Innovation, Sciences et Développement économique Canada
Office de la Propriété Intellectuelle du Canada

Innovation, Science and Economic Development Canada
Canadian Intellectual Property Office

CA 3019042 A1 2019/04/11

(21) 3 019 042

(12) DEMANDE DE BREVET CANADIEN
CANADIAN PATENT APPLICATION

(13) A1

(22) Date de dépôt/Filing Date: 2018/09/28

(41) Mise à la disp. pub./Open to Public Insp.: 2019/04/11

(30) Priorité/Priority: 2017/10/11 (US15/730,305)

(51) Cl.Int./Int.Cl. *E21B 47/12* (2012.01),
E21B 33/03 (2006.01)

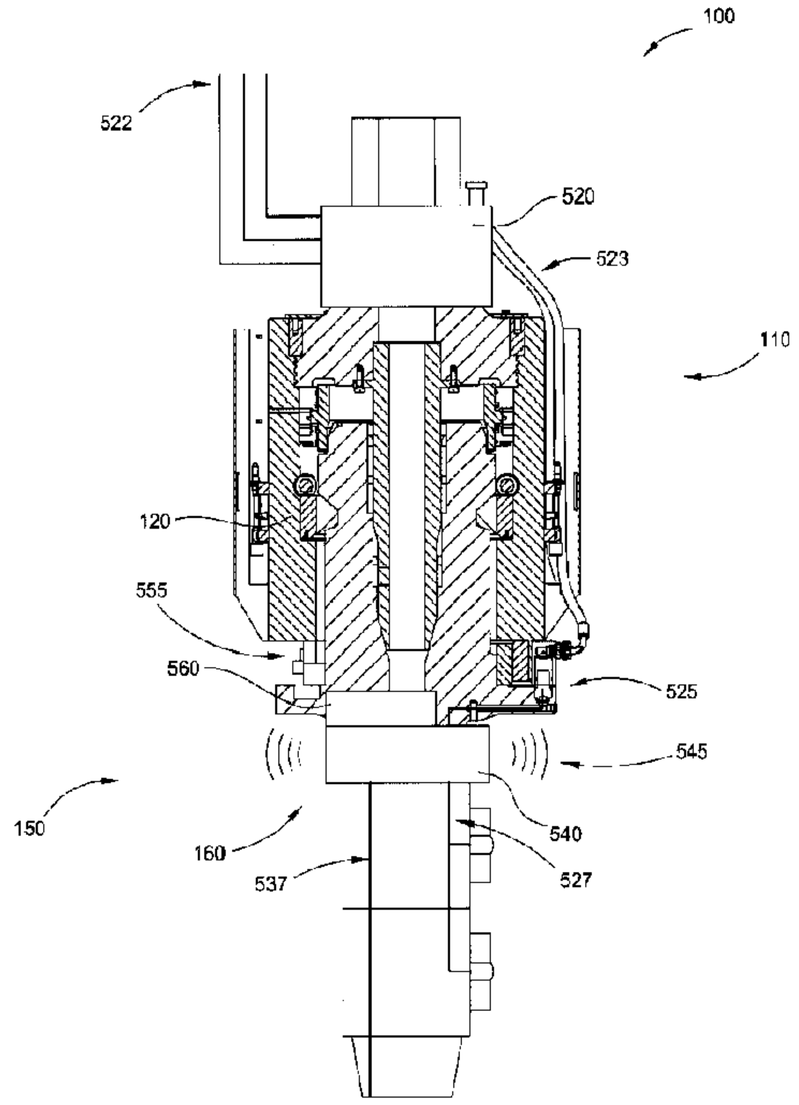
(71) Demandeur/Applicant:
WEATHERFORD TECHNOLOGY HOLDINGS, LLC, US

(72) Inventeurs/Inventors:
AMEZAGA, FEDERICO, US;
HEIDECKE, KARSTEN, US;
FUEHRING, ERNST, DE;
THIEMANN, BJOERN, DE

(74) Agent: DEETH WILLIAMS WALL LLP

(54) Titre : RACCORD D'OUTIL EQUIPE DE PROCEDES DE TRANSFERT DE DONNEES ET DE SIGNAL DESTINE A UN MECANISME D'ENTRAINEMENT SUPERIEUR

(54) Title: TOOL COUPLER WITH DATA AND SIGNAL TRANSFER METHODS FOR TOP DRIVE



(57) Abrégé/Abstract:
Equipment and methods for coupling a top drive to one or more tools to facilitate data and/or signal transfer therebetween include a receiver assembly connectable to a top drive; a tool adapter connectable to a tool string, wherein a coupling between the receiver assembly and the tool adapter transfers at least one of torque and load therebetween; and a stationary data uplink comprising at least one of: a data swivel coupled to the receiver assembly; a wireless module coupled to the tool adapter; and a wireless transceiver coupled to the tool adapter. Equipment and methods include coupling a receiver assembly to a tool adapter to transfer at least one of torque and load therebetween, the tool adapter being connected to the tool string; collecting data at one or more points proximal the tool string; and communicating the data to a stationary computer while rotating the tool adapter.

ABSTRACT OF THE DISCLOSURE

Equipment and methods for coupling a top drive to one or more tools to facilitate data and/or signal transfer therebetween include a receiver assembly connectable to a top drive; a tool adapter connectable to a tool string, wherein a coupling between the receiver assembly and the tool adapter transfers at least one of torque and load therebetween; and a stationary data uplink comprising at least one of: a data swivel coupled to the receiver assembly; a wireless module coupled to the tool adapter; and a wireless transceiver coupled to the tool adapter. Equipment and methods include coupling a receiver assembly to a tool adapter to transfer at least one of torque and load therebetween, the tool adapter being connected to the tool string; collecting data at one or more points proximal the tool string; and communicating the data to a stationary computer while rotating the tool adapter.

TOOL COUPLER WITH DATA AND SIGNAL TRANSFER METHODS FOR TOP DRIVE

BACKGROUND

Embodiments of the present disclosure generally relate to equipment and methods for coupling a top drive to one or more tools to facilitate data and/or signal transfer therebetween. The coupling may transfer both axial load and torque bi-directionally from the top drive to the one or more tools. The coupling may facilitate data and/or signal transfer, including tool string and/or downhole data feeds such as mud pulse telemetry, electromagnetic telemetry, wired drill pipe telemetry, and acoustic telemetry.

A wellbore is formed to access hydrocarbon-bearing formations (*e.g.*, crude oil and/or natural gas) or for geothermal power generation by the use of drilling. Drilling is accomplished by utilizing a drill bit that is mounted on the end of a tool string. To drill within the wellbore to a predetermined depth, the tool string is often rotated by a top drive on a drilling rig. After drilling to a predetermined depth, the tool string and drill bit are removed, and a string of casing is lowered into the wellbore. Well construction and completion operations may then be conducted.

During drilling and well construction/completion, various tools are used which have to be attached to the top drive. The process of changing tools is very time consuming and dangerous, requiring personnel to work at heights. The attachments between the tools and the top drive typically include mechanical, electrical, optical, hydraulic, and/or pneumatic connections, conveying torque, load, data, signals, and/or power.

Typically, sections of a tool string are connected together with threaded connections. Such threaded connections are capable of transferring load. Right-hand (RH) threaded connections are also capable of transferring RH torque. However, application of left-hand (LH) torque to a tool string with RH threaded connections (and vice versa) risks breaking the string. Methods have been employed to obtain bi-directional torque holding capabilities for connections. Some examples of these bi-

directional setting devices include thread locking mechanisms for saver subs, hydraulic locking rings, set screws, jam nuts, lock washers, keys, cross/thru-bolting, lock wires, clutches and thread locking compounds. However, these solutions have shortcomings. For example, many of the methods used to obtain bi-directional torque capabilities are limited by friction between component surfaces or compounds that typically result in a relative low torque resistant connection. Locking rings may provide only limited torque resistance, and it may be difficult to fully monitor any problem due to limited accessibility and location. For applications that require high bi-directional torque capabilities, only positive locking methods such as keys, clutches or cross/through-bolting are typically effective. Further, some high bi-directional torque connections require both turning and milling operations to manufacture, which increase the cost of the connection over just a turning operation required to manufacture a simple male-to-female threaded connection. Some high bi-directional torque connections also require significant additional components as compared to a simple male-to-female threaded connection, which adds to the cost.

Threaded connections also suffer from the risk of cross threading. When the threads are not correctly aligned before torque is applied, cross threading may damage the components. The result may be a weak or unsealed connection, risk of being unable to separate the components, and risk of being unable to re-connect the components once separated. Therefore, threading (length) compensation systems may be used to provide accurate alignment and/or positioning of components having threaded connections prior to application of make-up (or break-out) torque. Conventional threading compensation systems may require unacceptable increase in component length. For example, if a hydraulic cylinder positions a threaded component, providing threading compensation with the cylinder first requires an increase in the cylinder stroke length equal to the length compensation path. Next, the cylinder housing must also be increased by the same amount to accommodate the cylinder stroke in a retracted position. So adding conventional threading compensation to a hydraulic cylinder would require additional component space up to twice the length compensation path length. For existing rigs, where vertical clearance and component weight are important, this can cause problems.

Safer, faster, more reliable, and more efficient connections that are capable of conveying load, data, signals, power and/or bi-directional torque between the tool string and the top drive are needed.

SUMMARY

The present disclosure generally relates to equipment and methods for coupling a top drive to one or more tools to facilitate data and/or signal transfer therebetween. The coupling may transfer both axial load and torque bi-directionally from the top drive to the one or more tools. The coupling may facilitate data and/or signal transfer, including tool string and/or downhole data feeds such as mud pulse telemetry, electromagnetic telemetry, wired drill pipe telemetry, and acoustic telemetry.

In an embodiment, a tool coupler includes a receiver assembly connectable to a top drive; a tool adapter connectable to a tool string, wherein a coupling between the receiver assembly and the tool adapter transfers at least one of torque and load therebetween; and a stationary data uplink comprising at least one of: a data swivel coupled to the receiver assembly; a wireless module coupled to the tool adapter; and a wireless transceiver coupled to the tool adapter.

In an embodiment, a method of operating a tool string includes coupling a receiver assembly to a tool adapter to transfer at least one of torque and load therebetween, the tool adapter being connected to the tool string; collecting data at one or more points proximal the tool string; and communicating the data to a stationary computer while rotating the tool adapter.

In an embodiment, a top drive system for handling a tubular includes a top drive; a receiver assembly connectable to the top drive; a casing running tool adapter, wherein a coupling between the receiver assembly and the casing running tool adapter transfers at least one of torque and load therebetween; and a stationary data uplink comprising at least one of: a data swivel coupled to the receiver assembly; a wireless module coupled to the casing running tool adapter; and a wireless transceiver coupled to the casing running tool adapter; wherein the casing running tool adapter comprises: a spear; a plurality of bails, and a casing feeder at a distal end of the

plurality of bails, wherein, the casing feeder is pivotable at the distal end of the plurality of bails, the plurality of bails are pivotable relative to the spear, and the casing feeder is configured to grip casing.

In an embodiment, a method of handling a tubular includes coupling a receiver assembly to a tool adapter to transfer at least one of torque and load therebetween; gripping the tubular with a casing feeder of the tool adapter; orienting and positioning the tubular relative to the tool adapter; connecting the tubular to the tool adapter; collecting data including at least one of: tubular location, tubular orientation, tubular outer diameter, gripping diameter, clamping force applied, number of threading turns, and torque applied; and communicating the data to a stationary computer while rotating the tool adapter.

BRIEF DESCRIPTION OF THE DRAWINGS

So that the manner in which the above recited features of the present disclosure can be understood in detail, a more particular description of the disclosure, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this disclosure and are therefore not to be considered limiting of its scope, for the disclosure may admit to other equally effective embodiments.

Figure 1 illustrates a drilling system, according to embodiments of the present disclosure.

Figures 2A-2B illustrate an example tool coupler for a top drive system according to embodiments described herein.

Figures 3A-3C illustrate example central shaft profiles for the tool coupler of Figures 2A-2B.

Figures 4A-4D illustrate example ring couplers for the tool coupler of Figures 2A-2B.

Figures 5A-5B illustrate example actuators for the tool coupler of Figures 2A-2B.

Figures 6A-6C illustrate example ring couplers for the tool coupler of Figures 2A-2B.

Figures 7A-7C illustrate a multi-step process for coupling a receiver assembly to a tool adapter according embodiments described herein.

Figures 8A-8C illustrate another example tool coupler for a top drive system according to embodiments described herein.

Figures 9A-9B illustrate example ring couplers for the tool coupler of Figures 8A-8C.

Figures 10A-10B illustrate example sensors for the tool coupler of Figures 8A-8C.

Figures 11A-11B illustrate other example sensors for the tool coupler of Figures 8A-8C.

Figure 12 illustrates example components for the tool coupler of Figures 8A-8C.

Figure 13 illustrates an exemplary tool coupler that facilitates transmission of data between the tool string and the top drive according embodiments described herein.

Figure 14 illustrates another exemplary tool coupler that facilitates transmission of data between the tool string and the top drive.

Figure 15 illustrates another exemplary tool coupler that facilitates transmission of data between the tool string and the top drive.

Figure 16 illustrates another exemplary tool coupler that facilitates transmission of data between the tool string and the top drive.

Figure 17 illustrates another exemplary tool coupler that facilitates transmission of data between the tool string and the top drive.

Figures 18A-18F show an exemplary embodiment of a drilling system having a tool coupler with a casing running tool adapter.

DETAILED DESCRIPTION

The present disclosure provides equipment and methods for coupling a top drive to one or more tools to facilitate data and/or signal transfer therebetween. The top drive may include a control unit, a drive unit, and a tool coupler. The coupling may transfer torque bi-directionally from the top drive through the tool coupler to the one or more tools. The coupling may provide mechanical, electrical, optical, hydraulic, and/or pneumatic connections. The coupling may conveying torque, load, data, signals, and/or power. Data feeds may include, for example, mud pulse telemetry, electromagnetic telemetry, wired drill pipe telemetry, and/or acoustic telemetry. For example, axial loads of tool strings may be expected to be several hundred tons, up to, including, and sometimes surpassing 750 tons. Required torque transmission may be tens of thousands of foot-pounds, up to, including, and sometimes surpassing 100 thousand foot-pounds. Embodiments disclosed herein may provide axial connection integrity, capable to support high axial loads, good sealability, resistance to bending, high flow rates, and high flow pressures.

Some of the many benefits provided by embodiments of this disclosure include a tool coupler having a simple mechanism that is low maintenance. Benefits also include a reliable method to transfer full bi-directional torque, thereby reducing the risk of accidental breakout of threaded connections along the tool string. In some embodiments, the moving parts of the mechanism may be completely covered. During coupling or decoupling, no turning of exposed parts of the coupler or tool may be required. Coupling and decoupling is not complicated, and the connections may be release by hand as a redundant backup. Embodiments of this disclosure may also provide a fast, hands-free method to connect and transfer power from the top drive to the tools. Embodiments may also provide automatic connection for power, data, and/or signal communications. Embodiments may also provide threading (length) compensation to reduce impact, forces, and/or damage at the threads. Embodiments may provide confirmation of orientation and/or position of the components, for example a stab-in signal. During make-up or break-out, threading compensation may reduce the axial load at the thread and therefore the risk of damage of the thread.

Figure 1 illustrates a drilling system 1, according to embodiments of the present disclosure. The drilling system 1 may include a drilling rig derrick 3d on a drilling rig floor 3f. As illustrated, drilling rig floor 3f is at the surface of a subsurface formation 7, but the drilling system 1 may also be an offshore drilling unit, having a platform or subsea wellhead in place of or in addition to rig floor 3f. The derrick may support a hoist 5, thereby supporting a top drive 4. In some embodiments, the hoist 5 may be connected to the top drive 4 by threaded couplings. The top drive 4 may be connected to a tool string 2. At various times, top drive 4 may support the axial load of tool string 2. In some embodiments, the top drive 4 may be connected to the tool string 2 by threaded couplings. The rig floor 3f may have an opening through which the tool string 2 extends downwardly into a wellbore 9. At various times, rig floor 3f may support the axial load of tool string 2. During operation, top drive 4 may provide torque to tool string 2, for example to operate a drilling bit near the bottom of the wellbore 9. The tool string 2 may include joints of drill pipe connected together, such as by threaded couplings. As illustrated, tool string 2 extends without break from top drive 4 into wellbore 9. During some operations, such as make-up or break-out of drill pipe, tool string 2 may be less extensive. For example, at times, tool string 2 may include only a casing running tool connected to the top drive 4, or tool string 2 may include only a casing running tool and a single drill pipe joint.

At various times, top drive 4 may provide right hand (RH) torque or left hand (LH) torque to tool string 2, for example to make up or break out joints of drill pipe. Power, data, and/or signals may be communicated between top drive 4 and tool string 2. For example, pneumatic, hydraulic, electrical, optical, or other power, data, and/or signals may be communicated between top drive 4 and tool string 2. The top drive 4 may include a control unit, a drive unit, and a tool coupler. In some embodiments, the tool coupler may utilize threaded connections. In some embodiments, the tool coupler may be a combined multi-coupler (CMC) or quick connector to support load and transfer torque with couplings to transfer power, data, and/or signals (*e.g.*, hydraulic, electric, optical, and/or pneumatic).

Figure 2A illustrates a tool coupler 100 for a top drive system (*e.g.*, top drive 4 in Figure 1) according to embodiments described herein. Generally, tool coupler 100

includes a receiver assembly 110 and a tool adapter 150. The receiver assembly 110 generally includes a housing 120, one or more ring couplers 130, and one or more actuators 140 functionally connected to the ring couplers 130. Optionally, each ring coupler 130 may be a single component forming a complete ring, multiple components connected together to form a complete ring, a single component forming a partial ring, or multiple components connected together to form one or more partial rings. The housing 120 may be connected to a top drive (*e.g.*, top drive 4 in Figure 1). The actuators 140 may be fixedly connected to the housing 120. In some embodiments, the actuators 140 may be connected with bearings (*e.g.*, a spherical bearing connecting the actuator 140 to the housing, and another spherical bearing connecting the actuator 140 to the ring coupler 130. The ring couplers 130 may be connected to the housing 120 such that the ring couplers 130 may rotate 130-r relative to the housing 120. The ring couplers 130 may be connected to the housing 120 such that the ring couplers 130 may move translationally 130-t (*e.g.*, up or down) relative to the housing 120. The tool adapter 150 generally includes a tool stem 160, a profile 170 that is complementary to the ring couplers 130 of the receiver assembly 110, and a central shaft 180. The tool stem 160 generally remains below the receiver assembly 110. The tool stem 160 connects the tool coupler 100 to the tool string 2. The central shaft 180 generally inserts into the housing 120 of the receiver assembly 110. The housing 120 may include a central stem 190 with an outer diameter less than or equal to an inner diameter of central shaft 180. The central stem 190 and central shaft 180 may share a central bore 165 (*e.g.* providing fluid communication through the tool coupler 100). In some embodiments, central bore 165 is a sealed mud channel. In some embodiments, central bore 165 provides a fluid connection (*e.g.*, a high pressure fluid connection). The profile 170 may be disposed on the outside of the central shaft 180. The profile 170 may include convex features on the outer surface of central shaft 180. The housing 120 may have mating features 125 that are complementary to profile 170. The housing mating features 125 may be disposed on an interior of the housing 120. The housing mating features 125 may include convex features on an inner surface of the housing 120. When the receiver assembly 110 is coupled to the tool adapter 150, housing mating features 125 may be interleaved with

features of profile 170 around central shaft 180. During coupling or decoupling operations, the actuators 140 may cause the ring couplers 130 to rotate 130-r around the central shaft 180, and/or the actuators 140 may cause the ring couplers 130 to move translationally 130-t relative to central shaft 180. Rotation 130-r of the ring coupler 130 may be less than a full turn, less than 180 °, or even less than 30°. When the receiver assembly 110 is coupled to the tool adapter 150, tool coupler 100 may transfer torque and/or load between the top drive and the tool.

It should be understood that the components of tool couplers described herein could be usefully implemented in reverse configurations. For example, Figure 2B illustrates a tool coupler 100' having a reverse configuration of components as illustrated in Figure 2A. Generally, tool coupler 100' includes a receiver assembly 110' and a tool adapter 150'. The tool adapter 150' generally includes a housing 120', one or more ring couplers 130', and one or more actuators 140' functionally connected to the ring couplers 130'. The housing 120' may be connected to the tool string 2. The actuators 140' may be fixedly connected to the housing 120'. The ring couplers 130' may be connected to the housing 120' such that the ring couplers 130' may rotate and/or move translationally relative to the housing 120'. The receiver assembly 110' generally includes a drive stem 160', a profile 170' that is complementary to the ring couplers 130' of the tool adapter 150', and a central shaft 180'. The drive stem 160' generally remains above the tool adapter 150'. The drive stem 160' connects the tool coupler 100 to a top drive (*e.g.*, top drive 4 in Figure 1). The central shaft 180' generally inserts into the housing 120' of the tool adapter 150'. The housing 120' may include a central stem 190' with an outer diameter less than or equal to an inner diameter of central shaft 180'. The central stem 190' and central shaft 180' may share a central bore 165' (*e.g.* providing fluid communication through the tool coupler 100'). The profile 170' may be disposed on the outside of the central shaft 180'. The profile 170' may include convex features on the outer surface of central shaft 180'. The housing 120' may have mating features 125' that are complementary to profile 170'. The housing mating features 125' may be disposed on an interior of the housing 120'. The housing mating features 125' may include convex features on an inner surface of the housing 120'. During coupling or decoupling operations, the actuators 140' may cause

the ring couplers 130' to rotate and/or to move translationally relative to central shaft 180'. When the receiver assembly 110' is coupled to the tool adapter 150', tool coupler 100' may transfer torque and/or load between the top drive and the tool. Consequently, for each embodiment described herein, it should be understood that the components of the tool couplers could be usefully implemented in reverse configurations.

As illustrated in Figure 3, the profile 170 may include splines 275 distributed on the outside of central shaft 180. The splines 275 may run vertically along central shaft 180. (It should be understood that "vertically", "up", and "down" as used herein refer to the general orientation of top drive 4 as illustrated in Figure 1. In some instances, the orientation may vary somewhat, in response to various operational conditions. In any instance wherein the central axis of the tool coupler is not aligned precisely with the direction of gravitational force, "vertically", "up", and "down" should be understood to be along the central axis of the tool coupler.) The splines 275 may (as shown) or may not (not shown) be distributed symmetrically about the central axis 185 of the central shaft 180. The width of each spline 275 may (as shown) or may not (not shown) match the width of the other splines 275. The splines 275 may run contiguously along the outside of central shaft 180 (as shown in Figure 3A). The splines 275 may include two or more discontiguous sets of splines distributed vertically along the outside of central shaft 180 (*e.g.*, splines 275-a and 275-b in Figure 3B; splines 275-a, 275-b, and 275-c in Figure 3C). Figure 3A illustrates six splines 275 distributed about the central axis 185 of the central shaft 180. Figures 3B and 3C illustrate ten splines 275 distributed about the central axis 185 of the central shaft 180. It should be appreciated that any number of splines may be considered to accommodate manufacturing and operational conditions. Figure 3C also illustrates a stop surface 171 to be discussed below.

