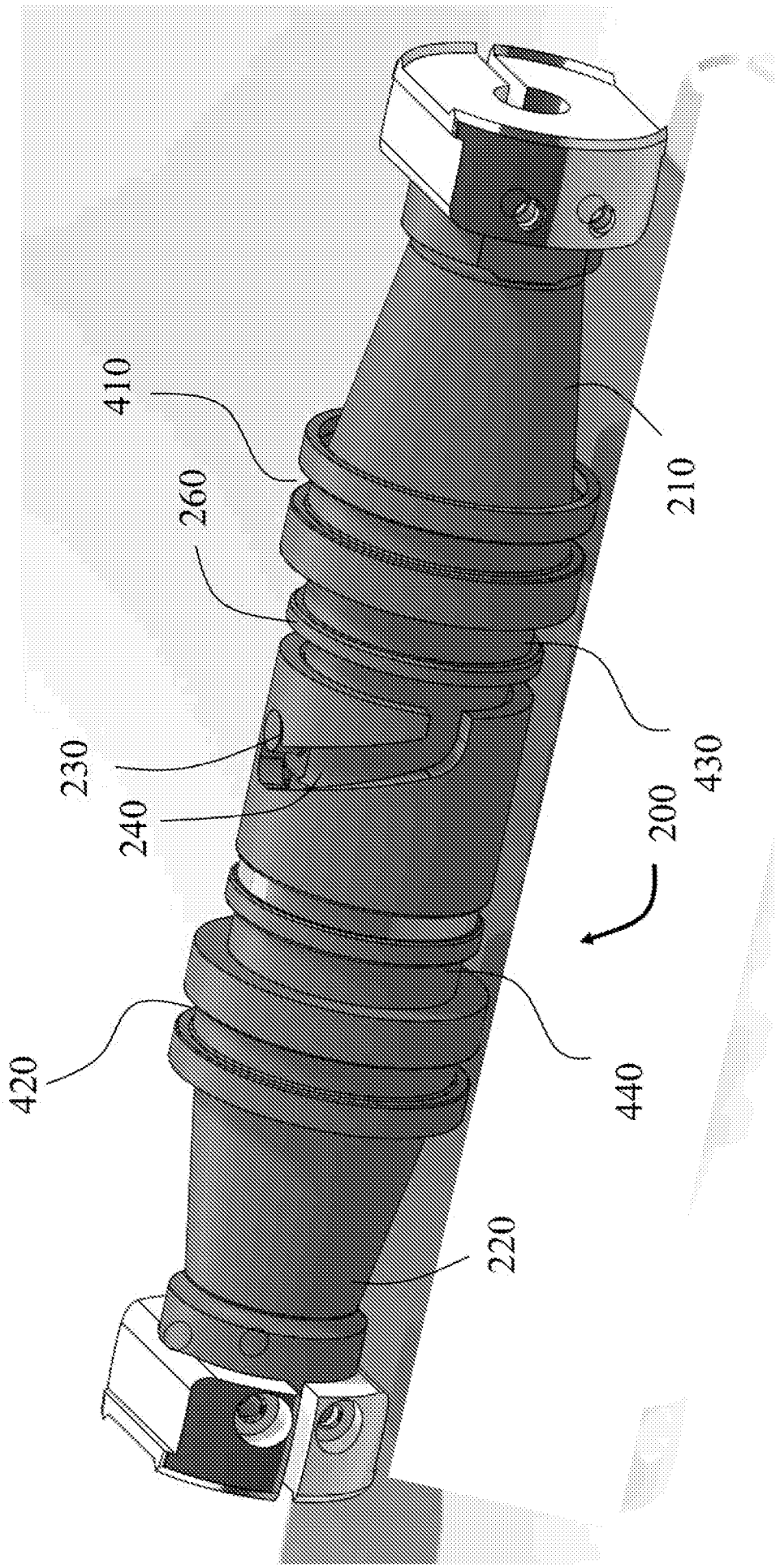


FIG. 4A

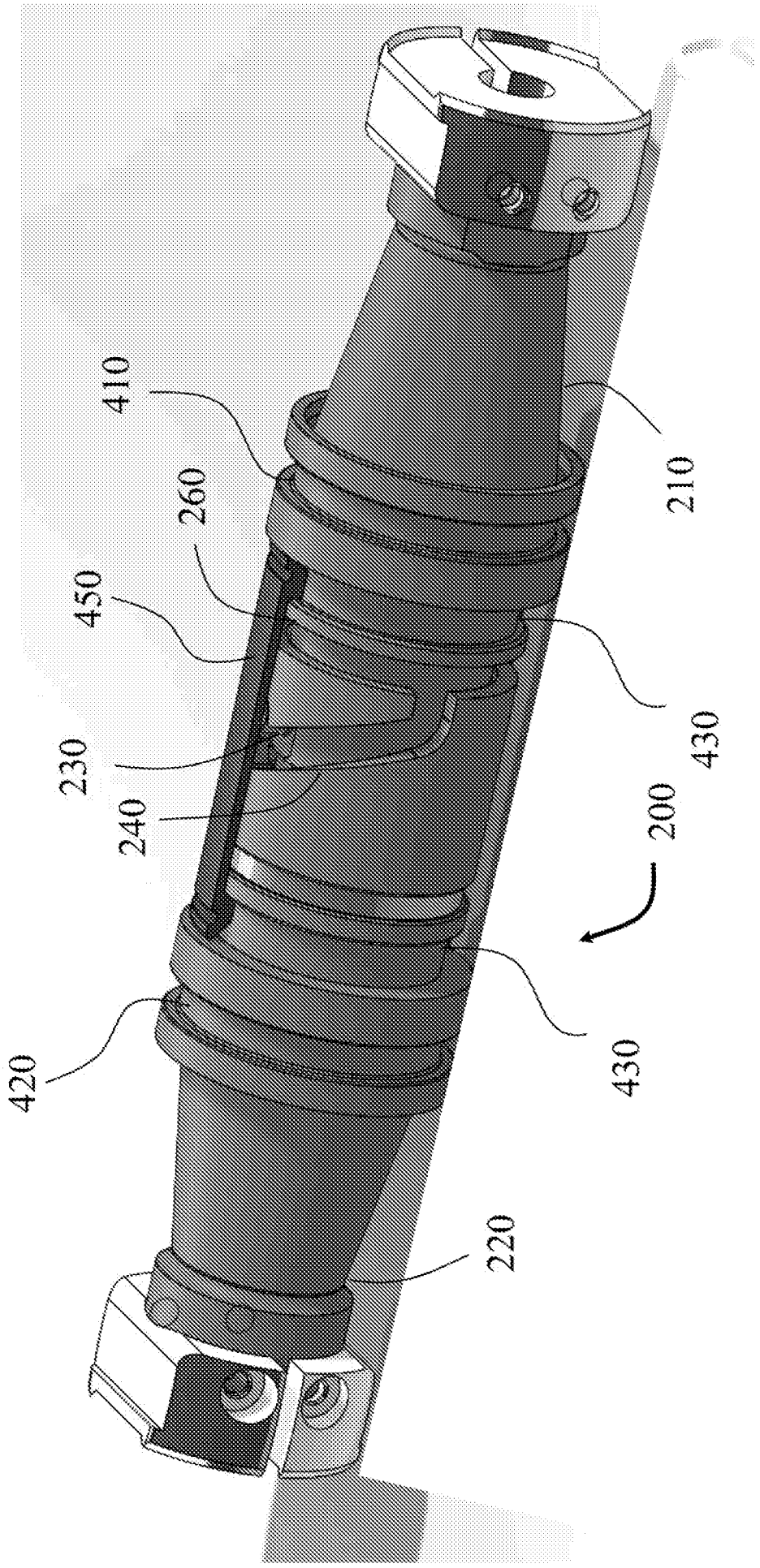


FIG. 4B

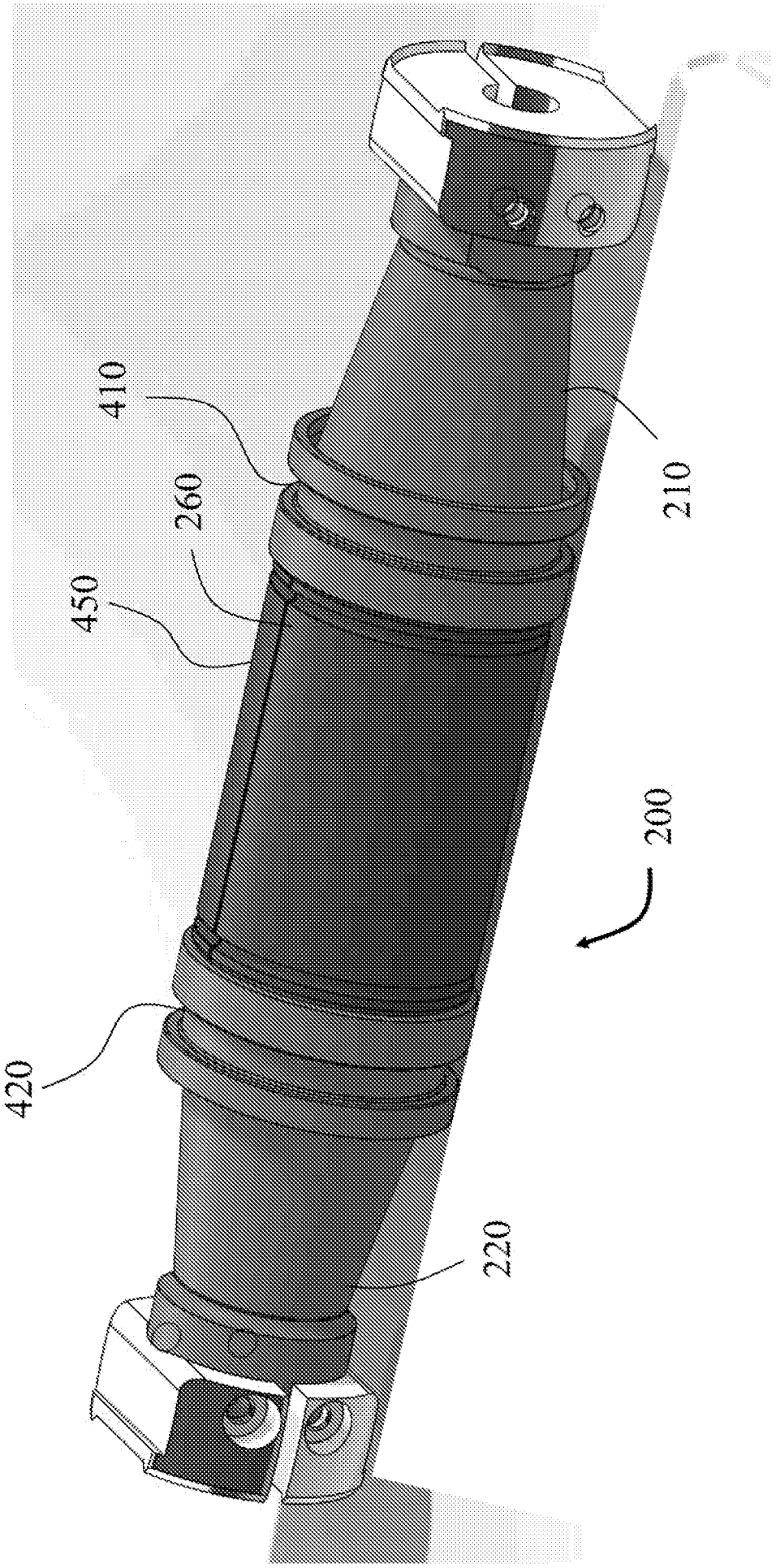


FIG. 4C

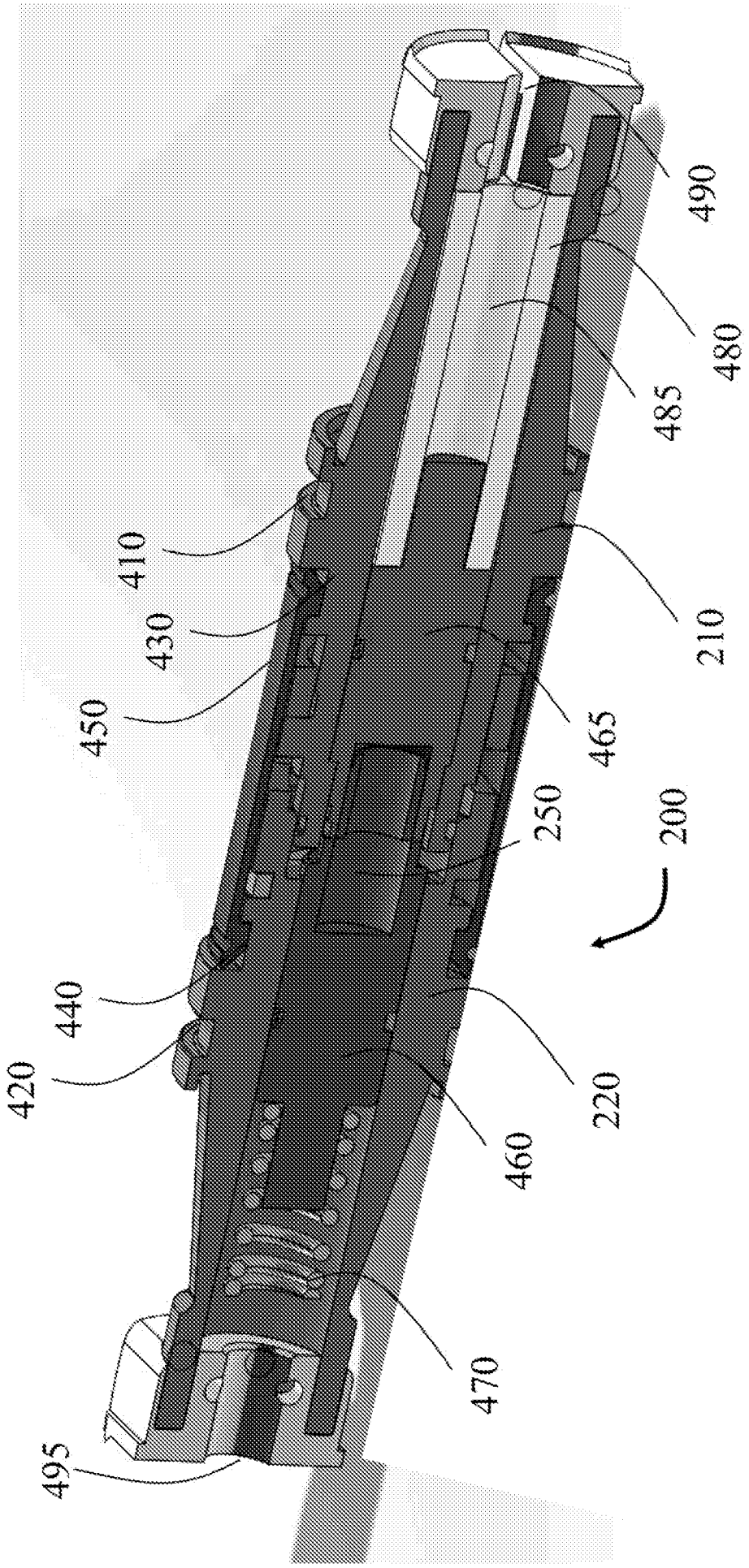


FIG. 4D

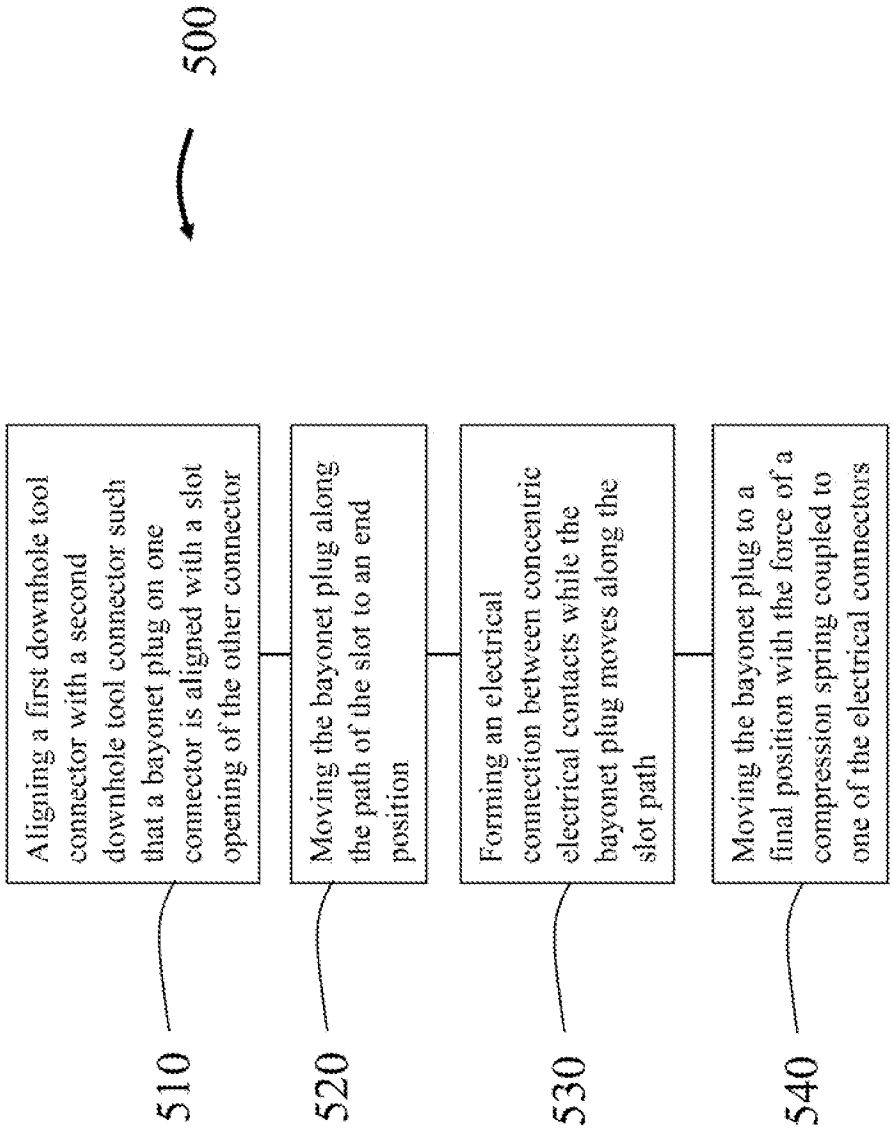

500
Aligning a first downhole tool connector with a second downhole tool connector such that a bayonet plug on one connector is aligned with a slot opening of the other connector
510
Moving the bayonet plug along the path of the slot to an end position
520
