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[Continued on next page]

- (54) Title:** COILED TUBING CONNECTOR FOR DOWNHOLE TOOLS

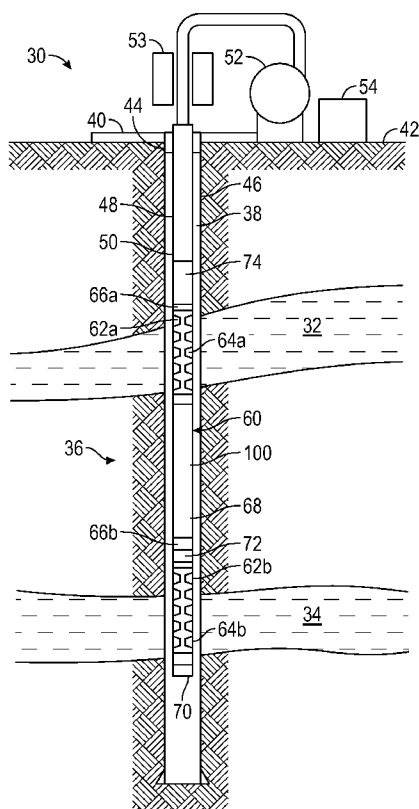


FIG. 1

- (57) Abstract:** A quick connection for coiled tubing run tools eases the assembly and disassembly while deploying such tools. The quick connection utilizes a locking collet and an inner mandrel with locking sleeve system. Such a quick connection does not require perfect alignment between mating pieces.





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- 1 -

TITLE: **COILED TUBING CONNECTOR FOR DOWNHOLE TOOLS**

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TECHNICAL FIELD

[0001] The present disclosure relates to devices and methods for connecting downhole tools.

BACKGROUND

[0002] One of the activities associated with the completion of an oil or gas well is the perforation of a well casing. During this procedure, perforations, such as passages or holes, are formed in the casing of the well to enable fluid communication between the wellbore and the hydrocarbon producing formation that is intersected by the well. These perforations are usually made with a perforating gun loaded with shaped charges. The gun is lowered into the wellbore on coiled tubing until it is at a desired target depth; *e.g.*, adjacent to a hydrocarbon producing formation.

[0003] One drawback with running tooling on coiled tubing involves correct alignment between threads on the two mating parts. This requires the two parts to be manually handled when hanging in the vertical position. This process becomes difficult to position the two mating pieces due to the weight of the gun assembly and environmental conditions (*e.g.*, high winds). Other issues include cross threading, and damaging the straight threads between the mating parts. This damage can occur due to misalignment of the threads.

[0004] The present disclosure addresses these and other drawbacks of the prior art.

SUMMARY

[0005] In aspects, the present disclosure provides a quick connection for coiled tubing run tools. These connections ease the assembly and disassembly while

- 2 -

deploying such tools. In embodiments, the connection utilizes a locking collet and an inner mandrel with locking sleeve system. Such a connection does not require perfect alignment between mating pieces.

[0006] It should be understood that examples of certain 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 to the art may be appreciated. There are, of course, additional features of the disclosure that will be described hereinafter and which will in some cases form the subject of the claims appended thereto.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] For detailed understanding of the present disclosure, references should be made to the following detailed description of the preferred embodiment, taken in conjunction with the accompanying drawings, in which like elements have been given like numerals and wherein:

[0008] **Fig. 1** schematically illustrates an elevation view of a surface facility adapted to perform one or more pre-defined tasks in a wellbore using one or more downhole tools;

[0009] **Fig. 2** illustrates a side sectional view of a quick connect and a time delay module according to one embodiment of the present disclosure; and

[0010] **Fig. 3** illustrates a side sectional view of the **FIG. 2** quick connect and time delay module in a locked state.

DETAILED DESCRIPTION

[0011] In one aspect, the present disclosure relates to devices and methods for providing a quick connect housing that is structurally and functionally integrated into a time delay module. The present disclosure is susceptible to embodiments of different forms. For example, the quick connect housing can be adapted to other downhole tools such as packers, tubing cutters, wellbore patches, and other wellbore completion tools. There are shown in the drawings, and herein will be described in

- 3 -

detail, specific embodiments of the present disclosure with the understanding that the present disclosure is to be considered an exemplification of the principles of the disclosure, and is not intended to limit the disclosure to that illustrated and described herein.