As illustrated in Figure 4, one or more of the ring couplers 130 may have mating features 235 on an interior thereof. The ring coupler mating features 235 may include convex features on an inner surface of the ring coupler 130. The ring coupler 130 may have cogs 245 distributed on an outside thereof (further discussed below). In some embodiments, the cogs 245 may be near the top of the ring coupler 130 (not shown).

The mating features 235 may be complementary with splines 275 from the respective central shaft 180. For example, during coupling or decoupling of receiver assembly 110 and tool adapter 150, the mating features 235 may slide between the splines 275. The mating features 235 may run vertically along the interior of ring coupler 130. The mating features 235 may (as shown) or may not (not shown) be distributed symmetrically about the central axis 285 of the ring coupler 130. The width of each mating feature 235 may (as shown) or may not (not shown) match the width of the other mating features 235. The mating features 235 may run contiguously along the interior of the ring couplers 130 (as shown in Figures 4A and 4B). The mating features 235 may include two or more discontiguous sets of mating features distributed vertically along the interior of the ring couplers 130. For example, as shown in Figure 4C, ring coupler 130-c includes mating features 235-c, while ring coupler 130-s includes mating features 235-s which are below mating features 235-c. In some embodiments, such discontiguous sets of mating features may be rotationally coupled. In the illustrated embodiment, ring coupler 130-c may be fixed to ring coupler 130-s, thereby rotationally coupling mating features 235-c with mating features 235-s. Figure 4A illustrates six mating features 235 distributed about the central axis 285 of the ring couplers 130. Figures 4B and 4C illustrates ten mating features 235 distributed about the central axis 285 of the central shaft 180. It should be appreciated that any number of mating features may be considered to accommodate manufacturing and operational conditions. Figure 4C also illustrates a stop surface 131 to be discussed below.

Likewise, as illustrated in Figure 4D, housing 120 may have mating features 125 on an interior thereof. As with the ring coupler mating features 235, the housing mating features 125 may be complementary with splines 275 from the respective central shaft 180. For example, during coupling or decoupling of receiver assembly 110 and tool adapter 150, the mating features 125 may slide between the splines 275. The mating features 125 may run vertically along the interior of housing 120. The housing mating features 125 may be generally located lower on the housing 120 than the operational position of ring couplers 130. The mating features 125 may (as shown) or may not (not shown) be distributed symmetrically about the central axis 385 of the housing 120. The width of each mating feature 125 may (as shown) or may not (not

shown) match the width of the other mating features 125. The mating features 125 may run contiguously along the interior of the housing 120 (as shown).

As illustrated in Figure 5, one or more actuators 140 may be functionally connected to ring couplers 130. Figure 5A illustrates an embodiment having three ring couplers 130 and two actuators 140. Figure 5B illustrates an embodiment showing one ring coupler 130 and two actuators 140. It should be appreciated that any number of ring couplers and actuators may be considered to accommodate manufacturing and operational conditions. The actuators 140 illustrated in Figure 5A are worm drives, and the actuators illustrated in Figure 5B are hydraulic cylinders. Other types of actuators 140 may be envisioned to drive motion of the ring couplers 130 relative to the housing 120. Adjacent to each actuator 140 in Figure 5A are ring couplers 130 having cogs 245 distributed on an outside thereof (better seen in Figure 4A). Gearing of the actuators 140 may mesh with the cogs 245. The two actuators 140 in Figure 5A can thereby independently drive the two adjacent ring couplers 130 to rotate 130-r about central axis 285. The two actuators 140 in Figure 5B (*i.e.*, the hydraulic cylinders) are both connected to the same ring coupler 130. The hydraulic cylinders are each disposed in cavity 115 in the housing 120 to permit linear actuation by the hydraulic cylinder. The two actuators 140 in Figure 5B can thereby drive the ring coupler 130 to rotate 130-r about central axis 285. For example, ring coupler 130 shown in Figure 4B includes pin holes 142 positioned and sized to operationally couple to pins 141 (shown in Figure 11A) of actuators 140. As illustrated in Figure 5B, linear motion of the actuators 140 may cause ring coupler 130 to rotate, for example between about 0° and about 18°. Actuators 140 may be hydraulically, electrically, or manually controlled. In some embodiments, multiple control mechanism may be utilized to provide redundancy.

In some embodiments, one or more ring couplers 130 may move translationally 130-t relative to the housing 120. For example, as illustrated in Figure 6, a ring coupler 130, such as upper ring coupler 130-u, may have threading 255 on an outside thereof. The threading 255 may mesh with a linear rack 265 on an interior of housing 120. As upper ring coupler 130-u rotates 130-r about central axis 285, threading 255 and linear rack 265 drive upper ring coupler 130-u to move translationally 130-t relative to

housing 120. Housing 120 may have a cavity 215 to allow upper ring coupler 130-u to move translationally 130-t. In the illustrated embodiment, upper ring coupler 130-u is connected to lower ring coupler 130-l such that translational motion is transferred between the ring couplers 130. The connection between upper ring coupler 130-u and lower ring coupler 130-l may or may not also transfer rotational motion. In the illustrated embodiment, the actuator 140 may drive upper ring coupler 130-u to rotate 130-r about central axis 285, thereby driving upper ring coupler 130-u to move translationally 130-t relative to housing 120, and thereby driving lower ring coupler 130-l to move translationally 130-t relative to housing 120.

In some embodiments, the lower ring coupler 130-l may be a bushing. In some embodiments, the interior diameter of the lower ring coupler 130-l may be larger at the bottom than at the top. In some embodiments, the lower ring coupler may be a wedge bushing, having an interior diameter that linearly increases from top to bottom.

Receiver assembly 110 may be coupled to tool adapter 150 in order to transfer torque and/or load between the top drive and the tool. Coupling may proceed as a multi-step process. In one embodiment, as illustrated in Figure 7A, coupling begins with inserting central shaft 180 of tool adapter 150 into housing 120 of receiver assembly 110. The tool adapter 150 is oriented so that splines 275 will align with mating features 235 of ring couplers 130 (shown in Figure 7B) and with mating features 125 of housing 120 (shown in Figure 7B). For example, during coupling, the ring coupler mating features 235 and the housing mating features 125 may slide between the splines 275. Coupling proceeds in Figure 7B, as one or more stop surfaces 131 of one or more ring couplers 130 engage complementary stop surfaces 171 of profile 170 of central shaft 180. As illustrated, stop surfaces 131 are disposed on an interior of lower ring coupler 130-l. It should be appreciated that other stop surface configurations may be considered to accommodate manufacturing and operational conditions. In some embodiments, position sensors may be used in conjunction with or in lieu of stop surfaces to identify when insertion of central shaft 180 into housing 120 has completed. Likewise, optical guides may be utilized to identify or confirm when insertion of central shaft 180 into housing 120 has completed. Coupling proceeds in Figure 7C as the profile 170 is clamped by ring couplers 130.

For example, support actuator 140-s may be actuated to drive support ring coupler 130-s to rotate 130-r about central axis 285. Rotation 130-r of the support ring coupler 130-s may be less than a full turn, less than 180°, or even less than 30°. Ring coupler mating features 235 may thereby rotate around profile 170 to engage splines 275. Pressure actuator 140-p may be actuated to drive upper ring coupler 130-u to rotate 130-r about central axis 285. For example, pressure actuator 140-p may include worm gears. Rotation 130-r of the upper ring coupler 130-u may be less than or more than a full turn. Threading 255 and linear rack 265 may thereby drive upper ring coupler 130-u to move translationally 130-t downward relative to housing 120, thereby driving lower ring coupler 130-l to move downwards. Profile 170 of central shaft 180 may thus be clamped by lower ring coupler 130-l and support ring coupler 130-s. Mating features 125 of housing 120 may mesh with and engage splines 275. Torque and/or load may thereby be transferred between the top drive and the tool.

In some embodiments, pressure actuator 140-p may be actuated to drive upper ring coupler 130-u to rotate 130-r about central axis 285, and thereby to drive lower ring coupler 130-l to move translationally 130-t in order to preload the tool stem 160.

Figure 8 provides another example of receiver assembly 110 coupling to tool adapter 150 in order to transfer torque and/or load between the top drive and the tool. In one embodiment, as illustrated in Figure 8A, coupling begins with inserting central shaft 180 of tool adapter 150 into housing 120 of receiver assembly 110. The tool adapter 150 is oriented so that splines 275 will align with mating features 235 of ring couplers 130 (shown in Figures 4B and 8B) and with mating features 125 of housing 120 (shown in Figures 4D and 8A). For example, during coupling, the ring coupler mating features 235 and the housing mating features 125 may slide between the splines 275 (*e.g.*, load splines 275-a, torque splines 275-b). Coupling proceeds in Figure 8B, as one or more stop surfaces 121 of housing 120 engage complementary stop surfaces 171 of profile 170 of central shaft 180. It should be appreciated that other stop surface configurations may be considered to accommodate manufacturing and/or operational conditions. In some embodiments, position sensors may be used in conjunction with or in lieu of stop surfaces to identify when insertion of central shaft 180 into housing 120 has completed. Likewise, optical guides may be utilized to

identify or confirm when insertion of central shaft 180 into housing 120 has completed. Coupling proceeds in Figure 8C as the profile 170 is engaged by ring couplers 130. For example, support actuators 140-s may be actuated to drive support ring coupler 130-s to rotate 130-r about central axis 285. Ring coupler mating features 235 may thereby rotate around profile 170 to engage load splines 275-a. It should be understood that, while support ring coupler 130-s is rotating 130-r about central axis 285, the weight of tool string 2 may not yet be transferred to tool adapter 150. Engagement of ring coupler mating features 235 with load splines 275-a may include being disposed in close proximity and/or making at least partial contact. Mating features 125 of housing 120 may then mesh with and/or engage torque splines 275-b. Torque and/or load may thereby be transferred between the top drive and the tool.

In some embodiments, receiver assembly 110 may include a clamp 135 and clamp actuator 145. For example, as illustrated in Figure 8C, clamp 135 may be an annular clamp, and clamp actuator 145 may be a hydraulic cylinder. Clamp 135 may move translationally 135-t relative to the housing 120. Clamp actuator 145 may drive clamp 135 to move translationally 135-t downward relative to housing 120. Load splines 275-a of profile 170 may thus be clamped by clamp 135 and support ring coupler 130-s. In some embodiments, clamp actuator 145 may be actuated to drive clamp 135 to move translationally 135-t in order to preload the tool stem 160.

In some embodiments, tool coupler 100 may provide length compensation for longitudinal positioning of tool stem 160. It may be beneficial to adjust the longitudinal position of tool stem 160, for example, to provide for threading of piping on tool string 2. Such length compensation may benefit from greater control of longitudinal positioning, motion, and/or torque than is typically available during drilling or completion operations. As illustrated in Figure 9, a compensation ring coupler 130-c may be configured to provide length compensation of tool stem 160 after load coupling of tool adapter 150 and receiver assembly 110.

Similar to support ring coupler 130-s, compensation ring coupler 130-c may rotate 130-r about central axis 285 to engage profile 170 of central shaft 180. For example, as illustrated in Figure 9A, compensation ring coupler 130-c may rotate 130-

r to engage compensation splines 275-c with ring coupler mating features 235-c. It should be understood that, while compensation ring coupler 130-c is rotating 130-r about central axis 285, the weight of tool string 2 may not yet be transferred to tool adapter 150. Engagement of ring coupler mating features 235-c with compensation splines 275-c may include being disposed in close proximity and/or making at least partial contact. In some embodiments, compensation ring coupler 130-c may be rotationally fixed to support ring coupler 130-s, so that support actuators 140-s may be actuated to drive support ring coupler 130-s and compensation ring coupler 130-c to simultaneously rotate 130-r about central axis 285.

Similar to clamp 135, compensation ring coupler 130-c may move translationally 135-t relative to the housing 120. For example, as illustrated in Figure 9B, compensation actuators 140-c may drive compensation ring coupler 130-c to move translationally 135-t relative to housing 120. More specifically, compensation actuators 140-c may drive compensation ring coupler 130-c to move translationally 135-t downward relative to housing 120, and thereby load splines 275-a of profile 170 may be clamped by compensation ring coupler 130-c and support ring coupler 130-s. In some embodiments, compensation actuators 140-c may be actuated to apply vertical force on compensation ring coupler 130-c. In some embodiments, compensation actuators 140-c may be one or more hydraulic cylinders. Actuation of the upper compensation actuator 140-c may apply a downward force and/or drive compensation ring coupler 130-c to move translationally 130-t downwards relative to housing 120 and/or support ring coupler 130-s, and thereby preload the tool stem 160. When compensation ring coupler 130-c moves downwards, mating features 235-c may push downwards on load splines 275-a. Actuation of the lower compensation actuator 140-c may apply an upward force and/or drive compensation ring coupler 130-c to move translationally 130-t upwards relative to housing 120 and/or support ring coupler 130-s, and thereby provide length compensation for tool stem 160. When compensation ring coupler 130-c moves upwards, mating features 235-c may push upwards on compensation splines 275-c. Compensation actuators 140-c may thereby cause compensation ring coupler 130-c to move translationally 130-t relative to housing 120 and/or support ring coupler 130-s. Housing 120 may have a cavity 315

to allow compensation ring coupler 130-c to move translationally 130-t. In some embodiments, compensation ring coupler 130-c may move translationally 130-t several hundred millimeters, for example, 120 mm. In some embodiments, a compensation actuator may be functionally connected to support ring coupler 130-s to provide an upward force in addition to or in lieu of a compensation actuator 140-c applying an upward force on compensation ring coupler 130-c.

One or more sensors may be used to monitor relative positions of the components of the tool coupler 100. For example, as illustrated in Figure 10, sensors may be used to identify or confirm relative alignment or orientation of receiver assembly 110 and tool adapter 150. In an embodiment, a detector 311 (*e.g.*, a magnetic field detector) may be attached to receiver assembly 110, and a marker 351 (*e.g.*, a magnet) may be attached to tool adapter 150. Prior to insertion, tool adapter 150 may be rotated relative to receiver assembly 110 until the detector 311 detects marker 351, thereby confirming appropriate orientation. It should be appreciated that a variety of orienting sensor types may be considered to accommodate manufacturing and operational conditions.

As another example, sensors may monitor the position of the ring couplers 130 relative to other components of the tool coupler 100. For example, as illustrated in Figure 11, external indicators 323 may monitor and/or provide indication of the orientation of support ring coupler 130-s. The illustrated embodiment shows rocker pins 323 positioned externally to housing 120. The rocker pins 323 are configured to engage with one or more indentions 324 on support ring coupler 130-s. By appropriately locating the indentions 324 and the rocker pins 323, the orientation of support ring coupler 130-s relative to housing 120 may be visually determined. Such an embodiment may provide specific indication regarding whether support ring coupler 130-s is oriented appropriately for receiving the load of the tool string 2 (*i.e.*, whether the ring coupler mating features 235 are oriented to engage the load splines 275-a). The load of the tool string 2 may be supported until, at least, the ring coupler mating features 235 on the support ring coupler 130-s have engaged the splines 275/275-a. For example, a spider may longitudinally supporting the tool string 2 from the rig floor 3f until the ring coupler mating features 235 on the support ring coupler 130-s have

engaged the splines 275/275-a. Likewise, during decoupling, the load of the tool string 2 may be supported prior to disengagement of the mating features 235 on the support ring coupler 130-s with the splines 275/275-a.

The relative sizes of the various components of tool coupler 100 may be selected for coupling/decoupling efficiency, load transfer efficiency, and/or torque transfer efficiency. For example, as illustrated in Figure 12, for a housing 120 having an outer diameter of between about 36 inches and about 40 inches, a clearance of 20 mm may be provided in all directions between the top of load splines 275-a and the bottom of housing mating features 125. Such relative sizing may allow for more efficient coupling in the event of initial translational misalignment between the tool adapter 150 and the receiver assembly 110. It should be understood that, once torque coupling is complete, the main body of torque splines 275-b and housing mating features 125 may only have a clearance on the order of 1 mm in all directions (*e.g.*, as illustrated in Figure 8C).

In some embodiments, guide elements may assist in aligning and/or orienting tool adapter 150 during coupling with receiver assembly 110. For example, one or more chamfer may be disposed at a lower-interior location on housing 120. One or more ridges and/or grooves may be disposed on central stem 190 to mesh with complementary grooves and/or ridges on central shaft 180. One or more pins may be disposed on tool adapter 150 to stab into holes on housing 120 to confirm and/or lock the orientation of the tool adapter 150 with the receiver assembly 110. In some embodiments, such pins/holes may provide stop surfaces to confirm complete insertion of tool adapter 150 into receiver assembly 110.

Optionally, seals, such as O-rings, may be disposed on central stem 190. The seals may be configured to be engaged only when the tool adapter 150 is fully aligned with the receiver assembly 110.

Optionally, a locking mechanism may be used that remains locked while the tool coupler 100 conveys axial load. Decoupling may only occur when tool coupler 100 is not carrying load. For example, actuators 140 may be self-locking (*e.g.*, electronic interlock or hydraulic interlock). Alternatively, a locking pin may be used.

It should be appreciated that, for tool coupler 100, a variety of configurations, sensors, actuators, and/or adapters types and/or configurations may be considered to accommodate manufacturing and operational conditions. For example, although the illustrated embodiments show a configuration wherein the ring couplers are attached to the receiver assembly, reverse configurations are envisioned (*e.g.*, wherein the ring couplers are attached to the tool adapter). Possible actuators include, for example, worm drives, hydraulic cylinders, compensation cylinders, etc. The actuators may be hydraulically, pneumatically, electrically, and/or manually controlled. In some embodiments, multiple control mechanism may be utilized to provide redundancy. One or more sensors may be used to monitor relative positions of the components of the top drive system. The sensors may be position sensors, rotation sensors, pressure sensors, optical sensors, magnetic sensors, etc. In some embodiments, stop surfaces may be used in conjunction with or in lieu of sensors to identify when components are appropriately positioned and/or oriented. Likewise, optical guides may be utilized to identify or confirm when components are appropriately positioned and/or oriented. In some embodiments, guide elements (*e.g.*, pins and holes, chamfers, etc.) may assist in aligning and/or orienting the components of tool coupler 100. Bearings and seals may be disposed between components to provide support, cushioning, rotational freedom, and/or fluid management.

In addition to the equipment and methods for coupling a top drive to one or more tools specifically described above, a number of other coupling solutions exist that may be applicable for facilitating data and/or signal (*e.g.*, modulated data) transfer. Several examples to note include US patents 8210268, 8727021, 9528326, published US patent applications 2016-0145954, 2017-0074075, 2017-0067320, 2017-0037683, and co-pending US patent applications having Serial Nos. 15/444,016, 15/445,758, 15/447,881, 15/447,926, 15/457,572, 15/607,159, 15/627,428. For ease of discussion, the following disclosure will address the tool coupler embodiment of Figures 8A-8C, though many similar tool couplers are considered within the scope of this disclosure.

A variety of data may be collected along a tool string and/or downhole, including pressure, temperature, stress, strain, fluid flow, vibration, rotation, salinity, relative

positions of equipment, relative motions of equipment, etc. Some data may be collected by making measurements at various points proximal the tool string (sometimes referred to as "along string measurements" or ASM). Downhole data may be collected and transmitted to the surface for storage, analysis, and/or processing. Downhole data may be collected and transmitted through a downhole data network. The downhole data may then be transmitted to one or more stationary components, such as a computer on the oil rig, via a stationary data uplink. Control signals may be generated at the surface, sometimes in response to downhole data. Control signals may be transmitted along the tool string and/or downhole (*e.g.*, in the form of modulated data) to actuate equipment and/or otherwise affect tool string and/or downhole operations. Downhole data and/or surface data may be transmitted between the generally rotating tool string and the generally stationary drilling rig bi-directionally. As previously discussed, embodiments may provide automatic connection for power, data, and/or signal communications between top drive 4 and tool string 2. The housing 120 of the receiver assembly 110 may be connected to top drive 4. The tool stem 160 of the tool adapter 150 may connect the tool coupler 100 to the tool string 2. Tool coupler 100 may thereby facilitate transmission of data between the tool string 2 and the top drive 4.

Data may be transmitted along the tool string through a variety of mechanisms (*e.g.*, downhole data networks), for example mud pulse telemetry, electromagnetic telemetry, fiber optic telemetry, wired drill pipe (WDP) telemetry, acoustic telemetry, etc.. For example, WDP networks may include conventional drill pipe that has been modified to accommodate an inductive coil embedded in a secondary shoulder of both the pin and box. Data links may be used at various points along the tool string to clean and/or boost the data signal for improved signal-to-noise ratio. ASM sensors may be used in WDP networks, for example to measure physical parameters such as pressure, stress, strain, vibration, rotation, etc.

Figure 13 illustrates an exemplary tool coupler 100 that facilitates transmission of data between the tool string 2 and the top drive 4. As illustrated, tool coupler 100 includes a hydraulic swivel 520 and a data swivel 530. The hydraulic swivel 520 and data swivel 530 may be located above the housing 120 on receiver assembly 110.

The hydraulic swivel 520 and data swivel 530 may be coaxial with the receiver assembly 110, with either hydraulic swivel 520 above data swivel 530, or vice versa. Each swivel may serve as a coupling between the generally rotating tool string 2 and the generally stationary top drive 4. Hydraulic swivel 520 may have hydraulic stator lines 522 connected to stationary components. Hydraulic swivel 520 may have hydraulic rotator lines 523 connected to hydraulic coupling 525 (*e.g.*, quick connect) on receiver assembly 110. Hydraulic coupling 525 may make a hydraulic connection between hydraulic lines in receiver assembly 110 and hydraulic lines in tool adapter 150. For example, hydraulic coupling 525 may make a hydraulic connection between hydraulic rotator lines 523 in receiver assembly 110 and hydraulic lines 527 (*e.g.*, hydraulic lines to an upper IBOP and/or to a lower IBOP) in tool stem 160. Data swivel 530 may have data stator lines 532 connected to stationary components (*e.g.*, a computer on the drilling rig derrick 3d or drilling rig floor 3f). Data swivel 530 may have data rotator lines 533 (*e.g.*, electric wires or fiber optic cables) connected to data coupling 535 (*e.g.*, quick connect) on receiver assembly 110. Data swivel 530 may thereby act as a stationary data uplink, extracting and/or relaying data from the rotating tool string 2 to the stationary rig computer. In some embodiments, data may be communicated bi-directionally by data swivel 530. Data coupling 535 may make a data connection between data lines (*e.g.*, electric wires or fiber optic cables) in receiver assembly 110 and data lines (*e.g.*, electric wires or fiber optic cables) in tool adapter 150. For example, data coupling 535 may make a data connection between data rotator lines 533 in receiver assembly 110 and data lines 537 (*e.g.*, data lines to a WDP network) in tool stem 160.

Figure 14 illustrates another exemplary tool coupler 100 that facilitates transmission of data between the tool string 2 and the top drive 4. As illustrated, tool coupler 100 includes a hydraulic swivel 520, similar to that of Figure 13, but no data swivel 530. Rather, tool coupler 100 of Figure 14 includes a wireless module 540. Wireless module 540 may be configured to communicate wirelessly (*e.g.*, via Wi-Fi, Bluetooth, and/or radio signals 545) with stationary components (*e.g.*, a computer on the drilling rig derrick 3d or drilling rig floor 3f). Wireless module 540 may make a data connection with data lines in tool adapter 150. For example, wireless module 540 may

make a data connection with data lines 537 (*e.g.*, data lines to a WDP network) in tool stem 160. Wireless module 540 may thereby act as a stationary data uplink, extracting and/or relaying data from the rotating tool string 2 to the stationary rig computer. In some embodiments, wireless module 540 may provide bi-directional, wireless communication between the rotating tool string 2 and the stationary rig computer.