Forming an electrical connection between concentric electrical contacts while the bayonet plug moves along the slot path
530
Moving the bayonet plug to a final position with the force of a compression spring coupled to one of the electrical connectors
540

FIG. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US15/28294

A. CLASSIFICATION OF SUBJECT MATTER
IPC(8) - E21B 33/038 (2015.01)
CPC - E21B 33/0385
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)
IPC(8) Classification(s): H02G 1/14; E21B 33/038; E21B 23/00 (2015.01)
CPC Classification(s): H01R 13/523, 13/64; E21B 17/028, 33/0385; USPC Classification(s): 166/65.1, 378

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
PatSeer (US, EP, WO, JP, DE, GB, CN, FR, KR, ES, AU, IN, CA, INPADOC Data); Google; Google Scholar; ProQuest; IP.com; keywords: relay, transmit, conduct, data, signal, electricity, well, bore, downhole, sub sea, under water, slot, j-shape, l-shape, spring, bias, concentric, contact, channel, groove, cam, coaxial

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	WO 92/20948 A1 (DEN NORSKE STATS OLJESELSKAP AS) 26 November 1992 (26.11.92); page 4, lines 10-15; page 8, lines 5-15; page 9, lines 25-27; page 9, line 30-page 10, line 10; page 11, lines 15-30; figures 2, 3, 5, 7	1-5, 9-11 --- 6- 8
Y	US 4,085,993 A (CAIRNS JL) April 25, 1978; figure 1; column 2, lines 15-25, 60-68	6
Y	US 5,906,511 A (BOZZER D et al.) May 25, 1999; figure 2; column 1, lines 30-35	7, 8
A	US 2014/0112699 A1 (ILLINOIS TOOL WORKS INC.) April 24, 2014; entire document	1-11
A	US 2013/0025419 A1 (OPSTAD K) January 31, 2013; entire document	1-11
A	US 6,644,410 B1 (LINDSEY-CURRAN CJ et al.) November 11, 2003; entire document	1-11

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

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"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
18 July 2015 (18.07.2015)	05 AUG 2015
Name and mailing address of the ISA/ 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 PCT Helpdesk: 571-272-4300 PCT OSP: 571-272-7774

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