[0012] Referring initially to **Fig. 1**, there is shown a well construction and/or hydrocarbon production facility **30** positioned over subterranean formations of interest **32, 34** separated by a gap section **36**. The teachings of the present disclosure, however, may be applied to any type of subsurface formation. The facility **30** can be a land-based or offshore rig adapted to drill, complete, or service a wellbore **38**. The facility **30** can include known equipment and structures such as a platform **40** at the earth's surface **42**, a wellhead **44**, and casing **46**. A work string **48** suspended within the wellbore **38** is used to convey tooling into and out of the wellbore **38**. The work string **48** can include coiled tubing **50** injected by a coiled tubing injector **52** and a lubricator **53**. Other work strings **48** can include tubing, drill pipe, wire line, slick line, or any other known conveyance means. A surface control unit (e.g., a power source and/or firing panel) **54** can be used to monitor and/or operate tooling connected to the work string **48**.

[0013] In one embodiment of the present disclosure, a perforating gun train **60** is coupled to an end of the work string **48**. An exemplary gun train **60** includes a plurality of guns or gun sets **62a-b**, each of which includes perforating shaped charges **64a-b**, and detonators or firing heads **66a-b**. It should be understood that the perforating gun train **60** can include three or more guns. Also, while a 'top-down' firing sequence is described, it should be understood that a 'bottom-up' sequence may also be utilized. That is, instead of the top most gun being fired first with the lower guns sequentially firing, the bottom most gun may be fired with the upper guns sequentially firing.

[0014] In some situations, it may be desirable to perforate one formation by firing a first gun and then move the gun train to another formation. An arrangement for accommodating such movement involves initiating the firing of a first gun and using the firing of the first gun to initiate the firing of a second gun. To provide the time

- 4 -

necessary to move the guns between two formations, a time delay module **100** may be inserted between two guns.

[0015] Referring now to **Fig. 2**, there is shown further details of a time delay module **100** configured to provide a predetermined amount of time delay for moving a gun train **60** (**Fig. 1**) between two formations. Advantageously, the time delay module **100** may include features that enable a quick connection between the perforating guns **62a** and **62b** (**Fig. 1**). In one non-limiting embodiment described below, the time delay module **100** includes a quick connect housing **110** and a time delay assembly **200**.

[0016] The quick connect housing **110** may use a translating action to interconnect the guns **62 a,b** (**Fig. 1**). In one arrangement, the housing **110** may include an upper section **112** and a lower section **114**. The upper section **112** has a gun end **116** that connects with a first perforating gun such as gun **62a** (**Fig. 1**) and a connector end **118**. The lower section **114** has a gun end **120** that connects with a second perforating gun such as gun **62b** (**Fig. 1**) and a connector end **122**. A connection is formed by mating the connector ends **118**, **122** of the sections **112**, **114**, respectively.

[0017] In one embodiment, the upper section **112** includes a cylindrical base **130** and a collet **132**. The base **130** may include an opening **134** that provides communication between a chamber **133** formed proximate to the gun end **116** and a bore **138** that traverses the base **130**. The collet **132** may include a passage **140**, a ring **135** that seats within the bore **138**, and a plurality of fingers **136** that axially project from the ring **135**. Additionally, the upper section **112** may also include seals **142** that form a fluid barrier between the base **130** and the ring **135**.

[0018] The fingers **136** are circumferentially distributed and formed of a flexible material such as spring steel. Thus, the fingers **136** may be forced to bend radially outward and return to an original shape when the force is removed.

[0019] In one embodiment, the lower section **114** may include a mandrel **160** and a locking sleeve **162**. The mandrel **160** may be a generally cylindrical member that includes a chamber **164** proximate to the gun end **120** and in communication with an

- 5 -

adjacent bore **166**. The mandrel **160** may have a pin section **168**, a locking section **170**, a sleeve support section **172**, and a base section **174**. The pin section **168** has an outer diameter sized to be received into the bore **140** of the collet **132**. The locking section **170** may have a projection **176** that are sized to axially engage the fingers **136**. By axial engagement, it is meant that engagement occurs between surfaces that are not parallel with the longitudinal axis of the upper and lower sections **112**, **114**. For example, the engagement can occur along inclined surfaces such that a compressive loading can occur. The sleeve support section **172** may include a shoulder region **178** on which are formed external threads **180** and a reduced diameter landing **182**.