In Figure 14, tool coupler 100 may optionally include an electric power supply. For example, electric power may be supplied to components of tool coupler 100 via an inductor 550. The inductor 550 may be located above the housing 120 on receiver assembly 110. The inductor 550 may include a generally rotating interior cylinder and a generally stationary exterior cylinder, each coaxial with the receiver assembly 110. Either hydraulic swivel 520 may be above inductor 550, or vice versa. Inductor 550 may serve as a coupling between the generally rotating tool string 2 and the generally stationary top drive 4. Inductor 550 may have power rotator lines 553 connected to power coupling 555 (*e.g.*, quick connect) on receiver assembly 110. Inductor 550 may supply power to components of tool adapter 150. For example, power coupling 555 may make a power connection between power rotator lines 553 in receiver assembly 110 and power lines 557 (*e.g.*, power lines to wireless module 540) in tool stem 160.

Figure 15 illustrates another exemplary tool coupler 100 wherein the optional electric power supply may include a battery, in addition to, or in lieu of, inductor 550. For example, electric power may be supplied to components of tool adapter 150 via battery 560. The battery 560 may be located near (*e.g.*, above) the wireless module 540 on tool adapter 150. Battery 560 may supply power to components of tool adapter 150 (*e.g.*, wireless module 540) in tool stem 160. In embodiments having both inductor 550 and battery 560, the battery 560 may act as a supplemental and/or back-up power supply. Power from inductor 550 may maintain the charge of battery 560.

Figure 16 illustrates another exemplary tool coupler 100 that facilitates transmission of data between the tool string 2 and the top drive 4. As illustrated, tool coupler 100 includes a hydraulic swivel 520, similar to that of Figure 14, but no wireless module 540. Rather, tool coupler 100 of Figure 16 includes a wireless transceiver 570. Similar to wireless module 540, wireless transceiver 570 may be

configured to communicate wirelessly (*e.g.*, via Wi-Fi, Bluetooth, and/or radio signals 575) with stationary components (*e.g.*, a computer on the drilling rig derrick 3d or drilling rig floor 3f). Wireless transceiver 570 may make a wireless data connection with a data network (*e.g.*, an acoustic telemetry network) in tool string 2. In some embodiments, wireless transceiver 570 includes a wireless module, similar to wireless module 540, and an electronic acoustic receiver (EAR). For example, wireless transceiver 570 may utilize an EAR to communicate acoustically with distributed measurement nodes along tool string 2. In some embodiments, wireless transceiver 570 may be configured to communicate wirelessly with an electromagnetic telemetry network (*e.g.*, an Wi-Fi, Bluetooth, and/or radio network) in tool string 2. In some embodiments, wireless transceiver 570 may be configured to communicate acoustically with stationary components (*e.g.*, a computer on the drilling rig derrick 3d or drilling rig floor 3f). Wireless transceiver 570 may thereby act as a stationary data uplink, extracting and/or relaying data (*e.g.*, ASM) from the rotating tool string 2 to the stationary rig computer. In some embodiments, wireless transceiver 570 may provide bi-directional, wireless communication between the rotating tool string 2 and the stationary rig computer.

Similar to the tool coupler 100 of Figure 14, tool coupler 100 of Figure 16 may optionally include an electric power supply. For example, electric power may be supplied to components of tool coupler 100 via inductor 550. Inductor 550 may have power rotator lines 553 connected to power coupling 555 (*e.g.*, quick connect) on receiver assembly 110. Inductor 550 may thereby supply power to wireless transceiver 570 in tool stem 160.

Figure 17 illustrates another exemplary tool coupler 100 that facilitates transmission of data between the tool string 2 and the top drive 4. Similar to the tool coupler 100 of Figure 15, the tool coupler of Figure 17 includes an optional electric power supply that may include a battery, in addition to, or in lieu of, inductor 550. For example, battery 560 may supply electric power to wireless transceiver 570 in tool stem 160.

During some operations, tool adapter 150 may be a casing running tool adapter. For example, Figures 18A-F show an exemplary embodiment of a drilling system 1 having a tool coupler 100 with a casing running tool adapter 450. Figure 18A illustrates casing 30 being presented at rig floor 3f. Tool coupler 100 includes receiver assembly 110 and casing running tool adapter 450. As illustrated, casing running tool adapter 450 includes two bails 422 and a central spear 423. The bails 422 may be pivoted relative to the top drive 4, as illustrated in Figures 18A-B. In some embodiments, the length of bails 422 may be adjustable. In some embodiments, casing running tool adapter 450 may include only one bail 422, while in other embodiments casing running tool adapter 450 may include three, four, or more bails 422. Bails 422 may couple at a distal end to a casing feeder 420. Casing feeder 420 may be able to pivot at the end of bails 422. The pivot angle of casing feeder 420 may be adjustable.

As illustrated in Figure 18B, the casing running tool adapter 450 may be lowered toward the rig floor 3f to allow the bails 422 to swing the casing feeder 420 to pick up a casing 30. The casing feeder 420 may be pivoted relative to the bails 422 so that the casing 30 may be inserted into the central opening of casing feeder 420. Once the casing 30 is inserted, clamping cylinders of the casing feeder 420 may be actuated to engage and/or grip the casing 30. In some embodiments, the grip strength of the clamping cylinders may be adjustable, and/or the gripping diameter of the casing feeder 420 may be adjustable. In some embodiments, sensors on casing feeder 420 may collect data regarding the gripping of the casing (*e.g.*, casing location, casing orientation, casing outer diameter, gripping diameter, clamping force applied, etc.) The data may be communicated to a stationary computer for logging, processing, analysis, and or decision making, for example through data swivel 530, wireless module 540, and/or wireless transceiver 570.

As illustrated in Figure 18C, the casing running tool adapter 450 may then be lifted by the traveling block, thereby raising the casing feeder 420 and the casing 30. After the casing 30 is lifted off the ground and/or lower support, the casing feeder 420 and the casing 30 may be swung toward the center of the drilling rig derrick 3d. In some embodiments, sensors on casing running tool adapter 450 may collect data

regarding the orientation and/or position of the casing (*e.g.*, casing location relative to the spear 423, casing orientation relative to the spear 423, etc.) The data may be communicated to a stationary computer for logging, processing, analysis, and or decision making, for example through data swivel 530, wireless module 540, and/or wireless transceiver 570.

As illustrated in Figures 18C-E, the bails 422, the casing feeder 420, and the casing 30 may be oriented and positioned to engage with casing running tool adapter 450. For example, casing feeder 420 and casing 30 may be positioned in alignment with the casing running tool adapter 450. Feeders (*e.g.*, drive rollers) of casing feeder 420 may be actuated to lift the casing 30 toward the spear 423 of the casing running tool adapter 450, and/or the length of the bails 422 may be adjusted to lift the casing 30 toward the spear 423 of the casing running tool adapter 450. In this manner, the casing 30 may be quickly and safely oriented and positioned for engagement with the casing running tool adapter 450. Figure 18F illustrates casing 30 fully engaged with casing running tool adapter 450. In some embodiments, sensors on tool coupler 100 and/or on the casing running tool adapter 450 may collect data regarding the orientation and/or position of the casing relative to the casing running tool adapter 450 (*e.g.*, orientation, position, number of threading turns, torque applied, etc.) The data may be communicated to a stationary computer for logging, processing, analysis, and or decision making, for example through data swivel 530, wireless module 540, and/or wireless transceiver 570.

In an embodiment, a tool coupler includes a first component comprising: a ring coupler having mating features and rotatable between a first position and a second position; an actuator functionally connected to the ring coupler to rotate the ring coupler between the first position and the second position; and a second component comprising a profile complementary to the ring coupler.

In one or more embodiments disclosed herein, with the ring coupler in the first position, the mating features do not engage the profile; and with the ring coupler in the second position, the mating features engage the profile to couple the first component to the second component.

In one or more embodiments disclosed herein, the first component comprises a housing, the second component comprises a central shaft, and the profile is disposed on an outside of the central shaft.

In one or more embodiments disclosed herein, the first component comprises a central shaft, the second component comprises a housing, and the profile is disposed on an inside of the housing.

In one or more embodiments disclosed herein, the first component is a receiver assembly and the second component is a tool adapter.

In one or more embodiments disclosed herein, a rotation of the ring coupler is around a central axis of the tool coupler.

In one or more embodiments disclosed herein, the ring coupler is a single component forming a complete ring.

In one or more embodiments disclosed herein, the actuator is fixedly connected to the housing.

In one or more embodiments disclosed herein, the ring coupler is configured to rotate relative to the housing, to move translationally relative to the housing, or to both rotate and move translationally relative to the housing.

In one or more embodiments disclosed herein, the actuator is functionally connected to the ring coupler to cause the ring coupler to rotate relative to the housing, to move translationally relative to the housing, or to both rotate and move translationally relative to the housing.

In one or more embodiments disclosed herein, the first component further comprises a central stem having an outer diameter less than an inner diameter of the central shaft.

In one or more embodiments disclosed herein, when the first component is coupled to the second component, the central stem and the central shaft share a central bore.

In one or more embodiments disclosed herein, the housing includes mating features disposed on an interior of the housing and complementary to the profile.

In one or more embodiments disclosed herein, the profile and the housing mating features are configured to transfer torque between the first component and the second component.

In one or more embodiments disclosed herein, when the first component is coupled to the second component, the housing mating features are interleaved with features of the profile.

In one or more embodiments disclosed herein, the profile includes convex features on an outside of the central shaft.

In one or more embodiments disclosed herein, the profile comprises a plurality of splines that run vertically along an outside of the central shaft.

In one or more embodiments disclosed herein, the splines are distributed symmetrically about a central axis of the central shaft.

In one or more embodiments disclosed herein, each of the splines have a same width.

In one or more embodiments disclosed herein, the profile comprises at least two discontiguous sets of splines distributed vertically along the outside of the central shaft.

In one or more embodiments disclosed herein, the mating features comprise a plurality of mating features that run vertically along an interior thereof.

In one or more embodiments disclosed herein, the mating features include convex features on an inner surface of the ring coupler.

In one or more embodiments disclosed herein, the mating features are distributed symmetrically about a central axis of the ring coupler.

In one or more embodiments disclosed herein, each of the mating features are the same width.

In one or more embodiments disclosed herein, the ring coupler comprises cogs distributed on an outside thereof.

In one or more embodiments disclosed herein, the actuator has gearing that meshes with the cogs.

In one or more embodiments disclosed herein, the actuator comprises at least one of a worm drive and a hydraulic cylinder.

In one or more embodiments disclosed herein, the housing has a linear rack on an interior thereof; the ring coupler has threading on an outside thereof; and the ring coupler and the linear rack are configured such that rotation of the ring coupler causes the ring coupler to move translationally relative to the housing.

In one or more embodiments disclosed herein, the first component further comprises a second ring coupler; the actuator is configured to drive the ring coupler to rotate about a central axis; and the ring coupler is configured to drive the second ring coupler to move translationally relative to the housing.

In one or more embodiments disclosed herein, the first component further comprises a second actuator and a second ring coupler.

In one or more embodiments disclosed herein, the second actuator is functionally connected to the second ring coupler.

In one or more embodiments disclosed herein, the second actuator is functionally connected to the ring coupler.

In one or more embodiments disclosed herein, the first component further comprises a wedge bushing below the ring coupler.

In one or more embodiments disclosed herein, the first component further comprises an external indicator indicative of an orientation of the ring coupler.

In one or more embodiments disclosed herein, the first component further comprises a second ring coupler and a second actuator; and the second actuator is functionally connected to the second ring coupler to cause the second ring coupler to move translationally relative to the ring coupler.

In one or more embodiments disclosed herein, the second ring coupler is rotationally fixed to the ring coupler.

In one or more embodiments disclosed herein, the profile comprises a first set of splines and a second set of splines, each distributed vertically along the outside of the central shaft; and the first set of splines is discontiguous with the second set of splines.

In one or more embodiments disclosed herein, the ring coupler includes mating features on an interior thereof that are complementary with the first set of splines; and the second ring coupler includes mating features on an interior thereof that are complementary with the second set of splines.

In one or more embodiments disclosed herein, when the central shaft is inserted into the housing, the first set of splines is between the ring coupler and the second ring coupler.

In one or more embodiments disclosed herein, the second ring coupler is capable of pushing downwards on the first set of splines; and the second ring coupler is capable of pushing upwards on the second set of splines.

In one or more embodiments disclosed herein, the second actuator comprises an upwards actuator that is capable of applying an upwards force on the second ring coupler, and a downwards actuator that is capable of applying a downwards force on the second ring coupler.

In one or more embodiments disclosed herein, the actuator comprises an upwards actuator that is capable of applying an upwards force on the ring coupler, and the second actuator comprises a downwards actuator that is capable of applying a downwards force on the second ring coupler.

In an embodiment, a method of coupling a first component to a second component includes inserting a central shaft of the first component into a housing of the second component; rotating a ring coupler around the central shaft; and engaging mating features of the ring coupler with a profile, wherein the profile is on an outside of the central shaft or an inside of the housing.

In one or more embodiments disclosed herein, the first component is a tool adapter and the second component is a receiver assembly.

In one or more embodiments disclosed herein, the method also includes, after engaging the mating features, longitudinally positioning a tool stem connected to the central shaft.

In one or more embodiments disclosed herein, the method also includes detecting when inserting the central shaft into the housing has completed.

In one or more embodiments disclosed herein, the profile comprises a plurality of splines distributed on an outside of the central shaft.

In one or more embodiments disclosed herein, the method also includes sliding the ring coupler mating features between the splines.

In one or more embodiments disclosed herein, the method also includes sliding a plurality of housing mating features between the splines.

In one or more embodiments disclosed herein, the method also includes, prior to inserting the central shaft, detecting an orientation of the splines relative to mating features of the housing.

In one or more embodiments disclosed herein, an actuator drives the ring coupler to rotate about a central axis of the ring coupler.

In one or more embodiments disclosed herein, rotating the ring coupler comprises rotation of less than a full turn.

In one or more embodiments disclosed herein, the method also includes, after engaging the mating features with the profile, transferring at least one of torque and load between the first component and the second component.

In one or more embodiments disclosed herein, the profile comprises an upper set and a lower set of splines distributed vertically along the outside of the central shaft; and the ring coupler rotates between the two sets of splines.

In one or more embodiments disclosed herein, the method also includes interleaving the lower set of splines with a plurality of housing mating features.

In one or more embodiments disclosed herein, the method also includes, after engaging the ring coupler mating features with the profile: transferring torque between the lower set of splines and the housing mating features, and transferring load between the upper set of splines and the ring coupler mating features.

In an embodiment, a method of coupling a first component to a second component includes inserting a central shaft of the first component into a housing of the second component; rotating a first ring coupler around the central shaft; and clamping a profile using the first ring coupler and a second ring coupler, wherein the profile is on an outside of the central shaft or an inside of the housing.

In one or more embodiments disclosed herein, the first component is a tool adapter and the second component is a receiver assembly.

In one or more embodiments disclosed herein, the method also includes, after rotating the first ring coupler, rotating a third ring coupler around the central shaft, wherein: rotating the first ring coupler comprises rotation of less than a full turn, and rotating the third ring coupler comprise rotation of more than a full turn.

In one or more embodiments disclosed herein, rotating the first ring coupler causes rotation of the second ring coupler.

In one or more embodiments disclosed herein, the method also includes, after rotating the first ring coupler, moving the second ring coupler translationally relative to the housing.

In one or more embodiments disclosed herein, the method also includes, after rotating the first ring coupler: rotating a third ring coupler around the central shaft; and moving the second ring coupler and the third ring coupler translationally relative to the housing.

In one or more embodiments disclosed herein, the method also includes, after clamping the profile, transferring at least one of torque and load between the first component and the second component.

In an embodiment, a method of coupling a first component to a second component includes inserting a central shaft of the first component into a housing of

the second component; rotating a first ring coupler around the central shaft; and moving a second ring coupler vertically relative to the housing to engage a profile, wherein the profile is on an outside of the central shaft or an inside of the housing.

In one or more embodiments disclosed herein, the first component is a tool adapter and the second component is a receiver assembly.

In one or more embodiments disclosed herein, engaging the profile comprises at least one of: clamping first splines of the profile between the first ring coupler and the second ring coupler; and pushing upwards on second splines of the profile.

In one or more embodiments disclosed herein, engaging the profile comprises both, at different times: pushing downward on first splines of the profile; and pushing upwards on second splines of the profile.

In one or more embodiments disclosed herein, the method also includes supporting a load from the first splines of the profile with the first ring coupler.

In an embodiment, a tool coupler includes a receiver assembly connectable to a top drive; a tool adapter connectable to a tool string, wherein a coupling between the receiver assembly and the tool adapter transfers at least one of torque and load therebetween; and a stationary data uplink comprising at least one of: a data swivel coupled to the receiver assembly; a wireless module coupled to the tool adapter; and a wireless transceiver coupled to the tool adapter.

In one or more embodiments disclosed herein, the stationary data uplink comprises the data swivel coupled to the receiver assembly, and the data swivel is communicatively coupled with a stationary computer by data stator lines.

In one or more embodiments disclosed herein, the stationary data uplink comprises the data swivel coupled to the receiver assembly, the tool coupler further comprising a data coupling between the receiver assembly and the tool adapter.

In one or more embodiments disclosed herein, the data swivel is communicatively coupled with the data coupling by data rotator lines.

In one or more embodiments disclosed herein, the data coupling is communicatively coupled with a downhole data feed comprising at least one of: a mud

pulse telemetry network, an electromagnetic telemetry network, a wired drill pipe telemetry network, and an acoustic telemetry network.

In one or more embodiments disclosed herein, the stationary data uplink comprises the wireless module coupled to the tool adapter, and the wireless module is communicatively coupled with a stationary computer by at least one of: Wi-Fi signals, Bluetooth signals, and radio signals.

In one or more embodiments disclosed herein, the stationary data uplink comprises the wireless module coupled to the tool adapter, and the wireless module is communicatively coupled with a downhole data feed comprising at least one of: a mud pulse telemetry network, an electromagnetic telemetry network, a wired drill pipe telemetry network, and an acoustic telemetry network.

In one or more embodiments disclosed herein, the stationary data uplink comprises the wireless transceiver coupled to the tool adapter, and the wireless transceiver comprises an electronic acoustic receiver.

In one or more embodiments disclosed herein, the wireless transceiver is communicatively coupled with a stationary computer by at least one of: Wi-Fi signals, Bluetooth signals, radio signals, and acoustic signals.

In one or more embodiments disclosed herein, the wireless transceiver is wirelessly communicatively coupled with a downhole data feed comprising at least one of: a mud pulse telemetry network, an electromagnetic telemetry network, a wired drill pipe telemetry network, and an acoustic telemetry network.

In one or more embodiments disclosed herein, the tool coupler also includes an electric power supply for the stationary data uplink.

In one or more embodiments disclosed herein, the electric power supply comprises at least one of: an inductor coupled to the receiver assembly, and a battery coupled to the tool adapter.

In an embodiment, a method of operating a tool string includes coupling a receiver assembly to a tool adapter to transfer at least one of torque and load therebetween, the tool adapter being connected to the tool string; collecting data at

one or more points proximal the tool string; and communicating the data to a stationary computer while rotating the tool adapter.

In one or more embodiments disclosed herein, communicating the data to the stationary computer comprises transmitting the data through a downhole data network comprising at least one of: a mud pulse telemetry network, an electromagnetic telemetry network, a wired drill pipe telemetry network, and an acoustic telemetry network.

In one or more embodiments disclosed herein, communicating the data to the stationary computer comprises transmitting the data through a stationary data uplink comprising at least one of: a data swivel coupled to the receiver assembly; a wireless module coupled to the tool adapter; and a wireless transceiver coupled to the tool adapter.

In one or more embodiments disclosed herein, the method also includes supplying power to the stationary data uplink with an electric power supply that comprises at least one of: an inductor coupled to the receiver assembly, and a battery coupled to the tool adapter.

In one or more embodiments disclosed herein, the method also includes communicating a control signal to the tool string.

In an embodiment, a top drive system for handling a tubular includes a top drive; a receiver assembly connectable to the top drive; a casing running tool adapter, wherein a coupling between the receiver assembly and the casing running tool adapter transfers at least one of torque and load therebetween; and a stationary data uplink comprising at least one of: a data swivel coupled to the receiver assembly; a wireless module coupled to the casing running tool adapter; and a wireless transceiver coupled to the casing running tool adapter; wherein the casing running tool adapter comprises: a spear; a plurality of bails, and a casing feeder at a distal end of the plurality of bails, wherein, the casing feeder is pivotable at the distal end of the plurality of bails, the plurality of bails are pivotable relative to the spear, and the casing feeder is configured to grip casing.

In one or more embodiments disclosed herein, at least one of: a length of at least one of the plurality of bails is adjustable to move the casing relative to the spear; and feeders of the casing feeder are actuatable to move the casing relative to the spear.

In an embodiment, a method of handling a tubular includes coupling a receiver assembly to a tool adapter to transfer at least one of torque and load therebetween; gripping the tubular with a casing feeder of the tool adapter; orienting and positioning the tubular relative to the tool adapter; connecting the tubular to the tool adapter; collecting data including at least one of: tubular location, tubular orientation, tubular outer diameter, gripping diameter, clamping force applied, number of threading turns, and torque applied; and communicating the data to a stationary computer while rotating the tool adapter.

While the foregoing is directed to embodiments of the present disclosure, other and further embodiments of the disclosure may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

Claims:

1. A tool coupler, comprising:

a receiver assembly connectable to a top drive;

a tool adapter connectable to a tool string, wherein a coupling between the receiver assembly and the tool adapter transfers at least one of torque and load therebetween; and

a stationary data uplink comprising at least one of:

a data swivel coupled to the receiver assembly;

a wireless module coupled to the tool adapter; and

a wireless transceiver coupled to the tool adapter.

2. The tool coupler of claim 1, wherein:

the stationary data uplink comprises the data swivel coupled to the receiver assembly, and

the data swivel is communicatively coupled with a stationary computer by data stator lines.

3. The tool coupler of claim 1, wherein the stationary data uplink comprises the data swivel coupled to the receiver assembly, the tool coupler further comprising a data coupling between the receiver assembly and the tool adapter.

4. The tool coupler of claim 3, wherein the data swivel is communicatively coupled with the data coupling by data rotator lines.

5. The tool coupler of claim 3, wherein the data coupling is communicatively coupled with a downhole data feed comprising at least one of:

a mud pulse telemetry network,

an electromagnetic telemetry network,

a wired drill pipe telemetry network, and

an acoustic telemetry network.

6. The tool coupler of claim 1, wherein:

the stationary data uplink comprises the wireless module coupled to the tool adapter, and

the wireless module is communicatively coupled with a stationary computer by at least one of:

Wi-Fi signals,

Bluetooth signals, and

radio signals.

7. The tool coupler of claim 1, wherein:

the stationary data uplink comprises the wireless module coupled to the tool adapter, and

the wireless module is communicatively coupled with a downhole data feed comprising at least one of:

a mud pulse telemetry network,

an electromagnetic telemetry network,

a wired drill pipe telemetry network, and

an acoustic telemetry network.