[0020] The locking sleeve **162** may be disposed on and surround the sleeve support section **172**. The locking sleeve **162** may be a tubular body having a bore **163** defined by an inner surface on which are formed inner threads **184** that are complementary to the external threads **180**. The bore **163** has a first section through which the shoulder region **178** can slide without obstruction. Thus, the sleeve **162** can slide axially along the landing **182** without rotation and then rotationally engage the external threads **180**. A lip **186** of the locking sleeve **162** is sized to receive and enclose the fingers **136** when they are not bent radially outward; *i.e.*, the fingers **136** are in a radially relaxed state. The length of the first section is selected to allow the lip **186** to axially slide over and surround the fingers **136**.

[0021] Advantageously, the quick connect housing **110** may be integrated with the time delay assembly **200** such that mating the quick connect upper and lower sections **112**, **114** also completes assembly of the time delay assembly **200**. In one non-limiting embodiment, the time delay assembly **200** may include an initiator assembly **210** integrated into the upper section **112** and a fuse assembly **220** and a detonation transfer assembly **230** integrated into the lower section **114**.

[0022] The initiator assembly **210** may include an explosive booster charge (not shown) that is energetically coupled to a detonator cord (not shown) associated with an immediately adjacent perforating gun. However, the initiator assembly **210** may also be energetically coupled to other sources for a detonation such as a firing pin, an

- 6 -

igniter assembly, or another booster. The initiator assembly **210** may be positioned inside the chamber **133** of the base **130** of the upper section **112** and generate a high-order output when activated. A high-order output generally consists of shock waves (*i.e.*, high-amplitude pressure waves) and thermal energy. Such detonations have a duration of no more than ten seconds and are more typically no greater than a second or no greater than a millisecond. This high order output travels to the bore **138** via the passage **134**.

[0023] The fuse assembly **220** may include one or more time delay fuse(s) element **222** and a fuse support **224** positioned in the lower section **112**. For instance, the fuse assembly **220** may be positioned inside the bore **166** of the mandrel **160**. The fuse support **224** may be a tubular member secures the fuse element **222** within the bore **166**. When so positioned, the high-order output exiting the passage **134** can impinge and detonate the fuse element(s) **222**.

[0024] The time delay fuse element **222** may provide a specified time delay (e.g., 6 minutes, 9 minutes, etc.) for adjusting or controlling the time needed for the gun train **60** to travel to the depth of the next formation to be perforated. Burn times less than one minute are generally not considered adequate to move a perforating gun. Thus, the burn time of the fuse element **222** may be at least one minute, at least five minutes, or at least eight minutes. By adjustable or controllable, it is meant that the time delay mechanism can be configured to increase or decrease the time between the firing of the first gun **62a** and the eventual firing of the gun **62b**. In one embodiment, the time delay mechanism includes a combination of energetic materials, each of which exhibit different burn characteristics, *e.g.*, the type or rate of energy released by that material. By appropriately configuring the chemistry, volume, and positioning of these energetic materials, a desired or predetermined time delay can be in the firing sequence. Generally, the energetic materials can include materials such as RDX, HMX that provides a high order detonation and a second energetic material that provides a low order detonation. Also, the number of fuses may be varied to control the duration of the time delay.

- 7 -

[0025] The detonator transfer assembly **230** may include one or more boosters that are detonated by the time delay fuse element **224**. The detonator transfer assembly **230** may be positioned inside the chamber **164** of the mandrel **160**. When detonated by the fuse assembly **220** in the adjacent bore **166**, the detonator transfer assembly **230** generates a high-order output that initiates the firing of the lower gun **62b** (**Fig. 1**). The duration of the detonation of the detonation transfer assembly **230** may be no more than ten seconds and are more typically no greater than a second or no greater than a millisecond.

[0026] One illustrative use of the time delay module **100** will be discussed in connection with **Figs. 1 - 3**. For clarity, the time delay module **100** will be discussed with reference to perforating guns **62a-b**. It should be appreciated, however, that certain aspects of the time delay module **100** is not limited to such use. For instance, the quick connect housing **110** may be adapted for use with other well tools.

[0027] In preparation for deployment, the upper section **112** of the quick connect housing **110** is fixed to the upper perforating gun **62a** and lower section **114** of the housing **110** is fixed to the lower perforating gun **62b**. The several components making up the time delay assembly **100** have already been installed in the upper and lower sections **112, 114**. It should be noted that at this time the time delay assembly **100** is not functional, *i.e.*, cannot transfer a detonation from the upper section **112** to the lower section **114**.

[0028] At the rig floor, the coiled tubing string **50** is unspooled and positioned over the wellhead **44** using the lubricator **53**. Thereafter, a work string **48** is conformed in a sequential manner. First, the upper perforating gun **62a** is attached to the coiled tubing string **50**. Next, the lower perforating gun **66b** is positioned below the upper perforating gun **62a**.

[0029] In order to have quick connection, the coiled tubing string **50** is lowered, which allows the connector end **118** of the upper section **112** to slide over the connector end **122** of the lower section **114**. This movement causes the pin section **168** to enter the bore **140** of the collet **132**. Also during this movement, the rib **176** contacts and bends the fingers **136** outward. Thereafter, the fingers **136** snap back to

- 8 -

their nominal relaxed or un-flexed condition. Now, the locking sleeve **162** may be axially slid into to contact with the threaded shoulder region **178**. Upon such contact, the locking sleeve **162** may be rotated such that the external threads **180** engage with the inner threads **184**. The locking sleeve **162** is rotated until the lip **186** encloses the fingers **136**, thereby preventing radial flexing of the fingers **136**. In some embodiments, a screw (not shown) may be used to fix the locking sleeve **162** to the locking section **170**.

[0030] Referring to **Fig. 3**, the housing **110** is shown in a locked state. In this locked state, a locking engagement is established between the upper section **112** and the lower section **114** by the fingers **136**. Specifically, a head portion **190** of the collets **136** is axially disposed between the rib **176** and a landing **192** formed on an inner surface of the locking sleeve **162**. The landing **192** may be a ramped or angled surface relative to the longitudinal axis of the lower section **114**. The head portion **190** provides surfaces that are transverse to a longitudinal axis of the lower section **114**. Thus, the lower section **112** cannot slide in a downhole direction **232** because the rib **176** interferingly engages the head portion **190**. Also, the lower section **112** cannot slide in an uphole direction **234** because the landing **192** interferingly engages the head portion **190**. Further, the fingers **136** cannot flex radially outward because they are surrounded and enclosed by the lip **186**.

[0031] It should be appreciated that rotational movement is limited only to locking the upper section **112** to the lower section **114**. That is, a sliding action is the primarily mode to connect the upper section **112** and the lower section **114**. It should also be noted that upon entering the locked state, the initiator assembly **210**, the fuse assembly **220**, and the detonation transfer assembly **230** are energetically coupled or connected to one another. By “energetically coupled or connected,” it is meant that energy released by one device will initiate the detonation of an adjacent device.

[0032] It should be understood that the quick connection described above does not depend on orientation. The lower section **114** may be fixed to the upper gun **62a** and the upper section **112** may be fixed to the lower gun **62b**. In such an

- 9 -

arrangement, the mandrel **160** of the lower section **114** can be lowered into position into the collet **132** of the upper section **112**.

[0033] Once the perforating gun train **60** is positioned at the desired target depth, a firing signal is transmitted into the wellbore **38**. The firing signal initiates a sequence of detonation events causes the firing of the upper gun **62a**. This detonation sequence also leads to the activation of the initiator assembly **210** after the upper gun **62** fires. The initiator assembly **210** generates a high-order output that detonates the fuse element(s) **222**. At this time, the perforation gun train **60** can be moved to another desired target depth. After burning for the prescribed time period, the fuse element(s) **222** detonate the detonator transfer assembly **230**, which then generates a high-order output to fire the lower gun **62b**.