8. The tool coupler of claim 1, wherein:

the stationary data uplink comprises the wireless transceiver coupled to the tool adapter, and

the wireless transceiver comprises an electronic acoustic receiver.

9. The tool coupler of claim 8, wherein the wireless transceiver is communicatively coupled with a stationary computer by at least one of:

Wi-Fi signals,

Bluetooth signals,

radio signals, and

acoustic signals.

10. The tool coupler of claim 8, wherein the wireless transceiver is wirelessly communicatively coupled with a downhole data feed comprising at least one of:

a mud pulse telemetry network,

an electromagnetic telemetry network,

a wired drill pipe telemetry network, and

an acoustic telemetry network.

11. The tool coupler of claim 1, further comprising an electric power supply for the stationary data uplink.

12. The tool coupler of claim 11, wherein the electric power supply comprises at least one of:

an inductor coupled to the receiver assembly, and

a battery coupled to the tool adapter.

13. A method of operating a tool string comprising:

coupling a receiver assembly to a tool adapter to transfer at least one of torque and load therebetween, the tool adapter being connected to the tool string;

collecting data at one or more points proximal the tool string; and

communicating the data to a stationary computer while rotating the tool adapter.

14. The method of claim 13, wherein communicating the data to the stationary computer comprises transmitting the data through a downhole data network comprising at least one of:

a mud pulse telemetry network,

an electromagnetic telemetry network,

a wired drill pipe telemetry network, and

an acoustic telemetry network.

15. The method of claim 13, wherein communicating the data to the stationary computer comprises transmitting the data through a stationary data uplink comprising at least one of:

a data swivel coupled to the receiver assembly;

a wireless module coupled to the tool adapter; and

a wireless transceiver coupled to the tool adapter.

16. The method of claim 15, further comprising supplying power to the stationary data uplink with an electric power supply that comprises at least one of:

an inductor coupled to the receiver assembly, and

a battery coupled to the tool adapter.

17. The method of claim 13, further comprising communicating a control signal to the tool string.

18. A top drive system for handling a tubular, comprising:

a top drive;

a receiver assembly connectable to the top drive;

a casing running tool adapter, wherein a coupling between the receiver assembly and the casing running tool adapter transfers at least one of torque and load therebetween; and

a stationary data uplink comprising at least one of:

a data swivel coupled to the receiver assembly;

a wireless module coupled to the casing running tool adapter; and

a wireless transceiver coupled to the casing running tool adapter;

wherein the casing running tool adapter comprises:

a spear;

a plurality of bails, and

a casing feeder at a distal end of the plurality of bails, wherein, the casing feeder is pivotable at the distal end of the plurality of bails, the plurality of bails

are pivotable relative to the spear, and the casing feeder is configured to grip casing.

19. The top drive system of claim 18, wherein at least one of:

a length of at least one of the plurality of bails is adjustable to move the casing relative to the spear; and

feeders of the casing feeder are actuatable to move the casing relative to the spear.

20. A method of handling a tubular comprising:

coupling a receiver assembly to a tool adapter to transfer at least one of torque and load therebetween;

gripping the tubular with a casing feeder of the tool adapter;

orienting and positioning the tubular relative to the tool adapter;

connecting the tubular to the tool adapter;

collecting data including at least one of: tubular location, tubular orientation, tubular outer diameter, gripping diameter, clamping force applied, number of threading turns, and torque applied; and

communicating the data to a stationary computer while rotating the tool adapter.

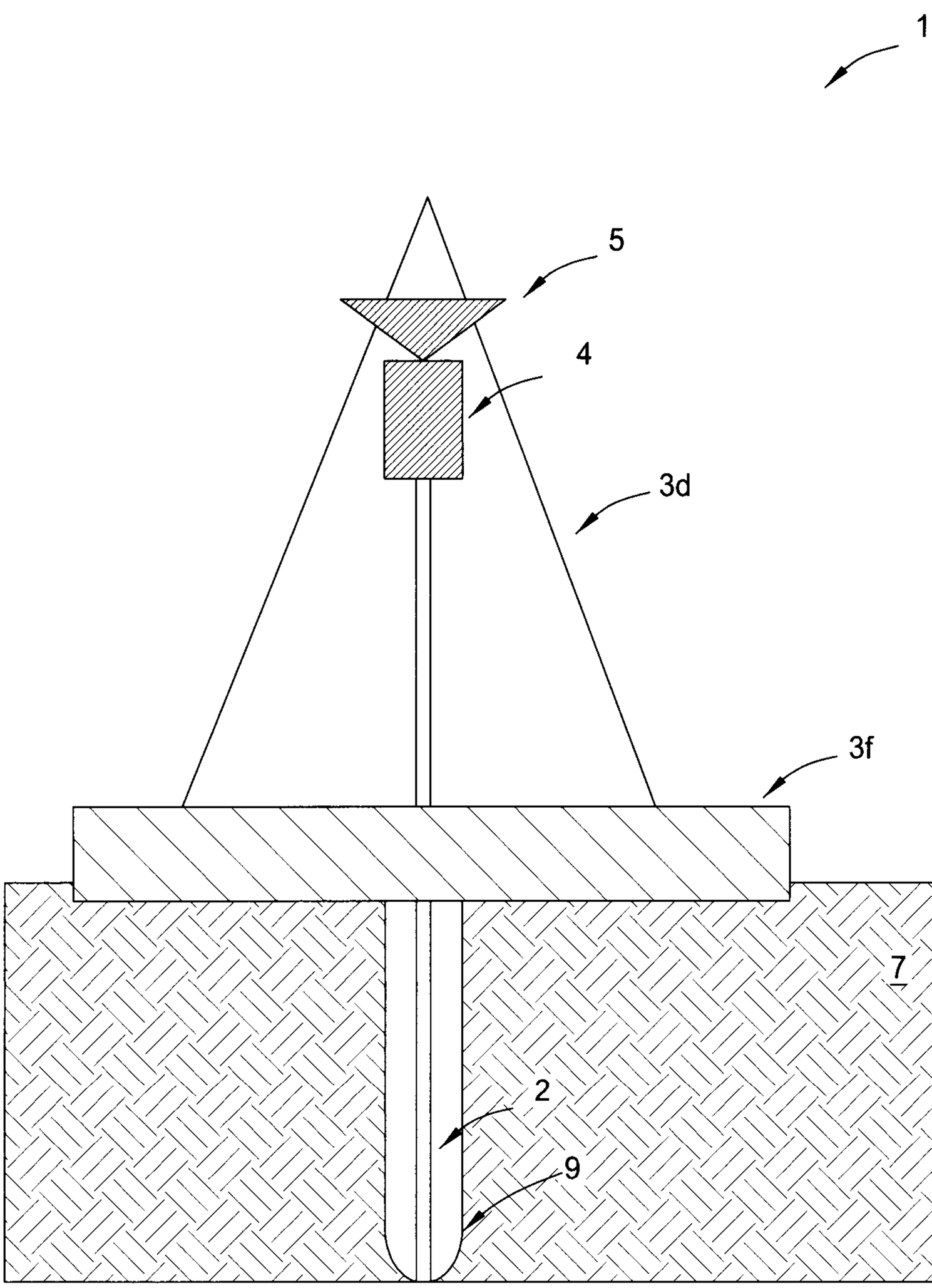


FIG. 1

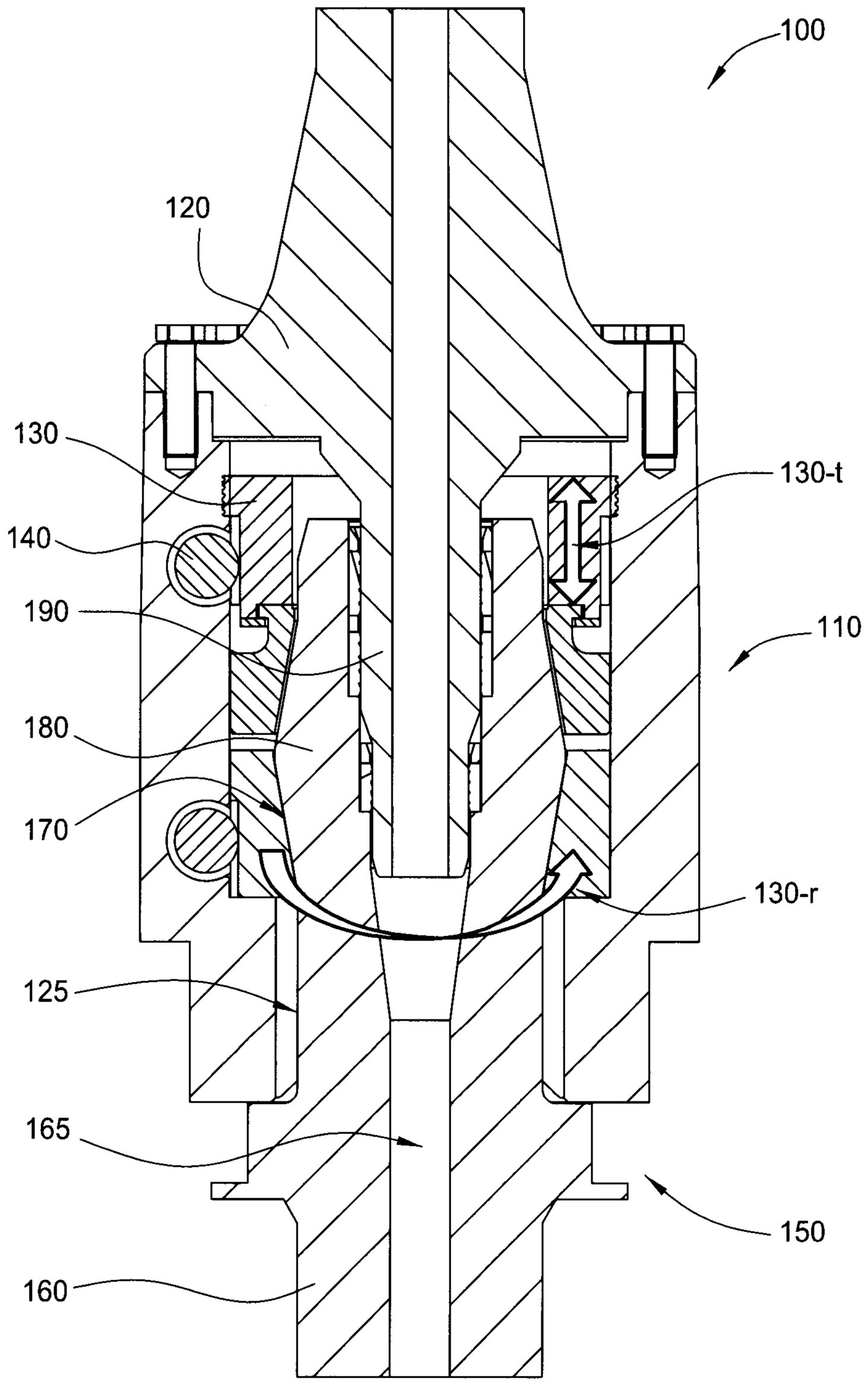


FIG. 2A

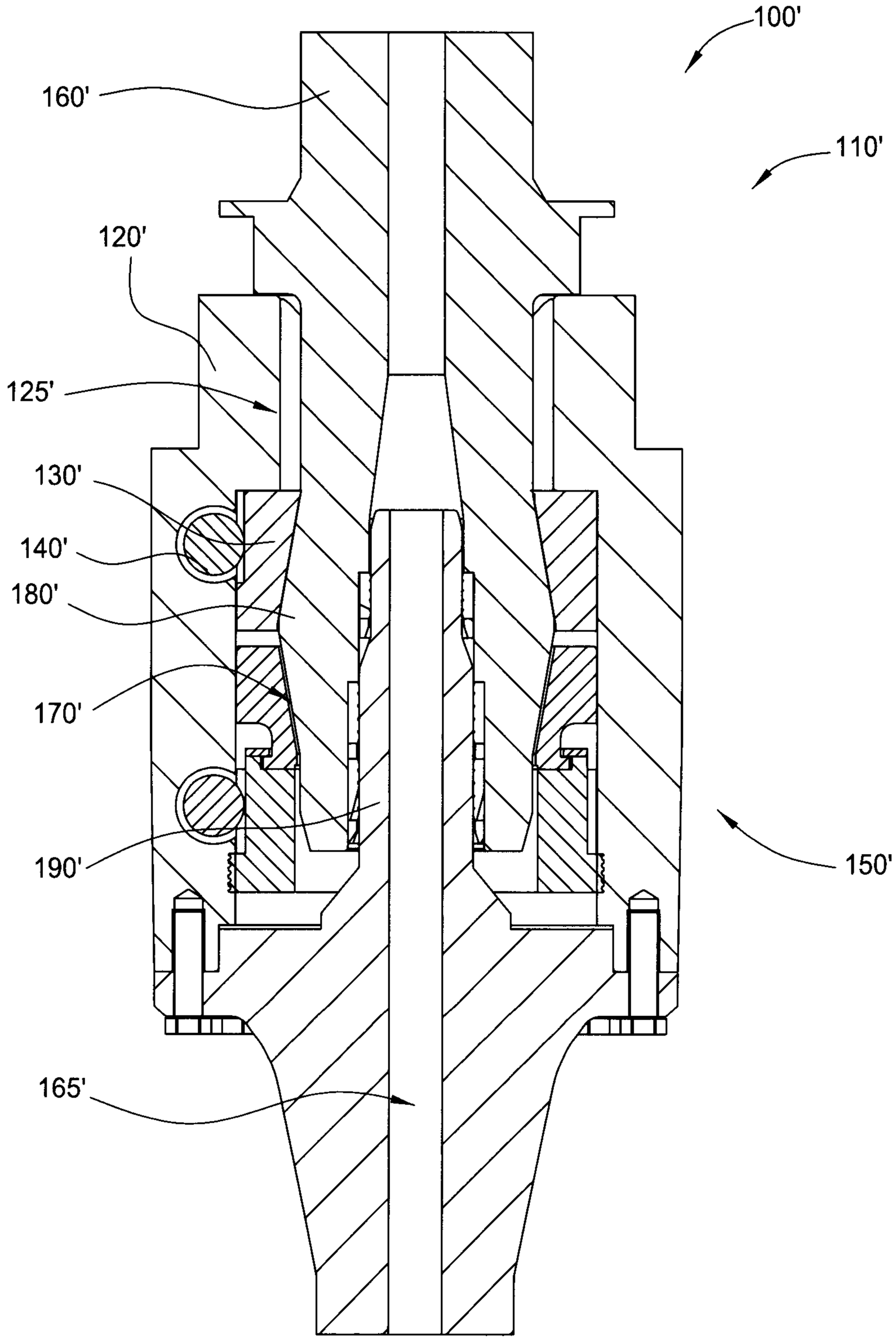
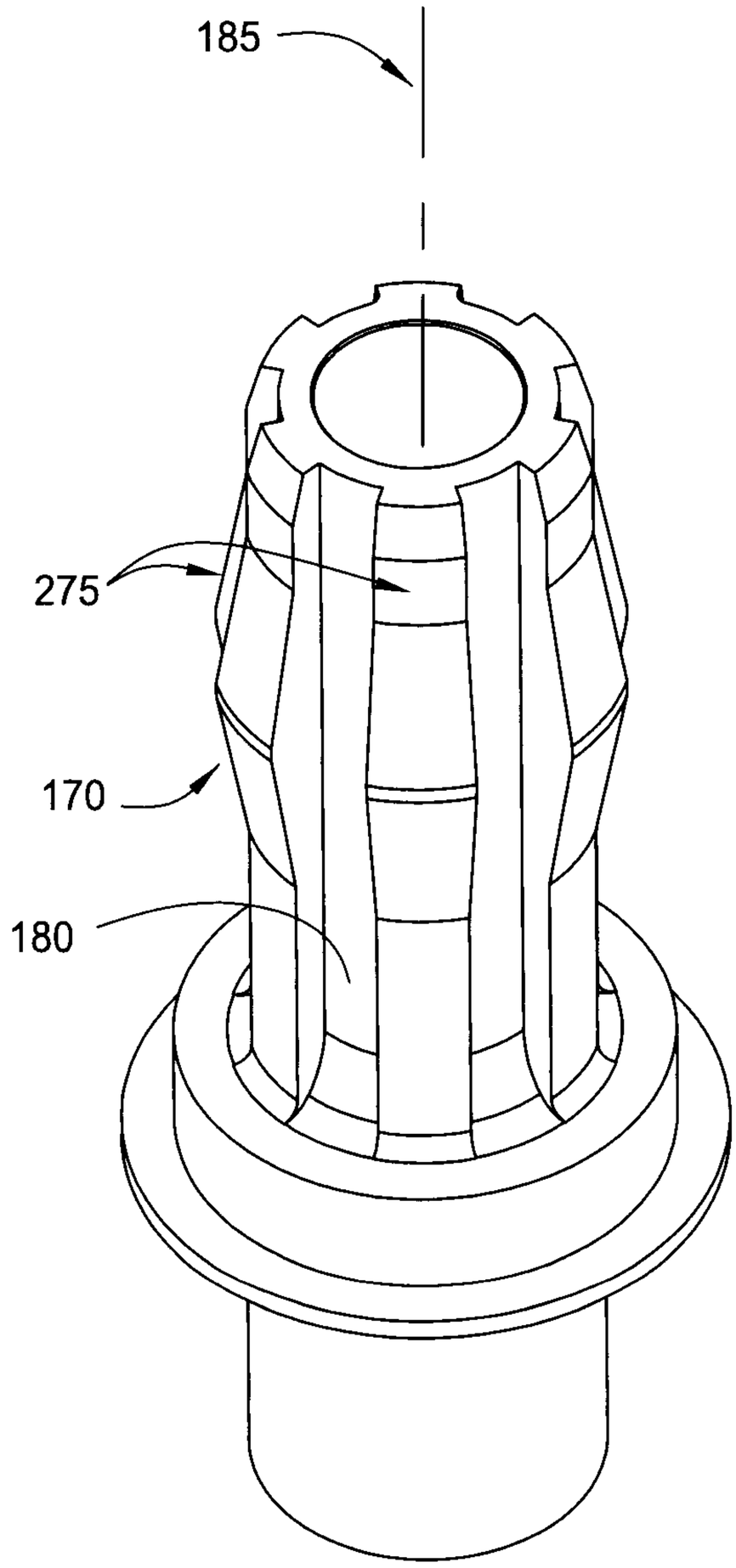


FIG. 2B



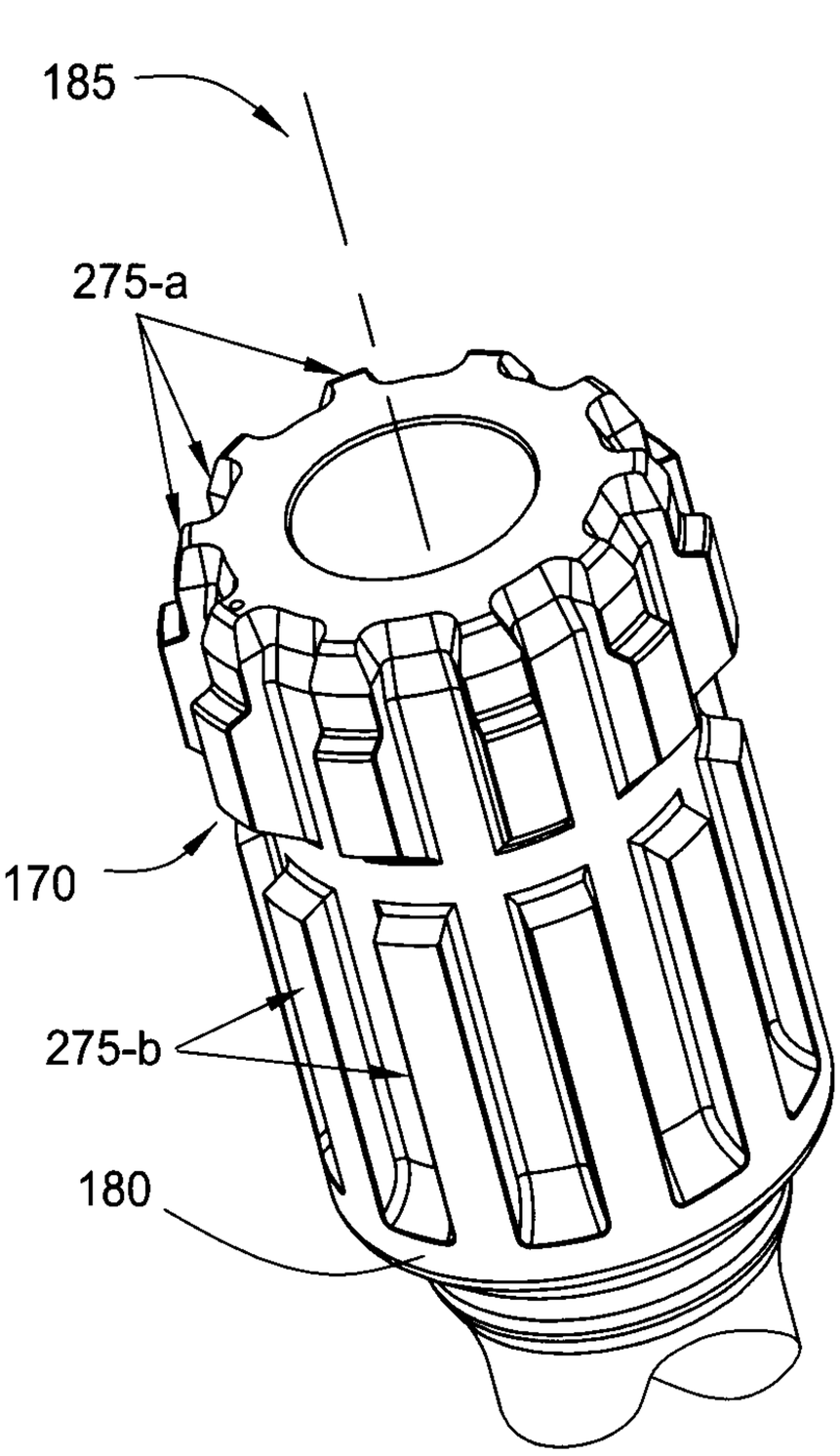


FIG. 3B

FIG. 3A

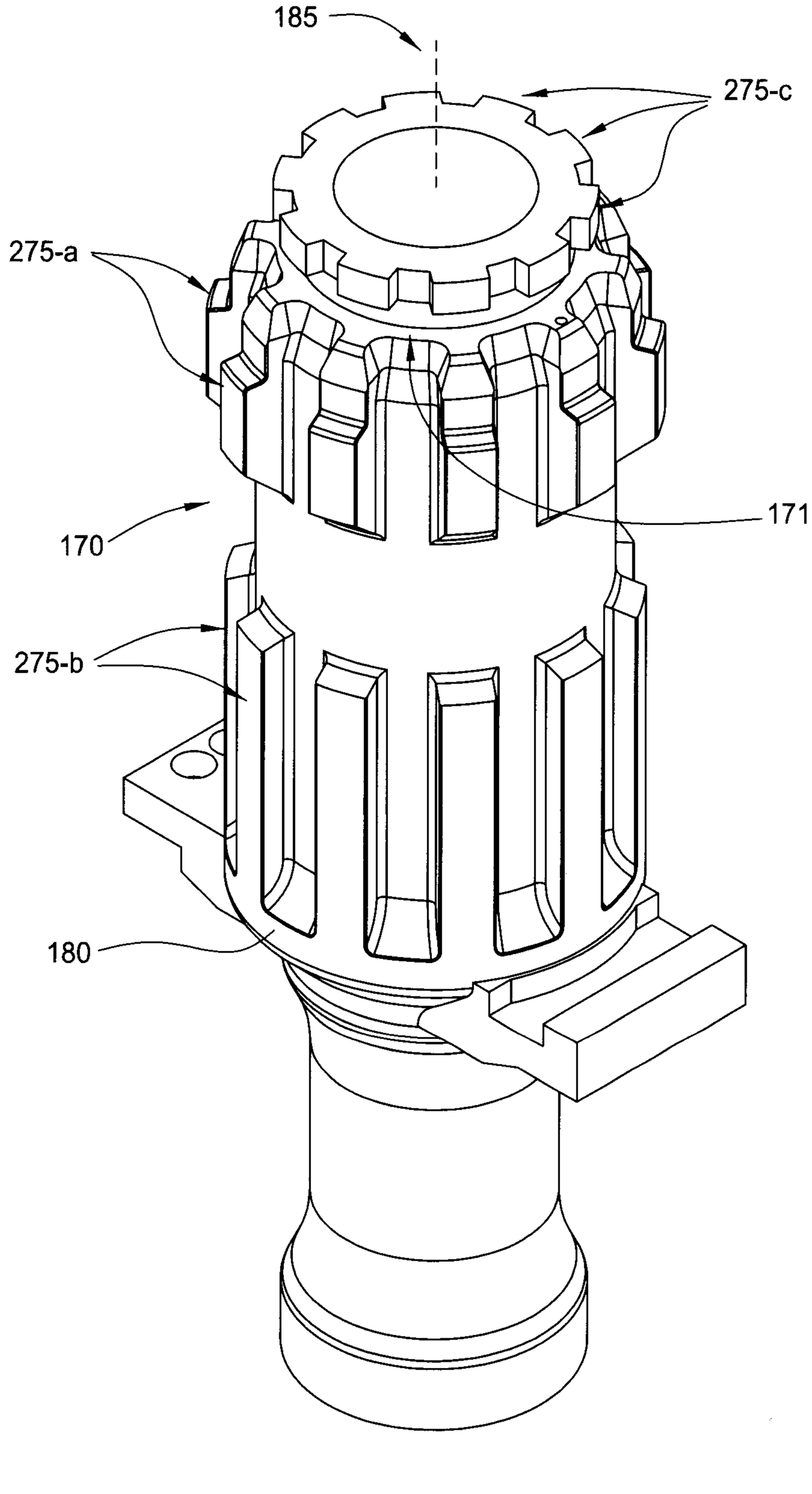


FIG. 3C

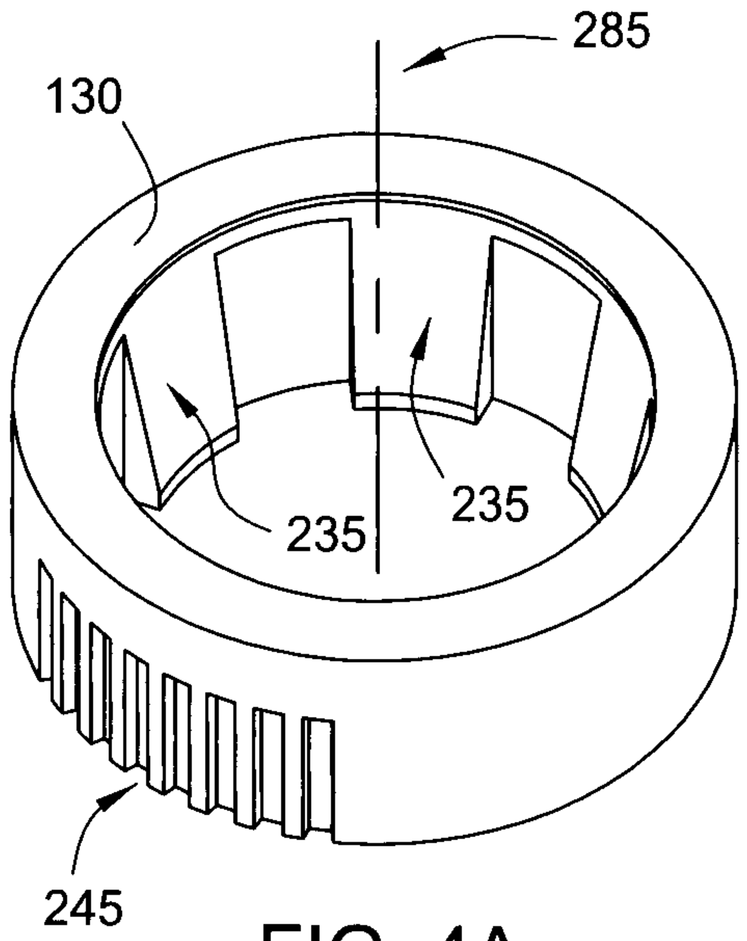


FIG. 4A

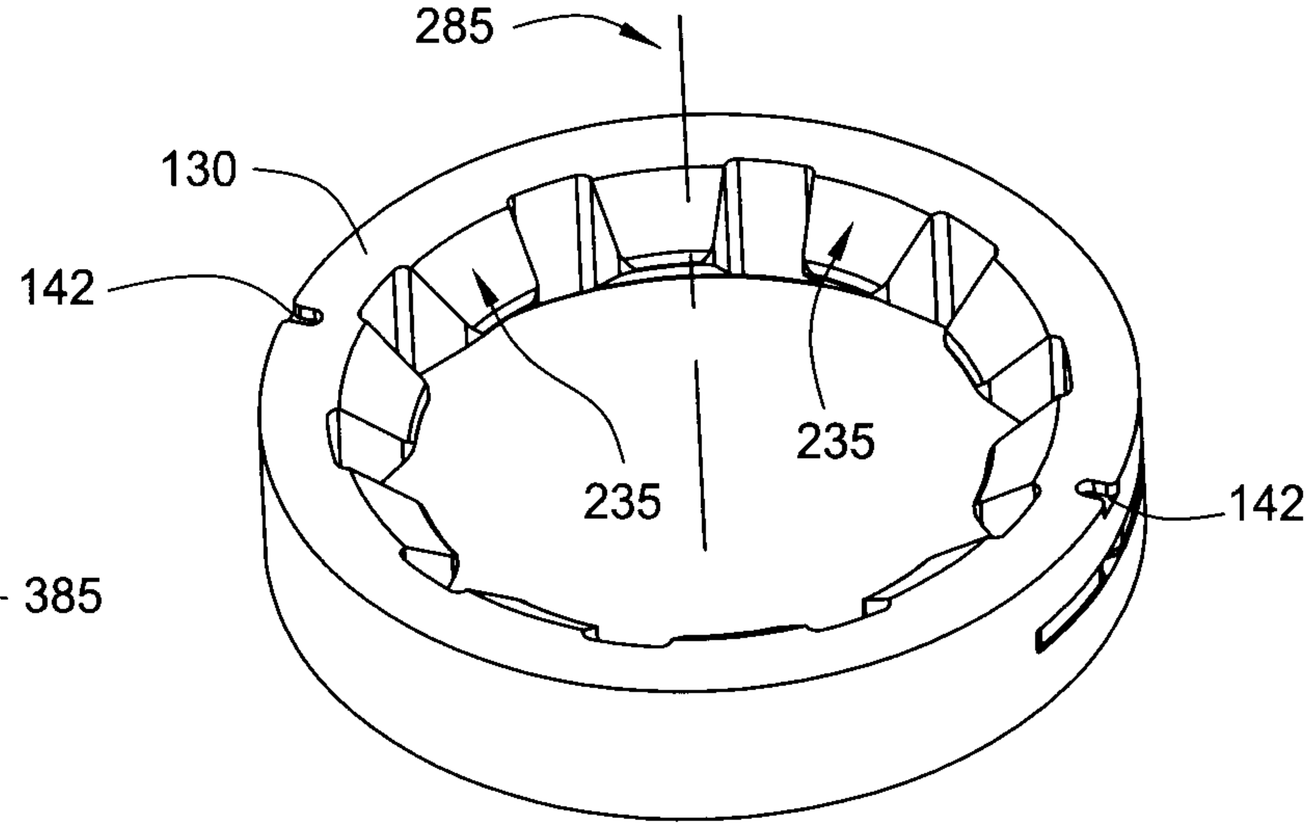


FIG. 4B

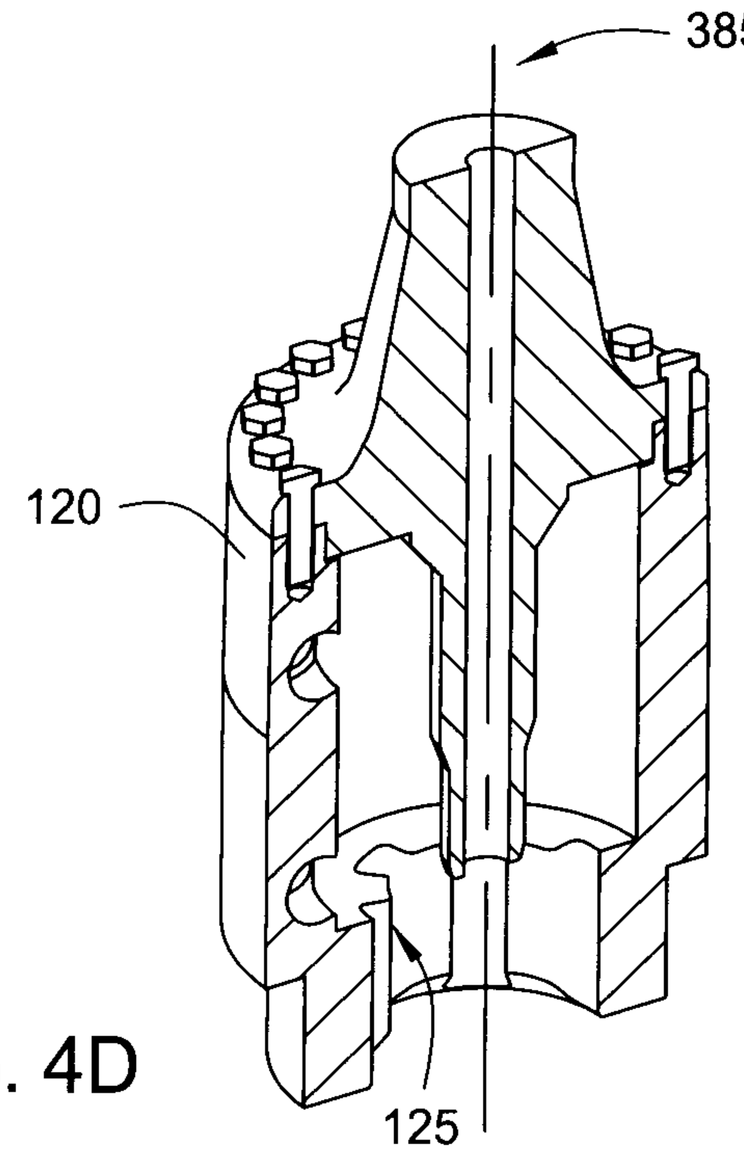


FIG. 4D

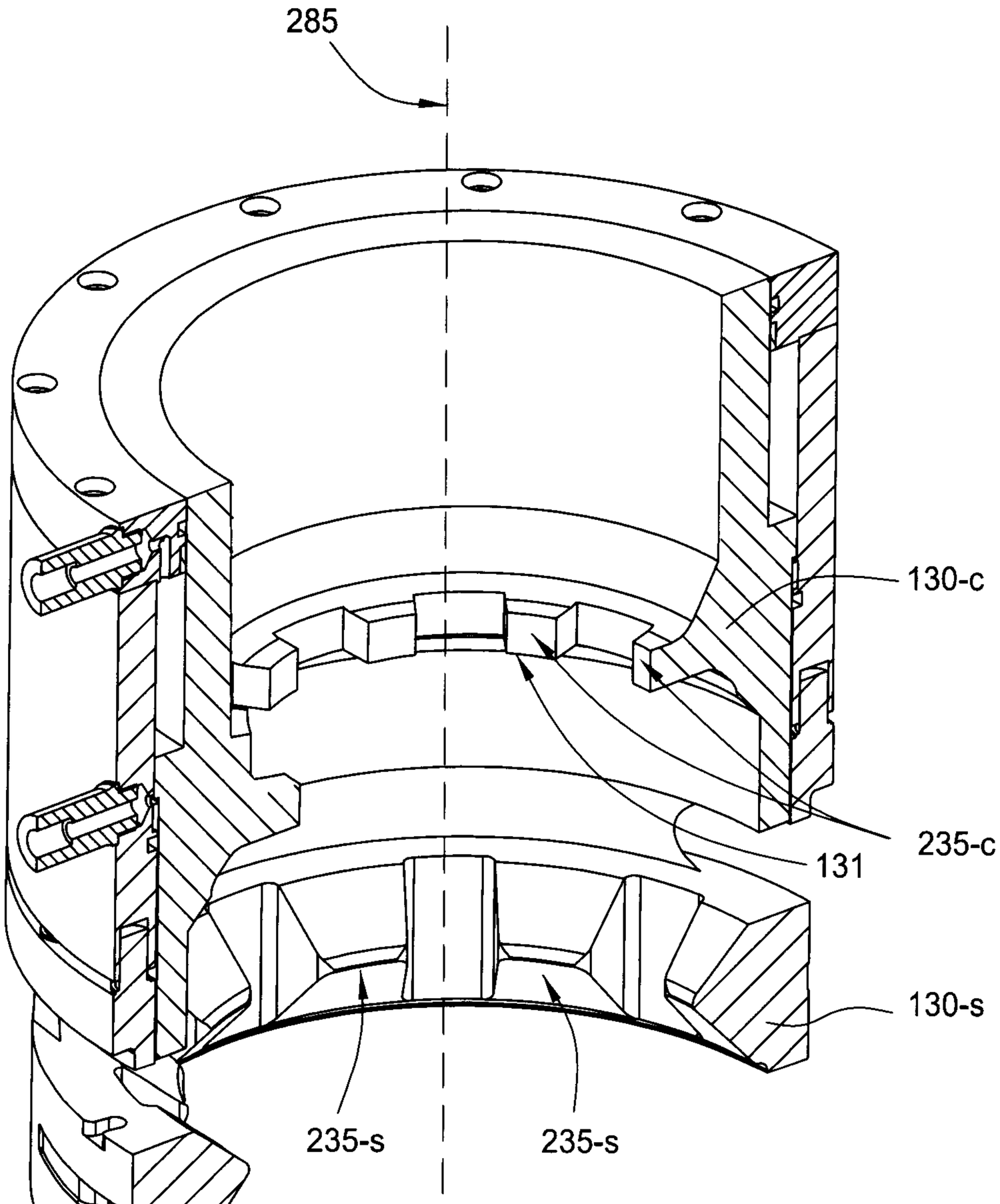


FIG. 4C

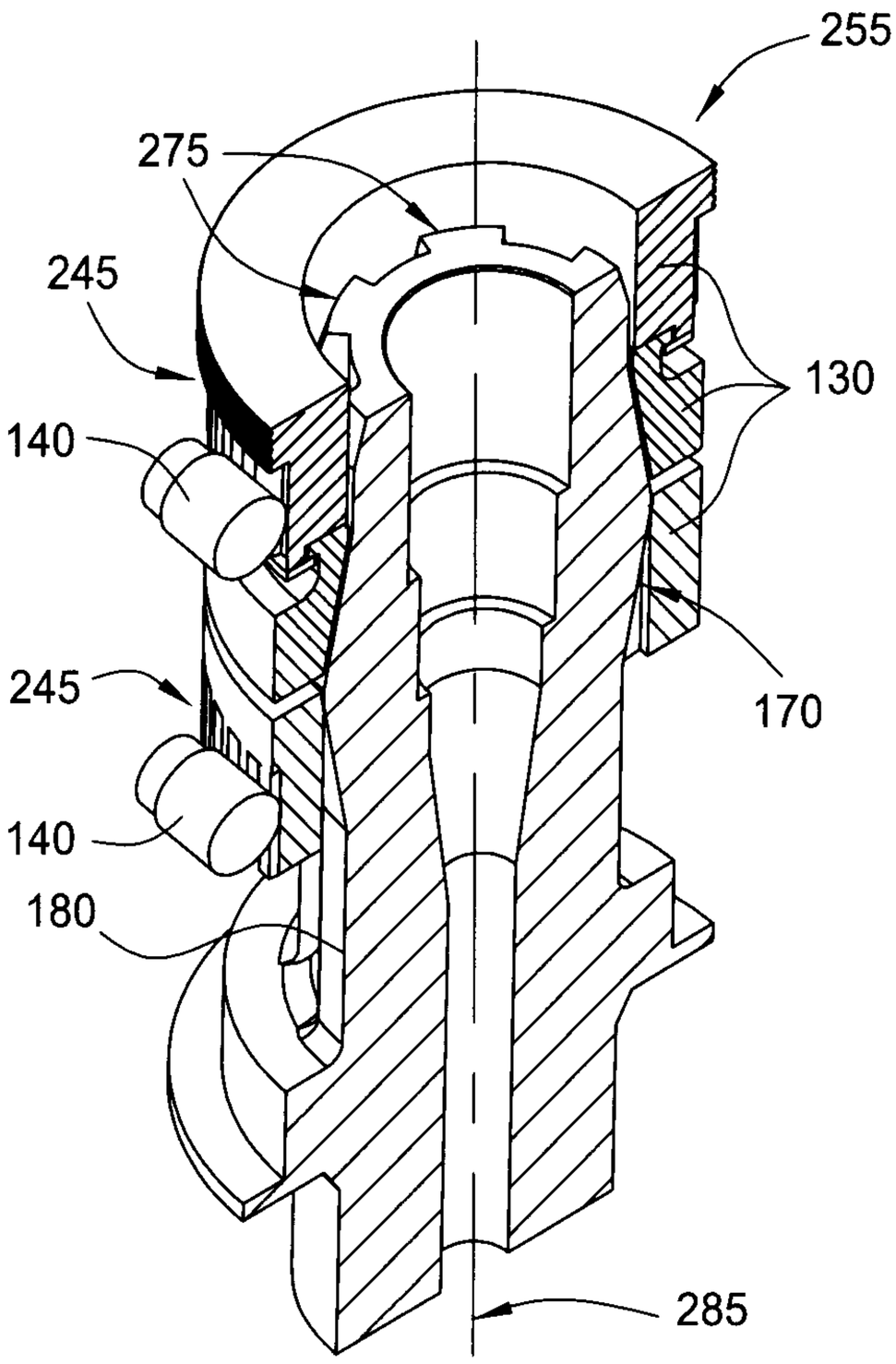

255
275
245
130
140
170
245
140
180
285

FIG. 5A

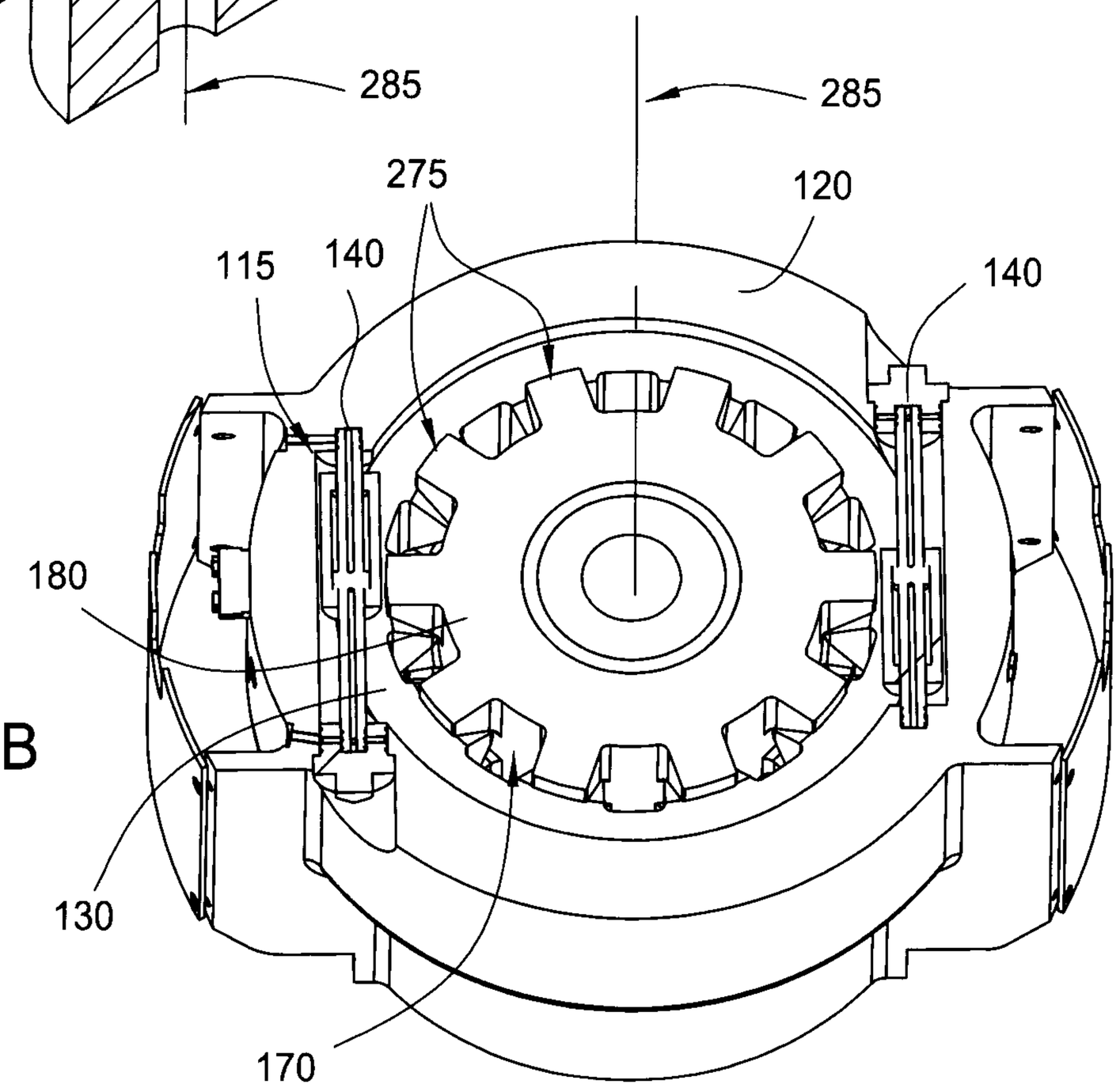