[0034] From the above, it should be appreciated that what has been described includes an apparatus for perforating a subsurface formation using at least a first perforating gun and a second perforating gun. The apparatus may include an upper section configured to connect to the first perforating gun. The upper section may include a base having a bore and a collet disposed in the bore. The collet may include a passage and a ring having a plurality of axially projecting fingers. The apparatus may also include a lower section configured to connect to the second perforating gun. The lower section may include a mandrel having a pin section received into the passage of the collet, a locking section having a projection sized to axially engage the fingers, and a sleeve support section having a reduced diameter landing and an adjacent shoulder region on which are formed external threads. The apparatus may further include a tubular locking sleeve disposed on and surrounding the sleeve support section. The locking sleeve may include inner threads that are complementary to the external threads on the shoulder region and a lip configured to at least partially enclose the plurality of fingers.

[0035] In variants, the locking sleeve may include a landing formed on an inner surface and the fingers may each include a head portion axially engaging the projection of the mandrel locking section and the landing of the locking sleeve. The upper section and lower section may have an unlocked state defined by the fingers

- 10 -

being disengaged from the pin section and a locked state defined by the head portions of the fingers being enclosed by the lip and interposed between the projection and the landing.

[0036] In further variants, the locking sleeve may include a bore having a first section through which the shoulder region can slide without obstruction, wherein a length of the first section is selected to allow the lip to enclose the fingers. Also, the external threads of the shoulder region may be positioned to engage the internal threads of the locking sleeve after the lip encloses the fingers.

[0037] In still further variants, the base may further include a chamber in communication with the bore via a passage, and the mandrel may further includes a chamber in communication with an adjacent bore. The apparatus may also include a time delay module having an initiator assembly disposed in the base chamber, a fuse assembly disposed in mandrel bore, and detonation transfer assembly disposed in the mandrel chamber.

[0038] In variants, the initiator assembly may be only energetically coupled to the fuse assembly during the locked state. In still further variants, the initiator assembly generates a high-order output when activated by the firing of the first perforating gun, the fuse assembly is detonated by the high-order output, and the detonator assembly initiates the firing of the second gun when activated by the fuse assembly.

[0039] For the above, it should also be appreciated that what has been described includes an apparatus for perforating a subsurface formation. The apparatus may include a first perforating gun; a second perforating gun axially spaced apart from the first perforating gun; and a quick connect assembly selectively connecting the first perforating gun and the second perforating gun. The quick connect assembly may include an upper section configured to connect to the first perforating gun, the upper section including a base having a chamber in communication with a bore via a passage, a collet disposed in the bore, the collet including a passage and a ring having a plurality of axially projecting fingers, wherein each finger includes a head portion, and a lower section configured to connect to the second perforating gun, the lower section including: a mandrel having: a chamber in communication with an adjacent

- 11 -

bore, a pin section received into the passage of the collet, a locking section having a projection sized to axially engage the fingers, and a sleeve support section having a reduced diameter landing and an adjacent shoulder region on which are formed external threads, and a tubular locking sleeve disposed on and surrounding the sleeve support section, the locking sleeve including inner threads that are complementary to the external threads of the shoulder region, a lip configured to at least partially enclose the fingers, and a landing formed on an inner surface that axially engages the head portions of the fingers, wherein the upper section and lower section have an unlocked state defined by the fingers being disengaged from the pin section and a locked state defined by the head portions of the fingers being enclosed by the lip and axially interposed between the projection and the landing.

[0040] The foregoing description is directed to particular embodiments of the present disclosure for the purpose of illustration and explanation. It will be apparent, however, to one skilled in the art that many modifications and changes to the embodiment set forth above are possible without departing from the scope of the disclosure. It is intended that the following claims be interpreted to embrace all such modifications and changes.

- 12 -

CLAIMS

What is claimed is:

1. An apparatus for perforating a subsurface formation using at least a first perforating gun and a second perforating gun, comprising:
 - an upper section configured to connect to the first perforating gun, the upper section including:
 - a base having a bore,
 - a collet disposed in the bore, the collet including a passage and a ring having a plurality of axially projecting fingers, and
 - a lower section configured to connect to the second perforating gun, the lower section including:
 - a mandrel having:
 - a pin section received into the passage of the collet,
 - a locking section having a projection sized to axially engage the fingers, and
 - a sleeve support section having a reduced diameter landing and an adjacent shoulder region on which are formed external threads, and
 - a tubular locking sleeve disposed on and surrounding the sleeve support section, the locking sleeve including inner threads that are complementary to the external threads on the shoulder region and a lip configured to at least partially enclose the plurality of fingers.
2. The apparatus of claim 1, wherein the locking sleeve includes a landing formed on an inner surface and the fingers each include a head portion axially engaging the projection of the mandrel locking section and the landing of the locking sleeve, wherein the upper section and lower section have an unlocked state defined by the fingers being disengaged from the pin section and a locked

- 13 -

state defined by the head portions of the fingers being enclosed by the lip and interposed between the projection and the landing.

3. The apparatus of claim 2, wherein the locking sleeve includes a bore having a first section through which the shoulder region can slide without obstruction, wherein a length of the first section is selected to allow the lip to enclose the fingers.
4. The apparatus of claim 3, wherein the external threads of the shoulder region are positioned to engage the internal threads of the locking sleeve after the lip encloses the fingers.
5. The apparatus of claim 2, wherein the base further includes a chamber in communication with the bore via a passage, and the mandrel further includes a chamber in communication with an adjacent bore, and further comprising a time delay module having:
 - an initiator assembly disposed in the base chamber;
 - a fuse assembly disposed in mandrel bore; and
 - detonation transfer assembly disposed in the mandrel chamber.
6. The apparatus of claim 5, wherein the initiator assembly is only energetically coupled to the fuse assembly during the locked state.
7. The apparatus of claim 5, wherein the initiator assembly generates a high-order output when activated by the firing of the first perforating gun, wherein the fuse assembly is detonated by the high-order output, and wherein the detonator assembly initiates the firing of the second gun when activated by the fuse assembly.
8. An apparatus for perforating a subsurface formation, comprising:
 - a first perforating gun;

- 14 -

- a second perforating gun axially spaced apart from the first perforating gun;
- a quick connect assembly selectively connecting the first perforating gun and the second perforating gun, the quick connect assembly comprising:
 - an upper section configured to connect to the first perforating gun, the upper section including:
 - a base having a chamber in communication with a bore via a passage,
 - a collet disposed in the bore, the collet including a passage and a ring having a plurality of axially projecting fingers, wherein each finger includes a head portion, and
 - a lower section configured to connect to the second perforating gun, the lower section including:
 - a mandrel having:
 - a chamber in communication with an adjacent bore,
 - a pin section received into the passage of the collet,
 - a locking section having a projection sized to axially engage the fingers, and
 - a sleeve support section having a reduced diameter landing and an adjacent shoulder region on which are formed external threads, and
 - a tubular locking sleeve disposed on and surrounding the sleeve support section, the locking sleeve including inner threads that are complementary to the external threads of the shoulder region, a lip configured to at least partially enclose the fingers, and a landing formed on an inner surface that axially engages the head portions of the fingers,

- 15 -

wherein the upper section and lower section have an unlocked state defined by the fingers being disengaged from the pin section and a locked state defined by the head portions of the fingers being enclosed by the lip and axially interposed between the projection and the landing.

9. The apparatus of claim 8, further comprising a time delay module having:
 - an initiator assembly disposed in the base chamber, wherein the initiator assembly generates a high-order output when activated by the firing of the first perforating gun;
 - a fuse assembly disposed in mandrel bore, wherein the fuse assembly is detonated by the high-order output, wherein the initiator assembly is only energetically coupled to the fuse assembly during the locked state; and
 - detonation transfer assembly disposed in the mandrel chamber wherein the detonator assembly initiates the firing of the second gun when activated by the fuse assembly.
10. The apparatus of claim 9, wherein a duration of the detonation of the initiator assembly is no greater than a second, wherein a burn time of the fuse assembly is at least a minute, and wherein a duration of the detonation of the detonation transfer assembly is no greater than a second.