285
275
120
115
140
140
180
130
170

FIG. 5B

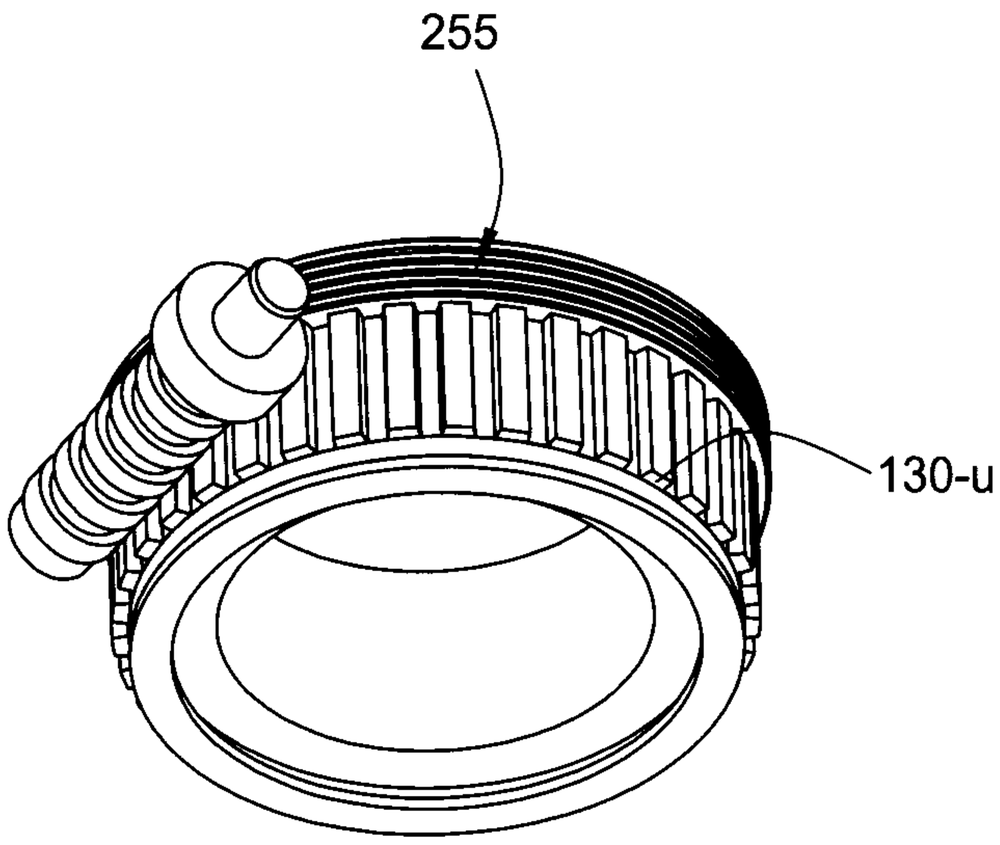


FIG. 6A

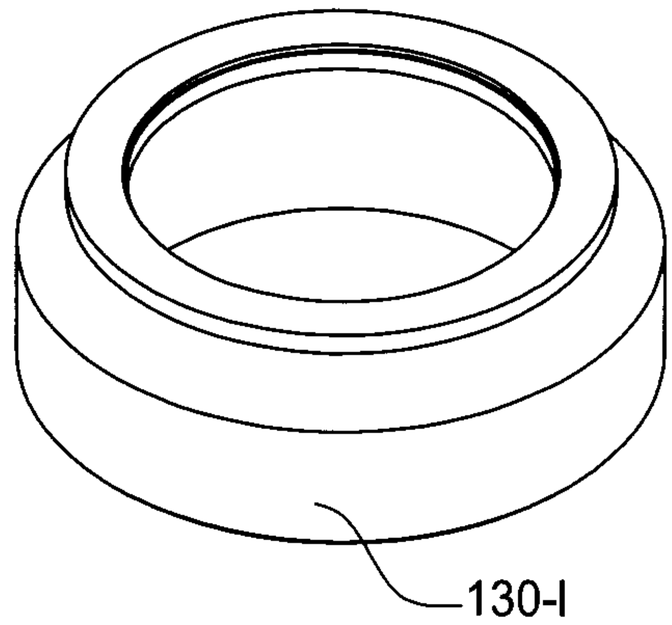


FIG. 6B

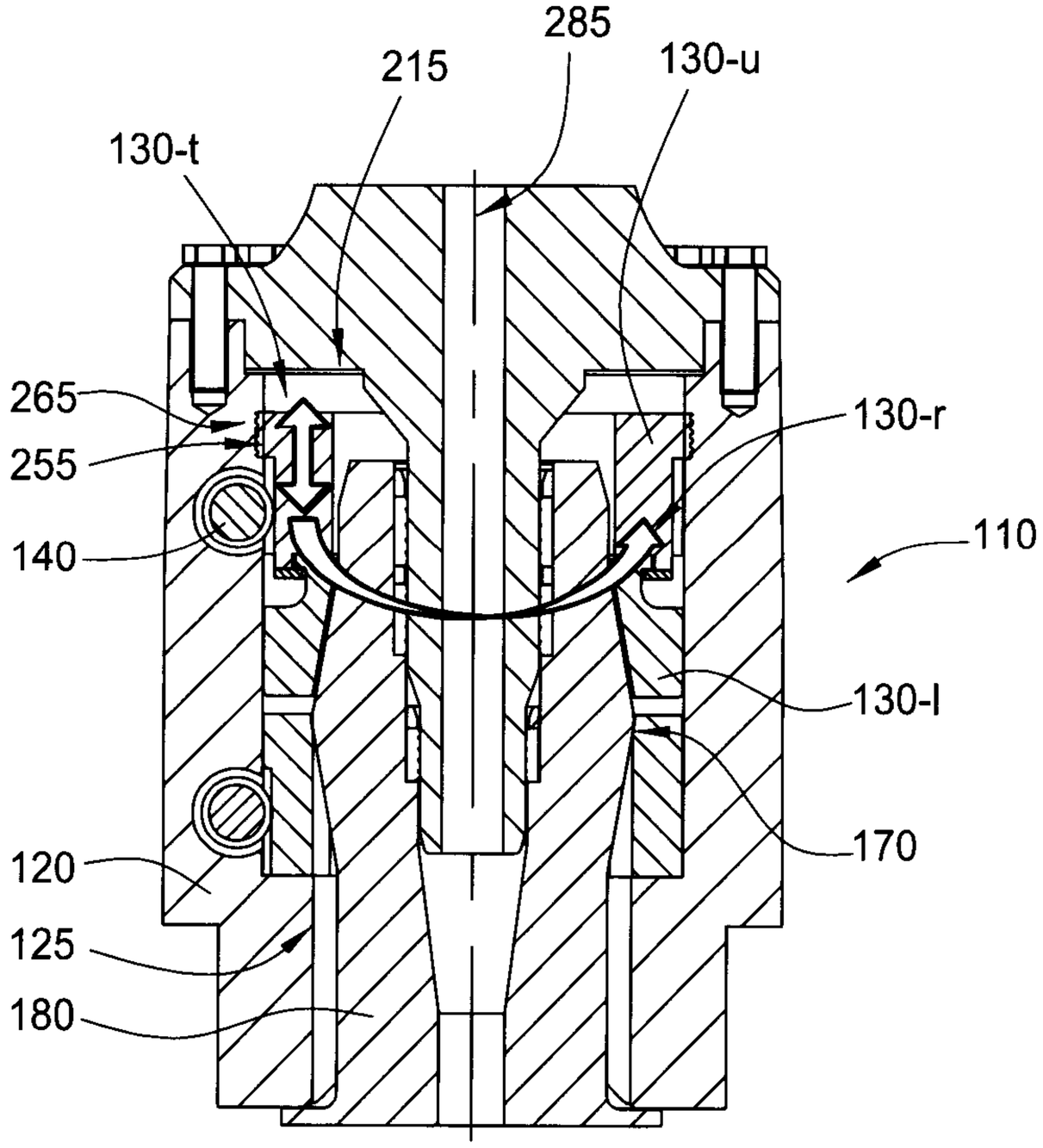


FIG. 6C

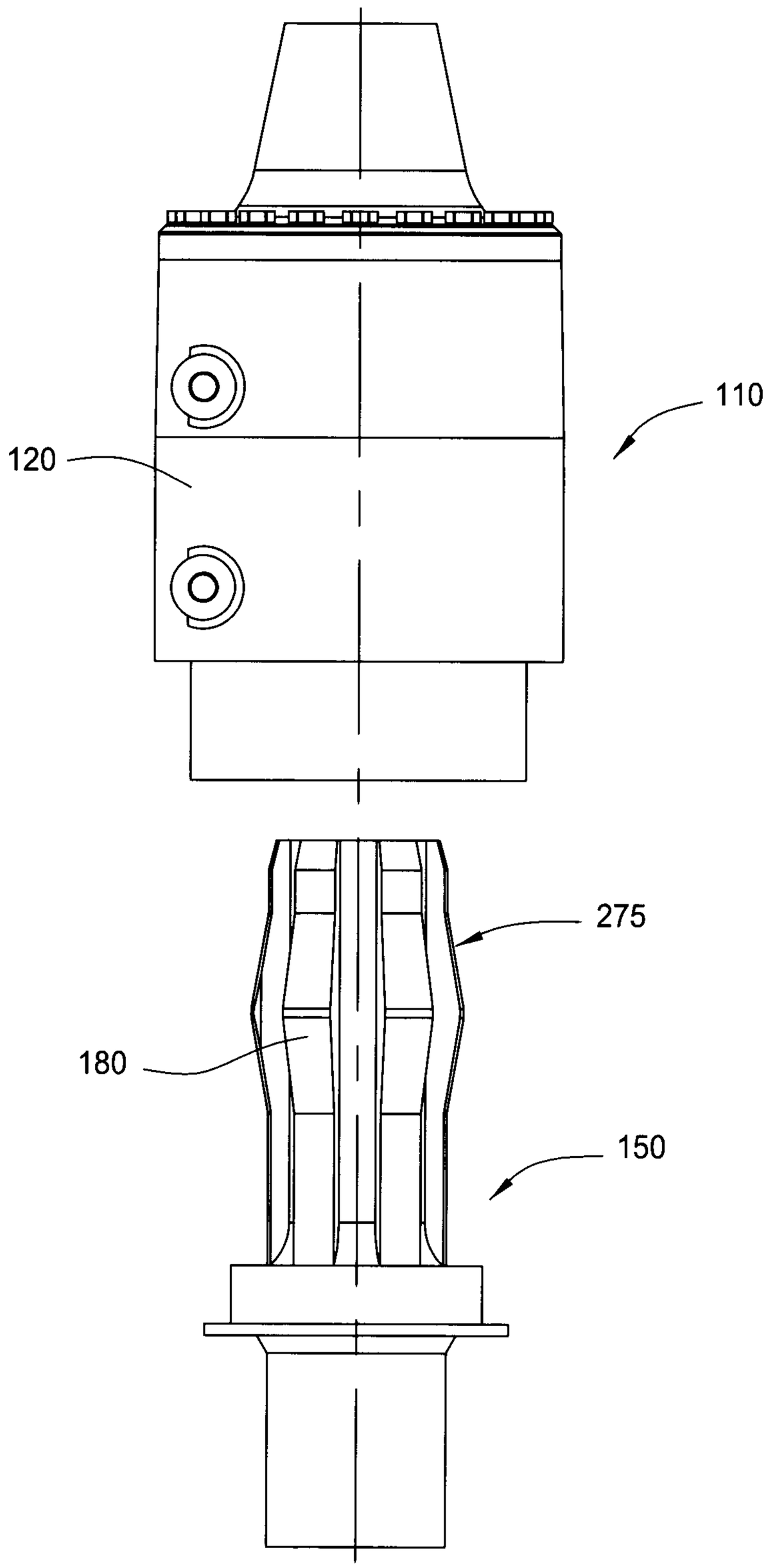


FIG. 7A

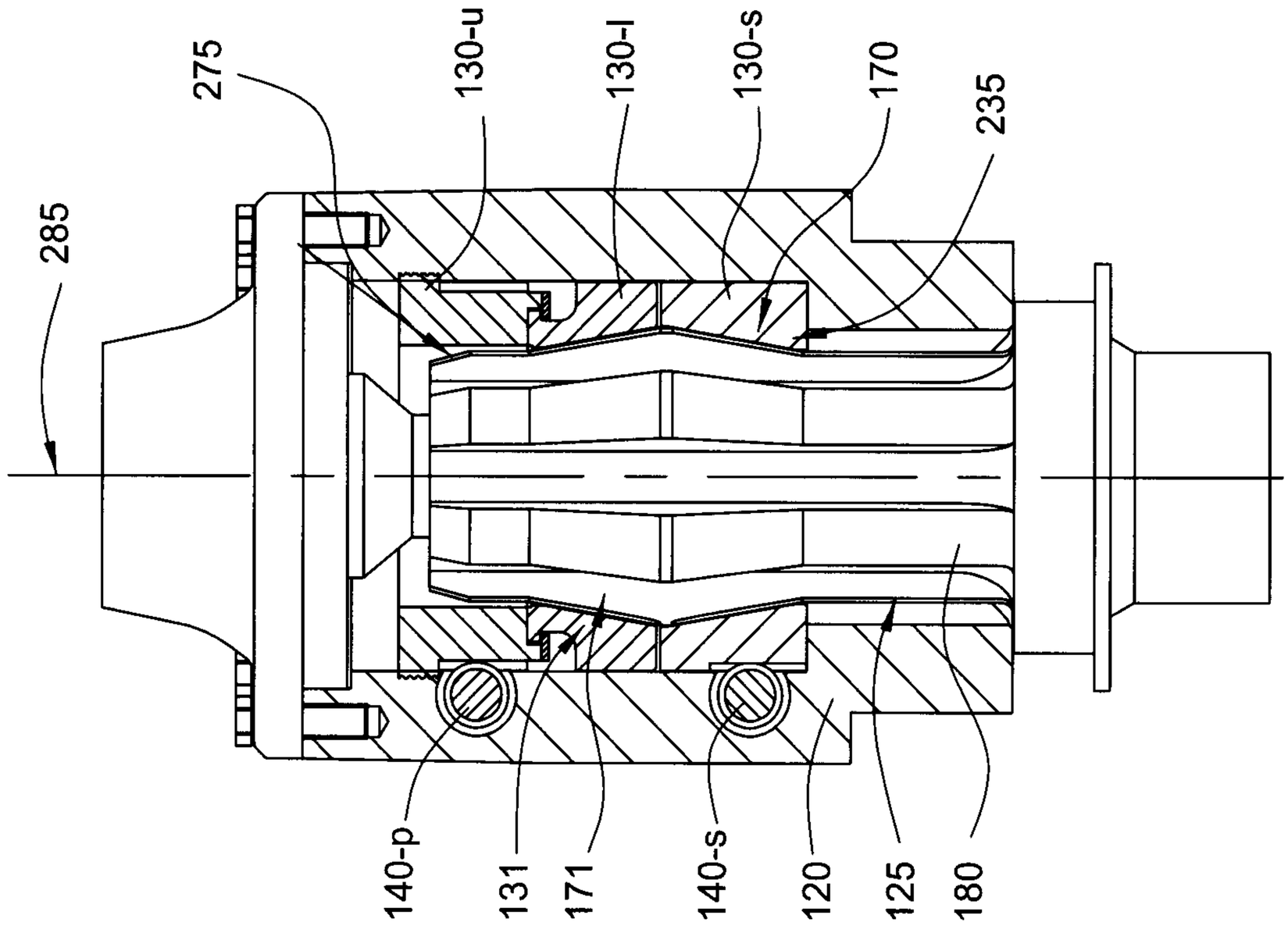

285
275
130-u
130-l
130-s
170
235
140-p
131
171
140-s
120
125
180

FIG. 7C

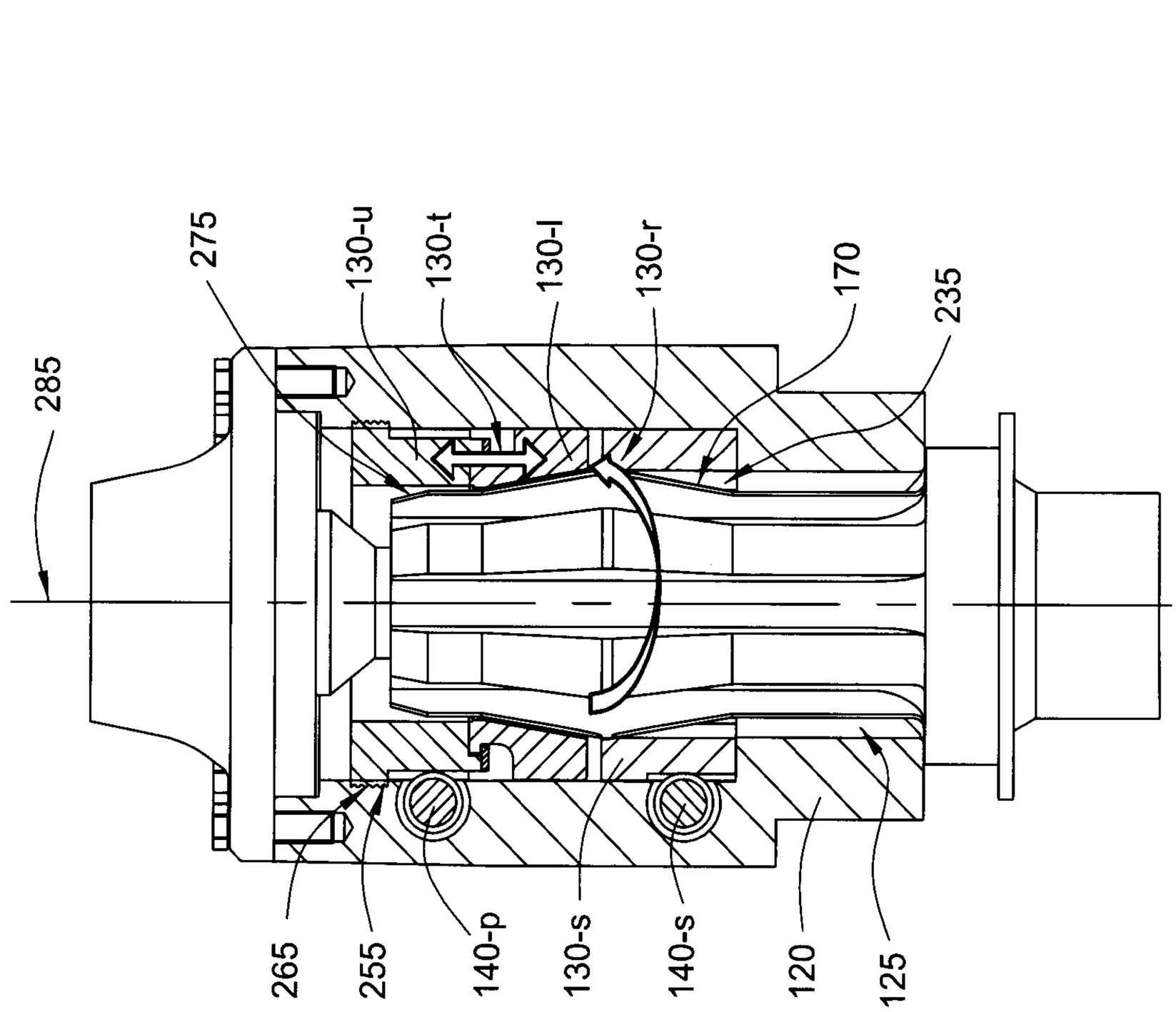

285
275
130-u
130-t
130-l
130-r
170
235
265
255
140-p