1/3

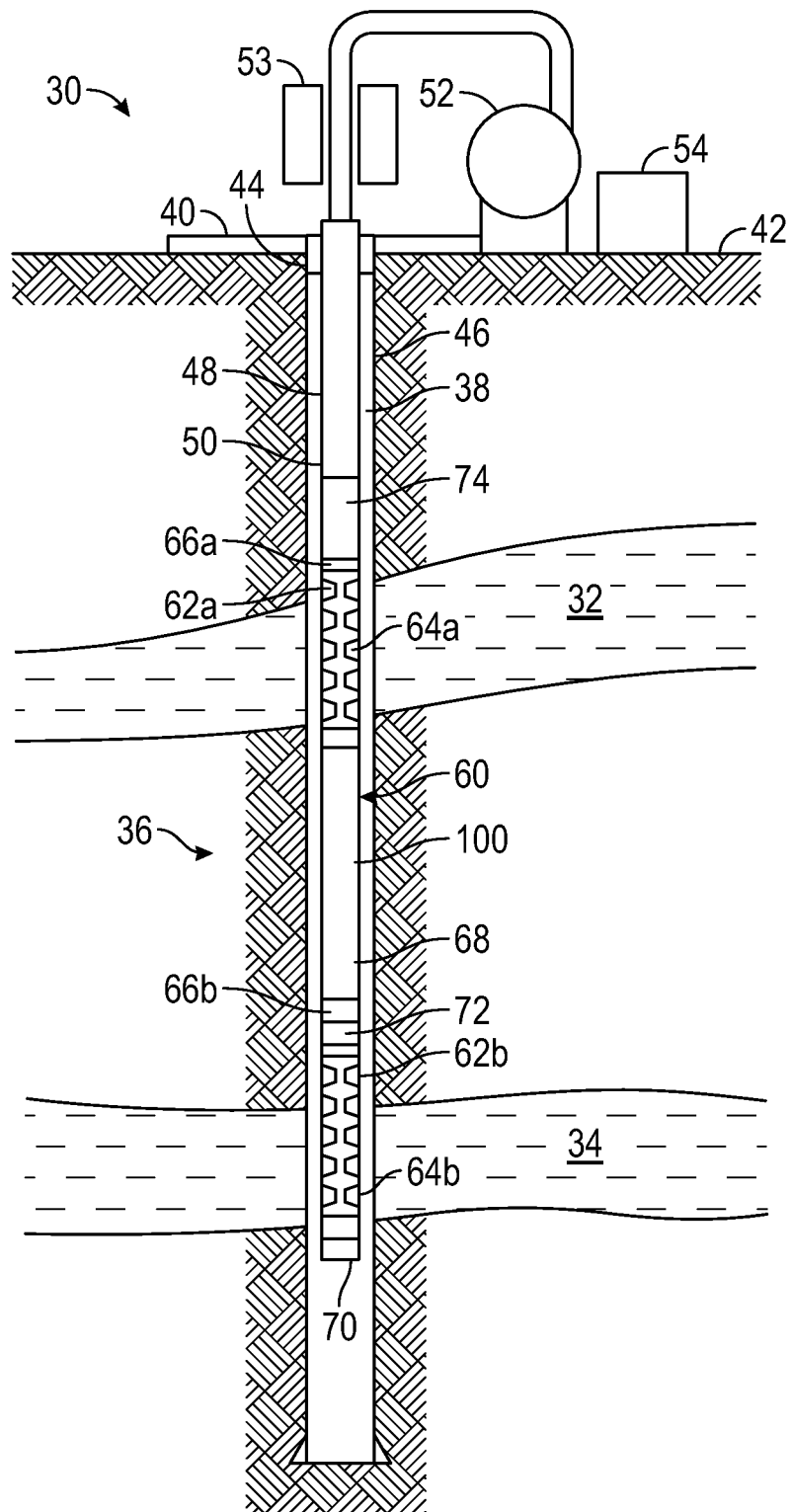


FIG. 1

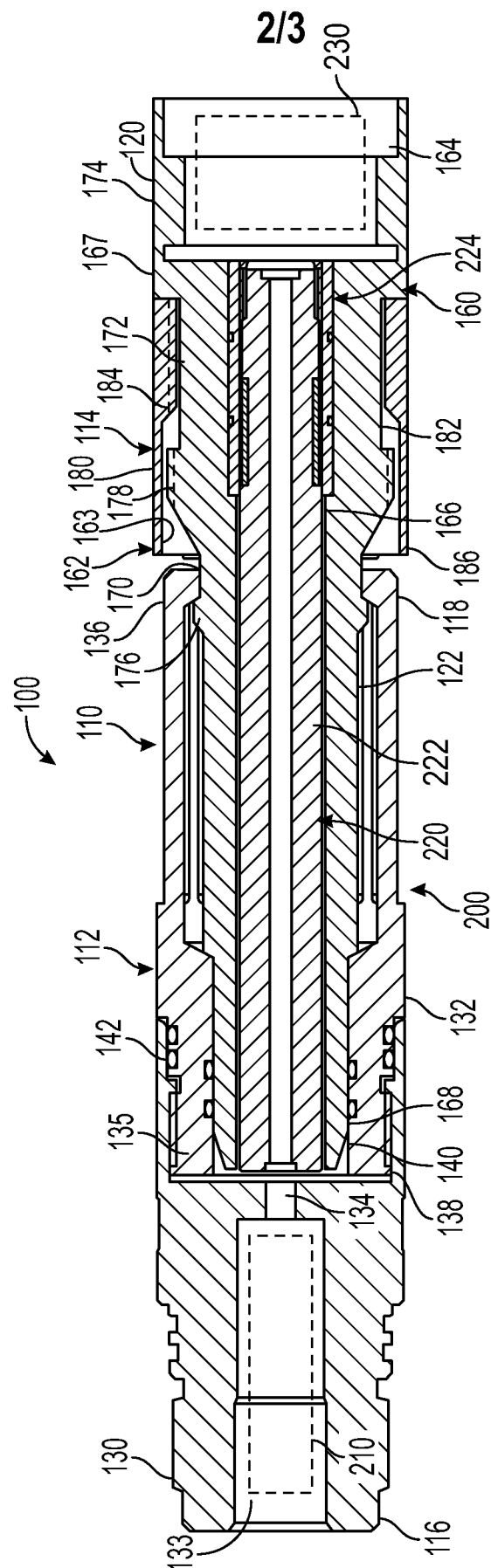