130-s
140-s
120
125

FIG. 7B

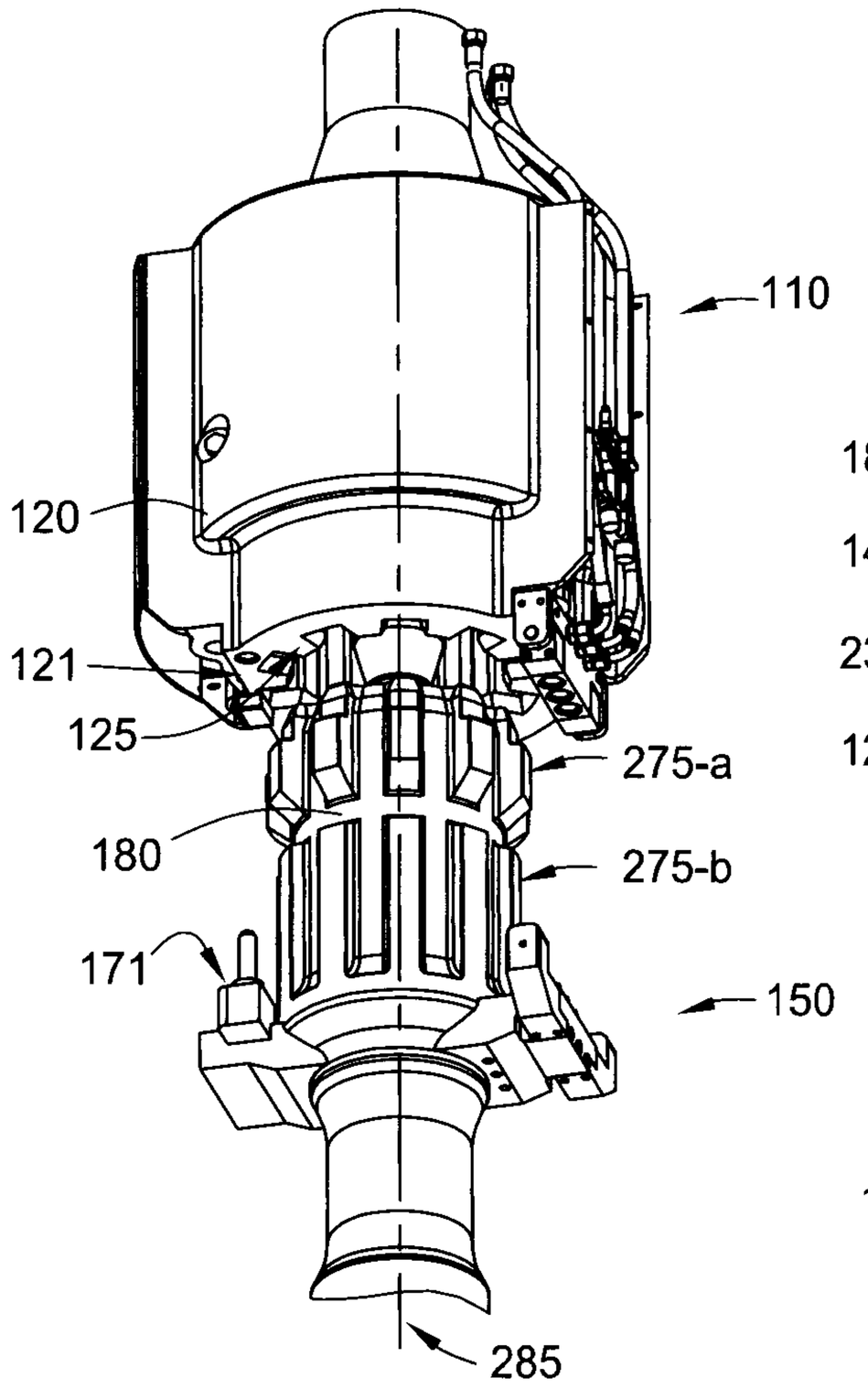


FIG. 8A

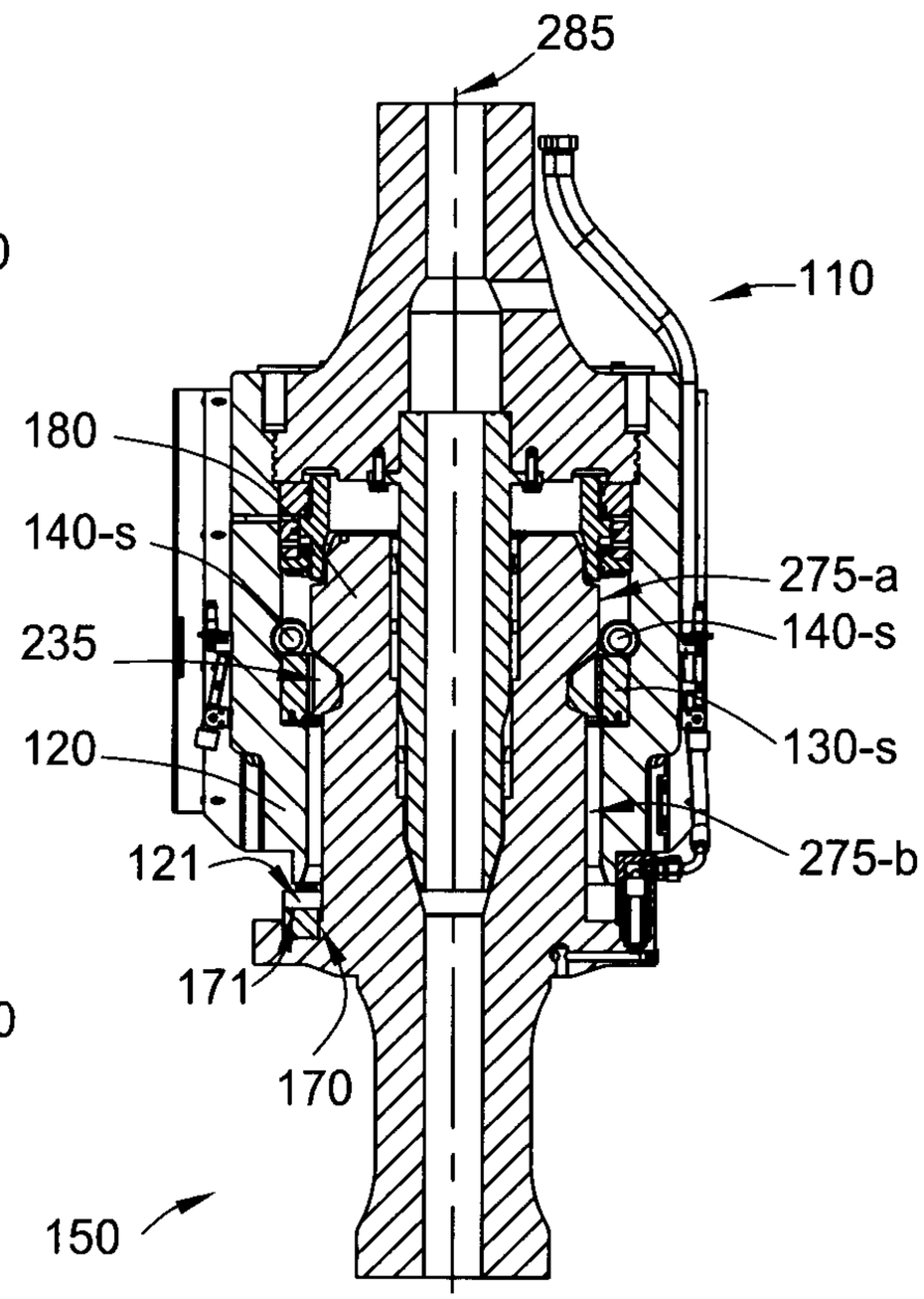


FIG. 8B

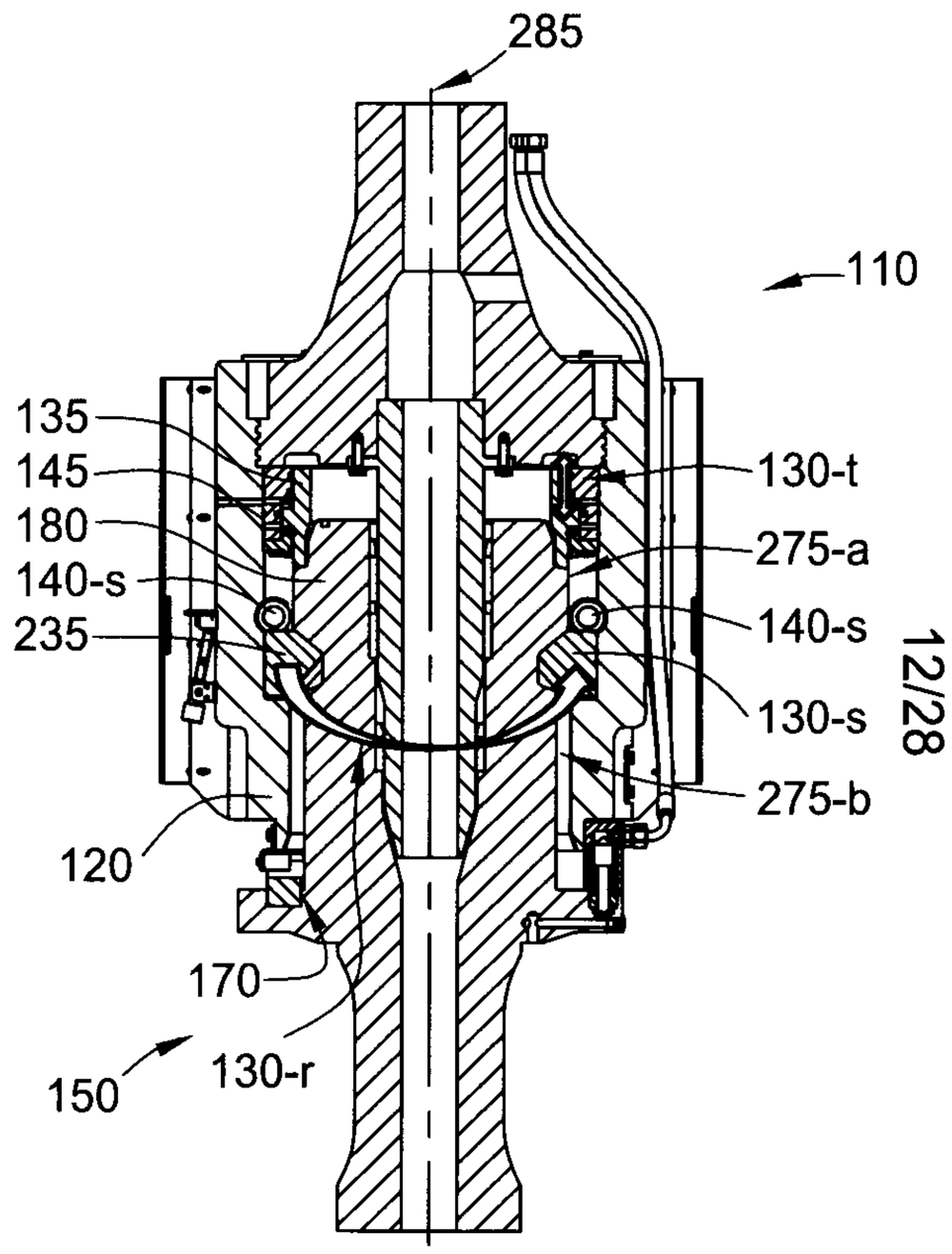


FIG. 8C

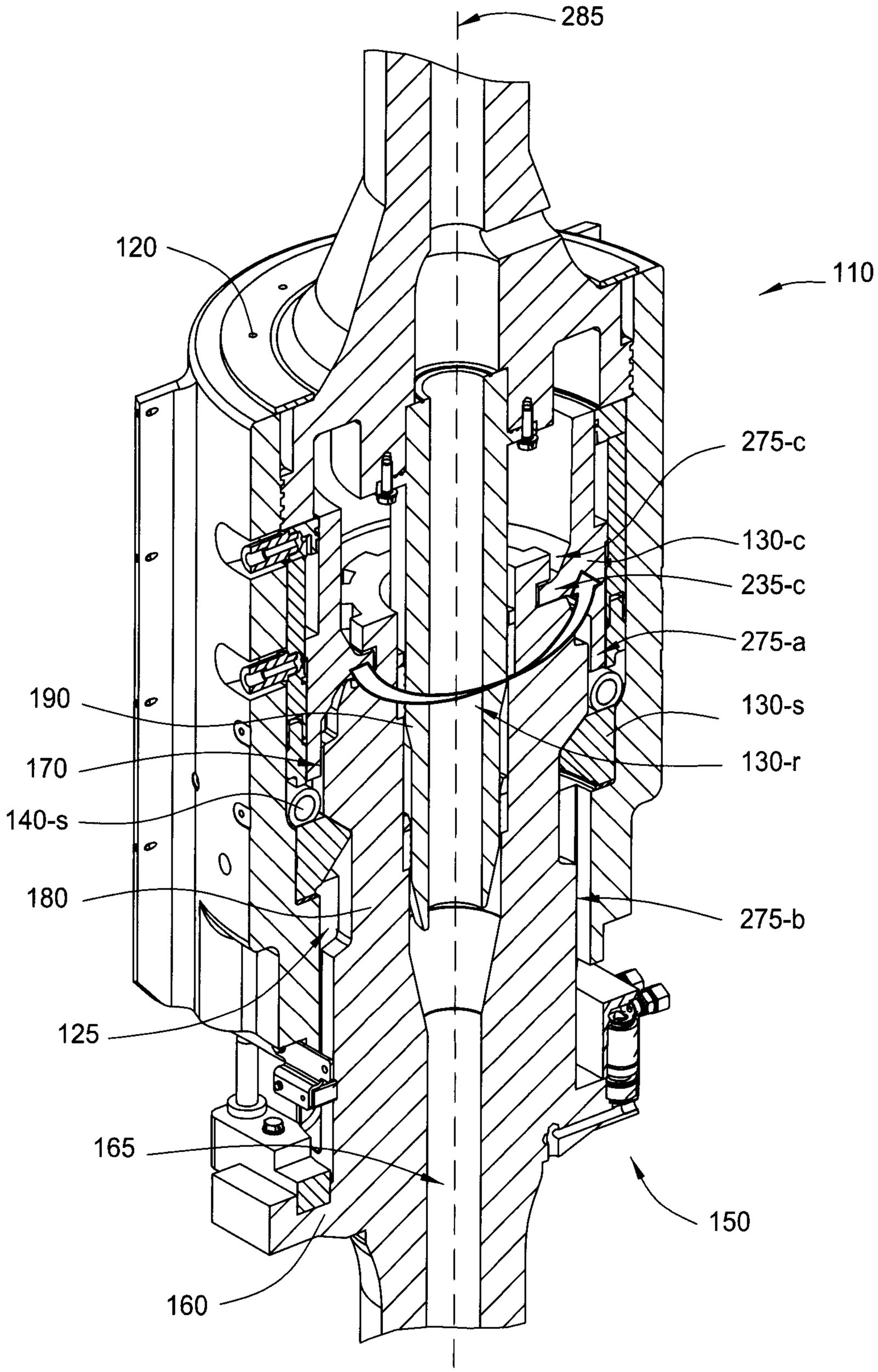

285
120
110
275-c
130-c
235-c
275-a
190
130-s
170
130-r
140-s
180
275-b
125
165
150
160

FIG. 9A

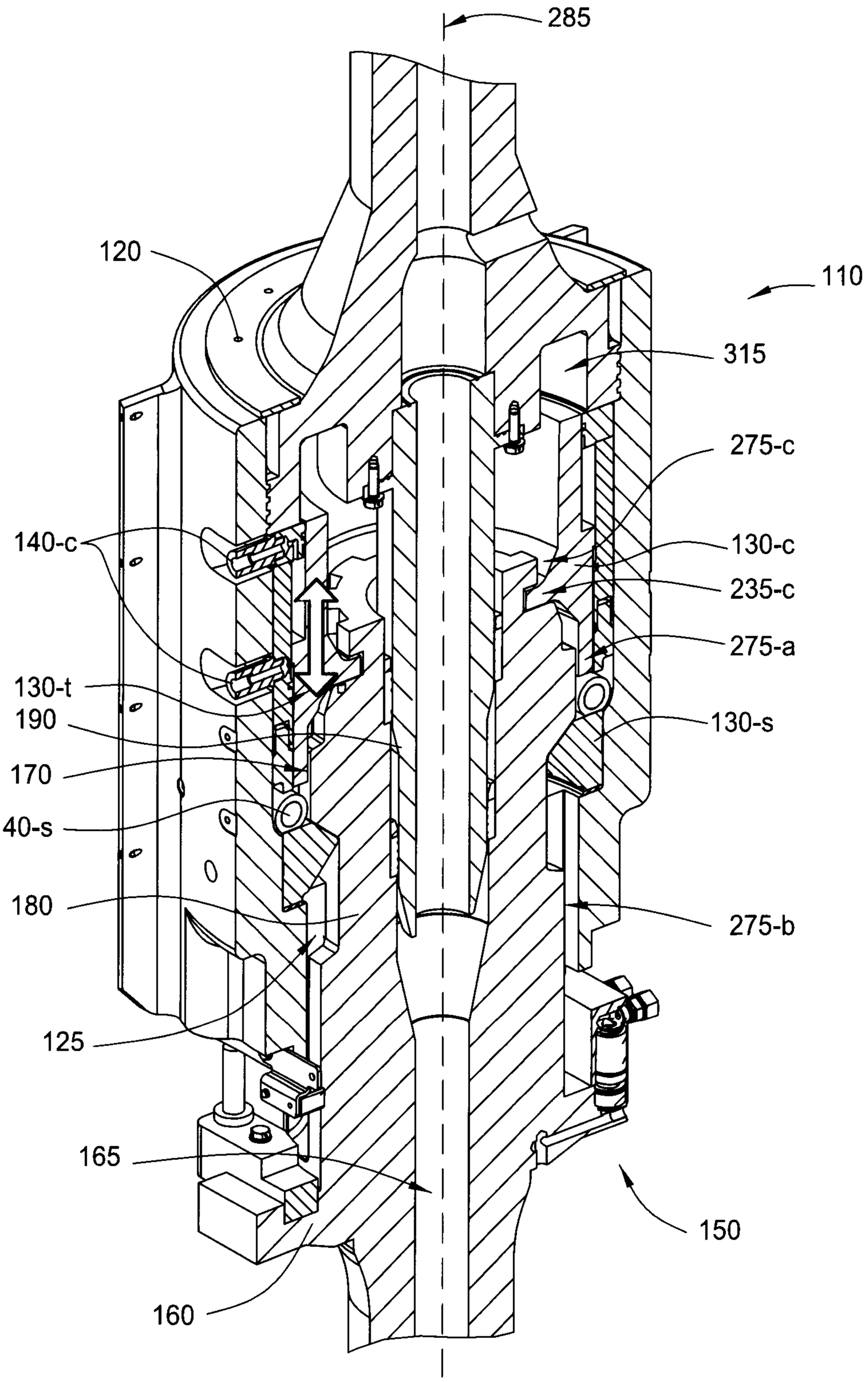

285
120
110
315
275-c
140-c
130-c
235-c
275-a
130-t
190
130-s
170
140-s
180
275-b
125
165
150
160