FIG. 2

3/3

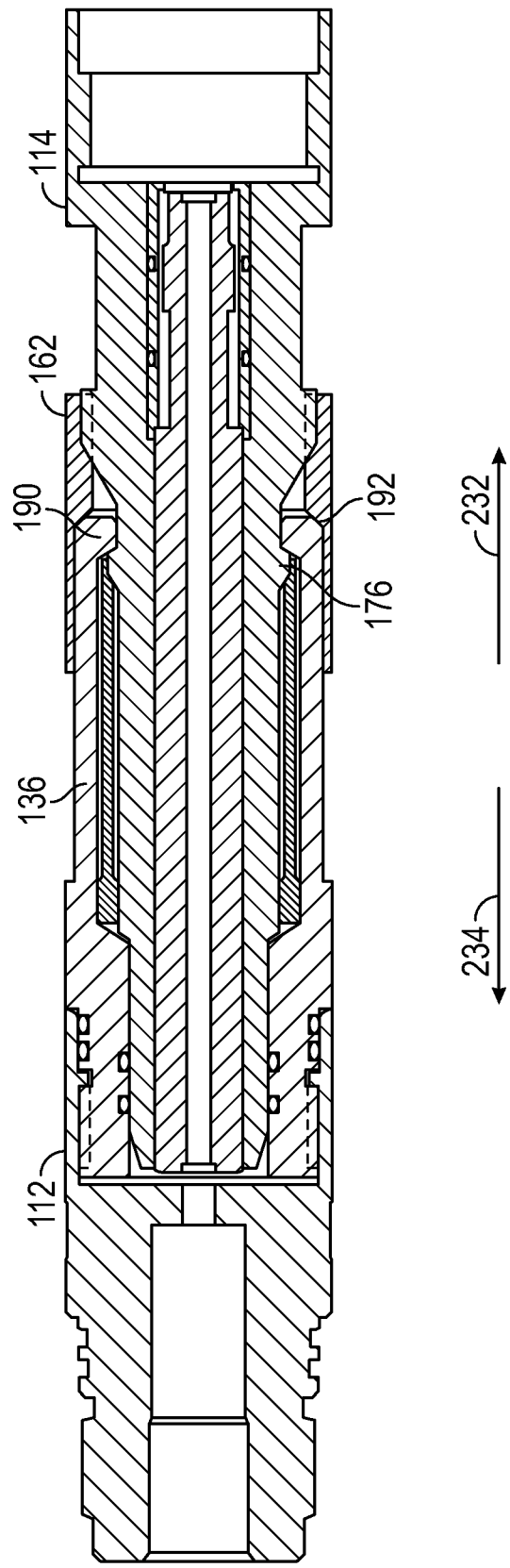


FIG. 3