FIG. 9B

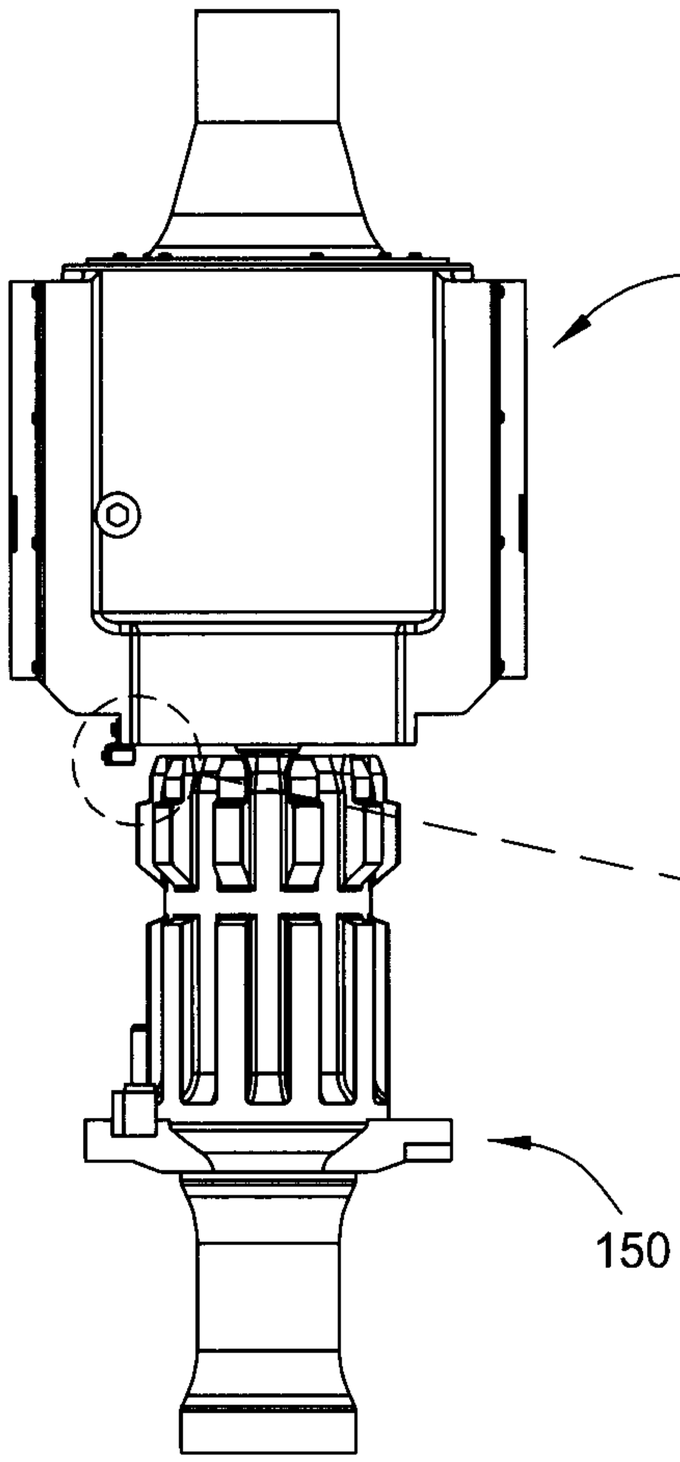


FIG. 10A

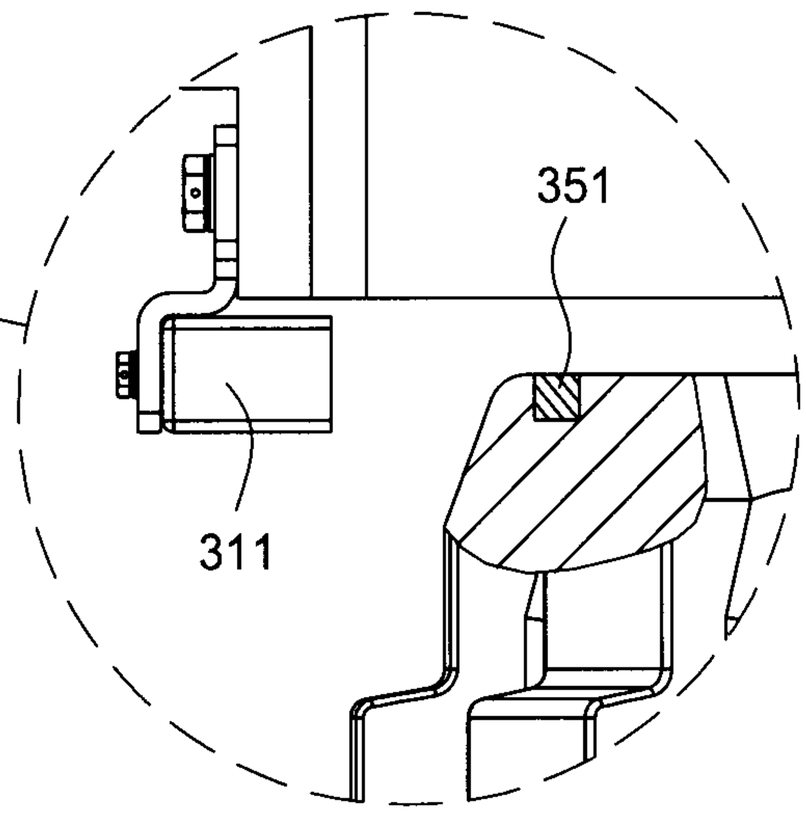


FIG. 10B

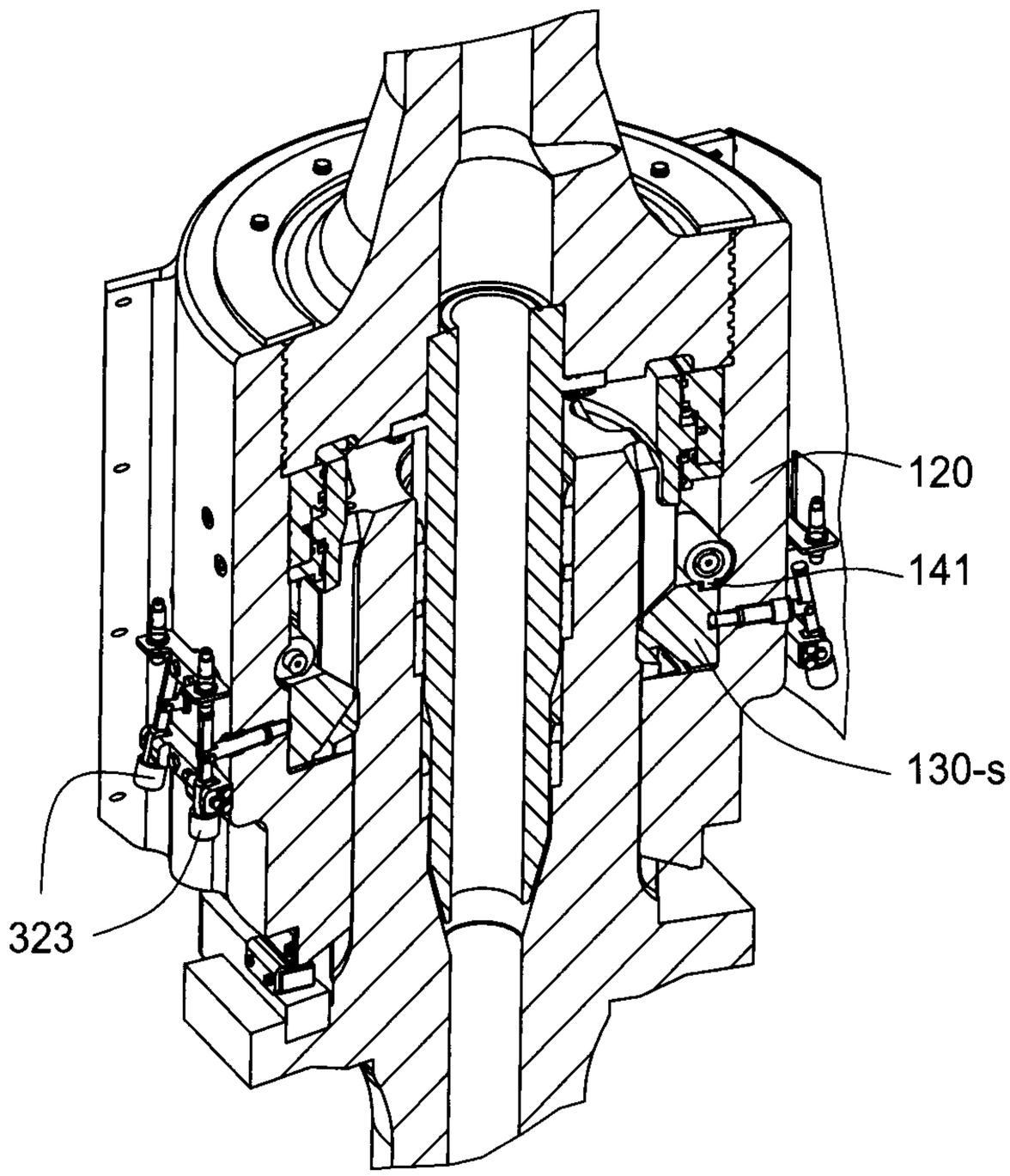


FIG. 11A

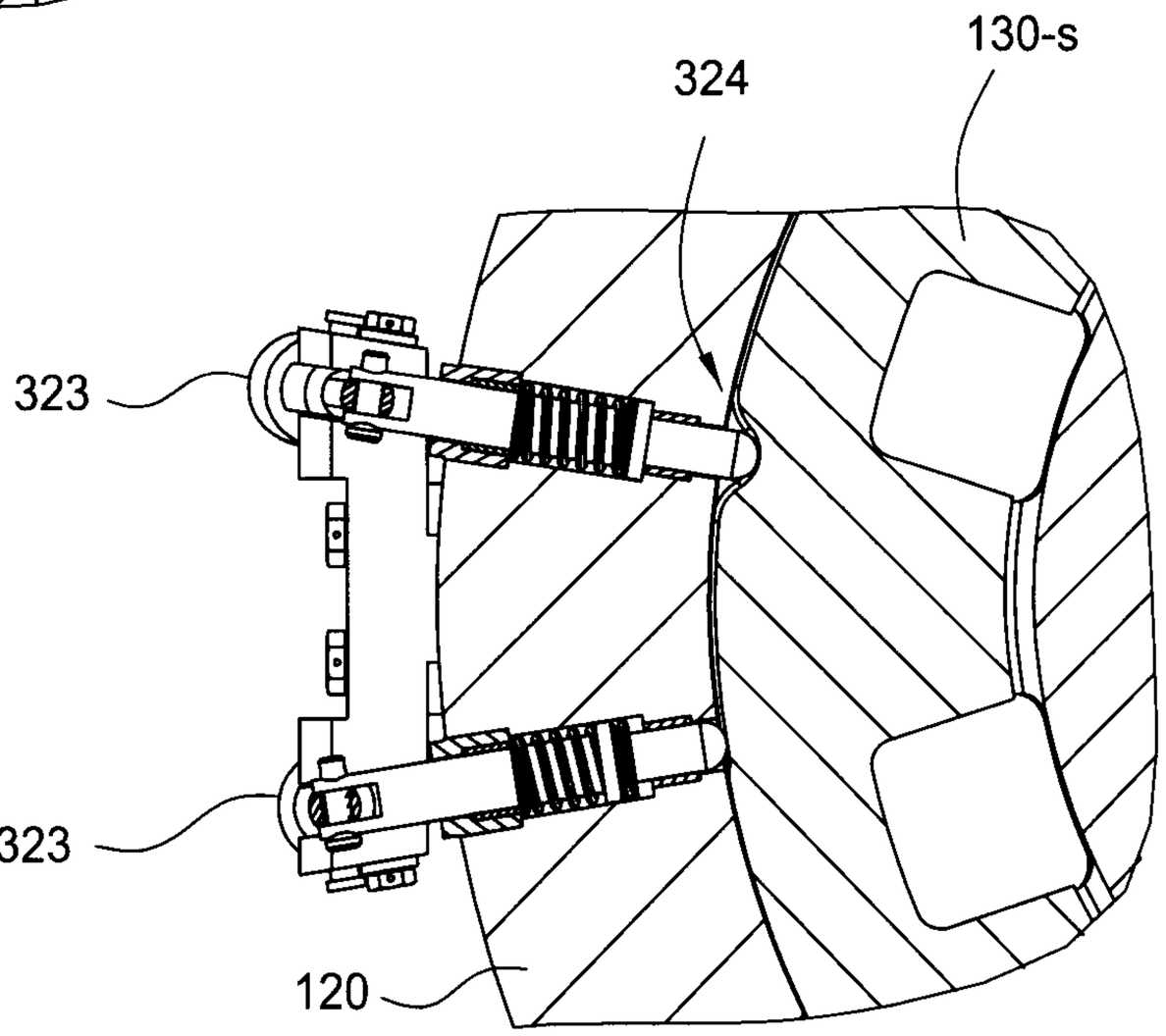


FIG. 11B

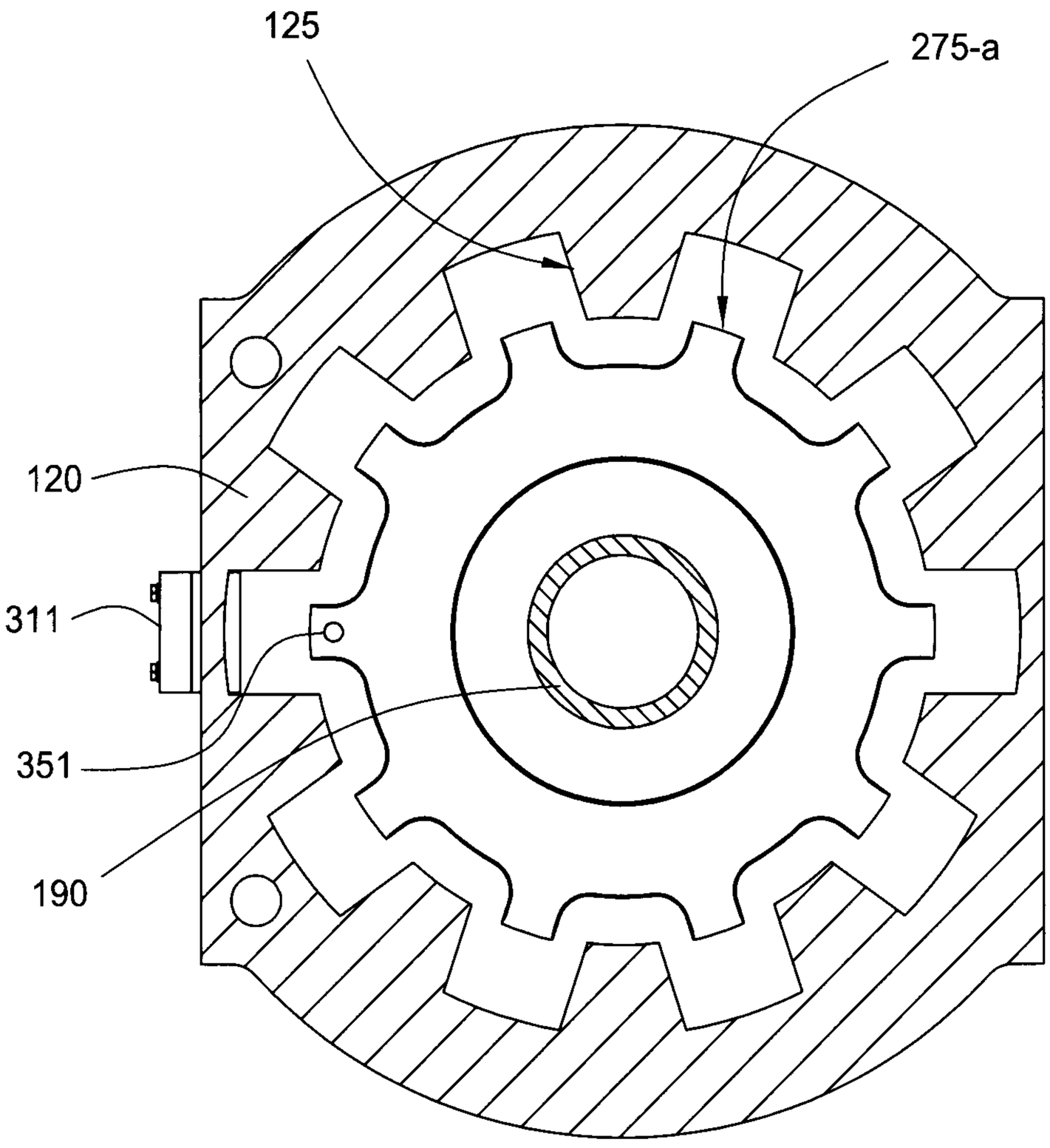


FIG. 12

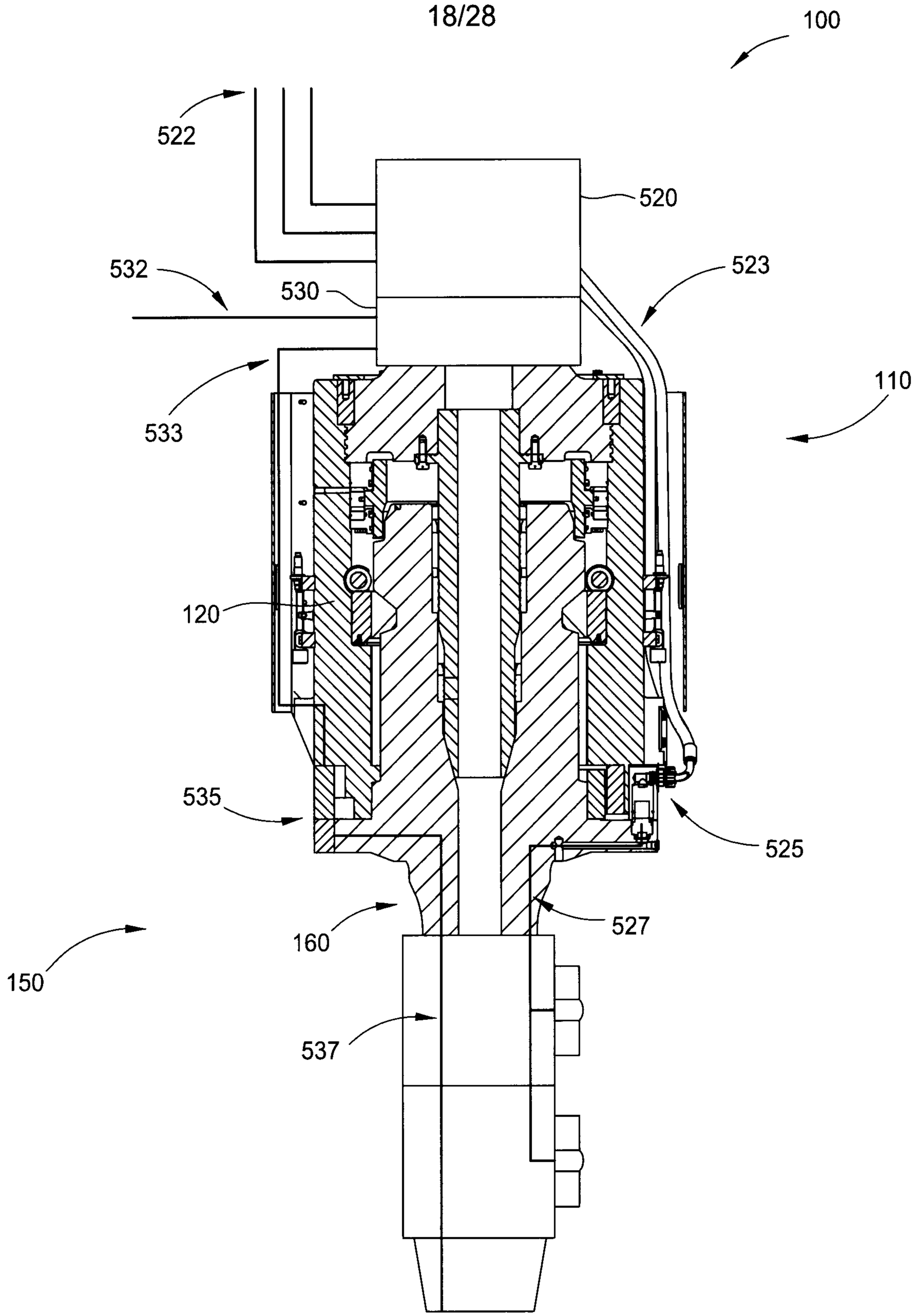


FIG. 13

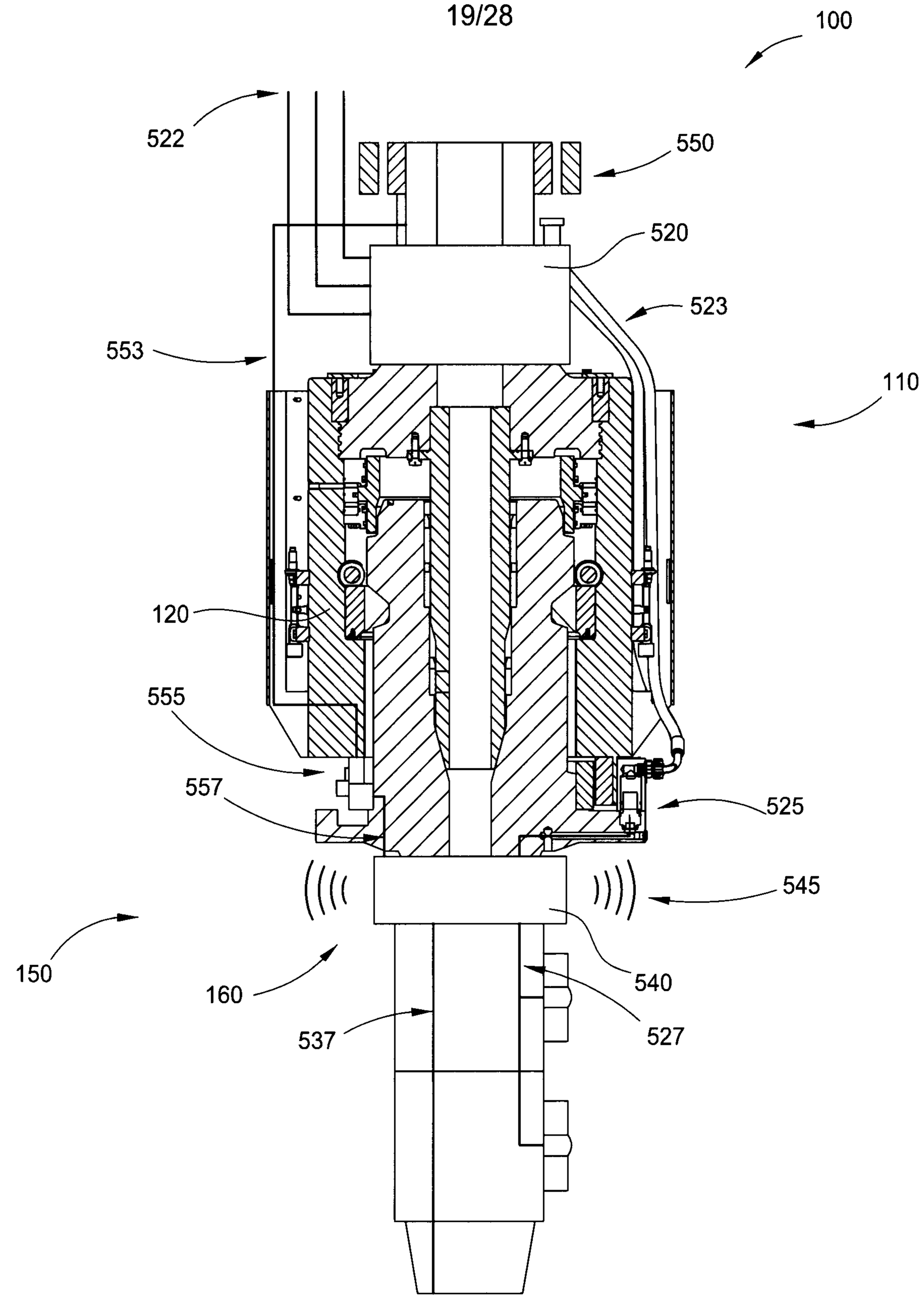

100
522
550
520
523
553
110
120
555
557
525
545
150
160
540
537
527

FIG. 14

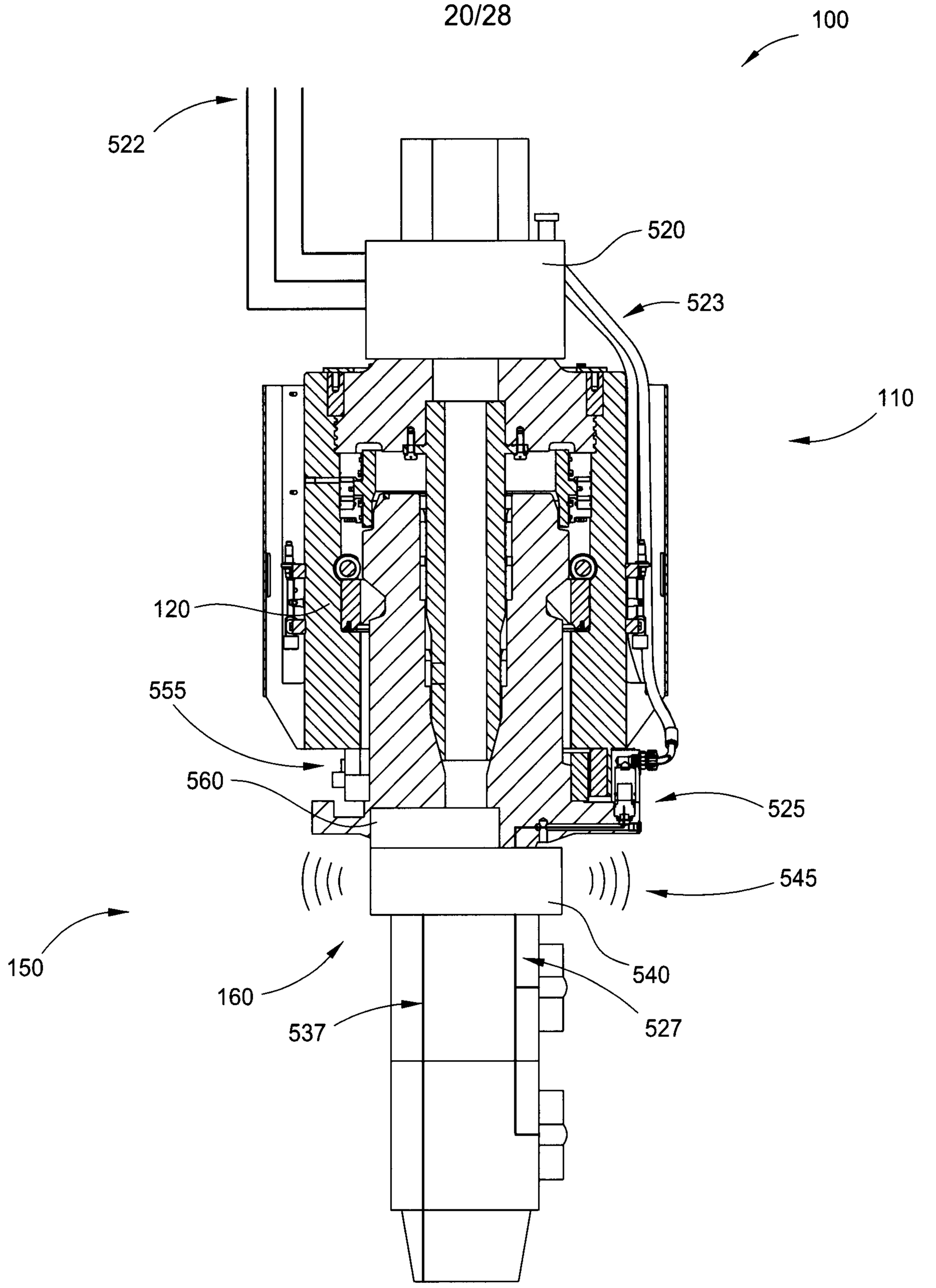


FIG. 15

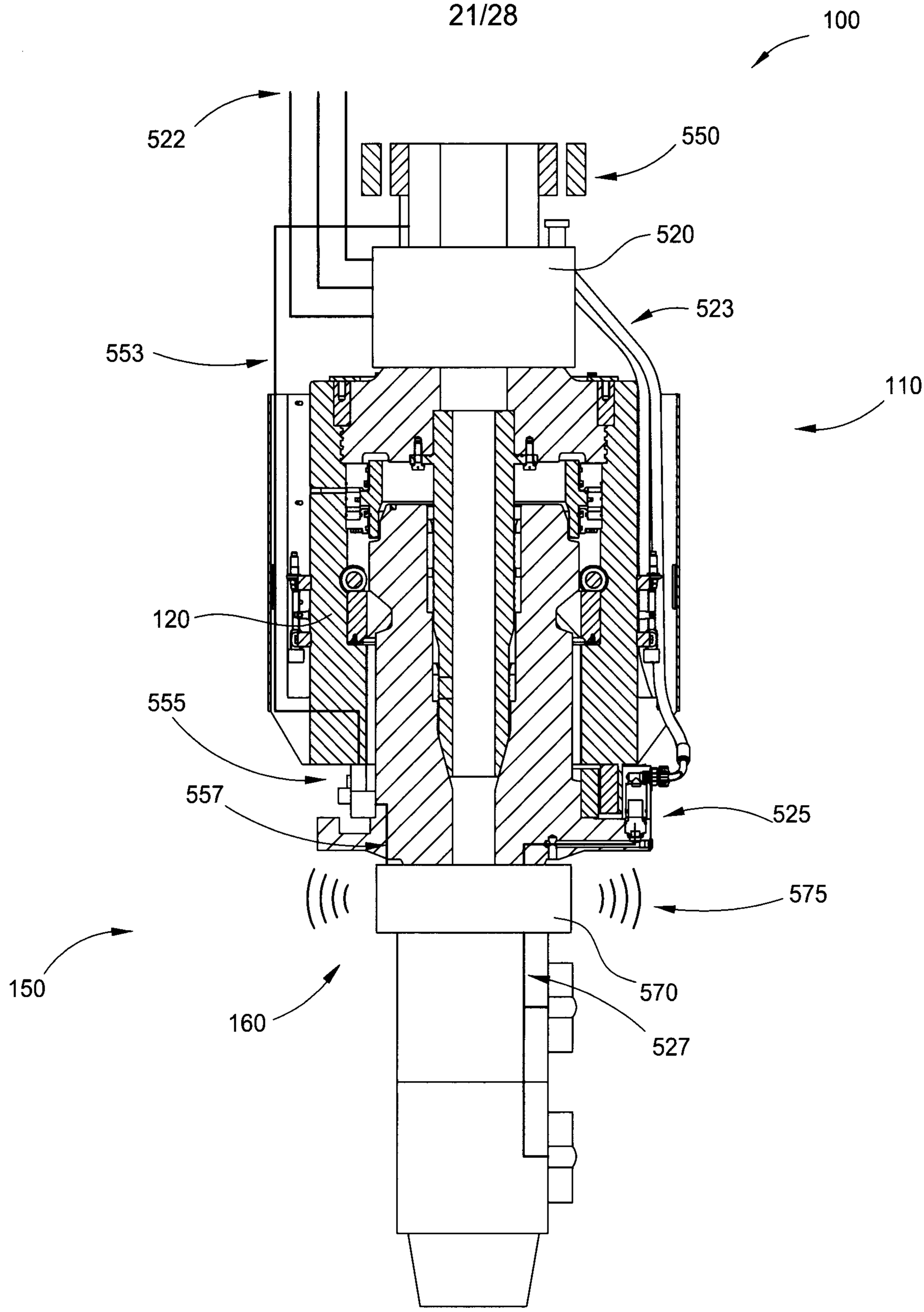


FIG. 16

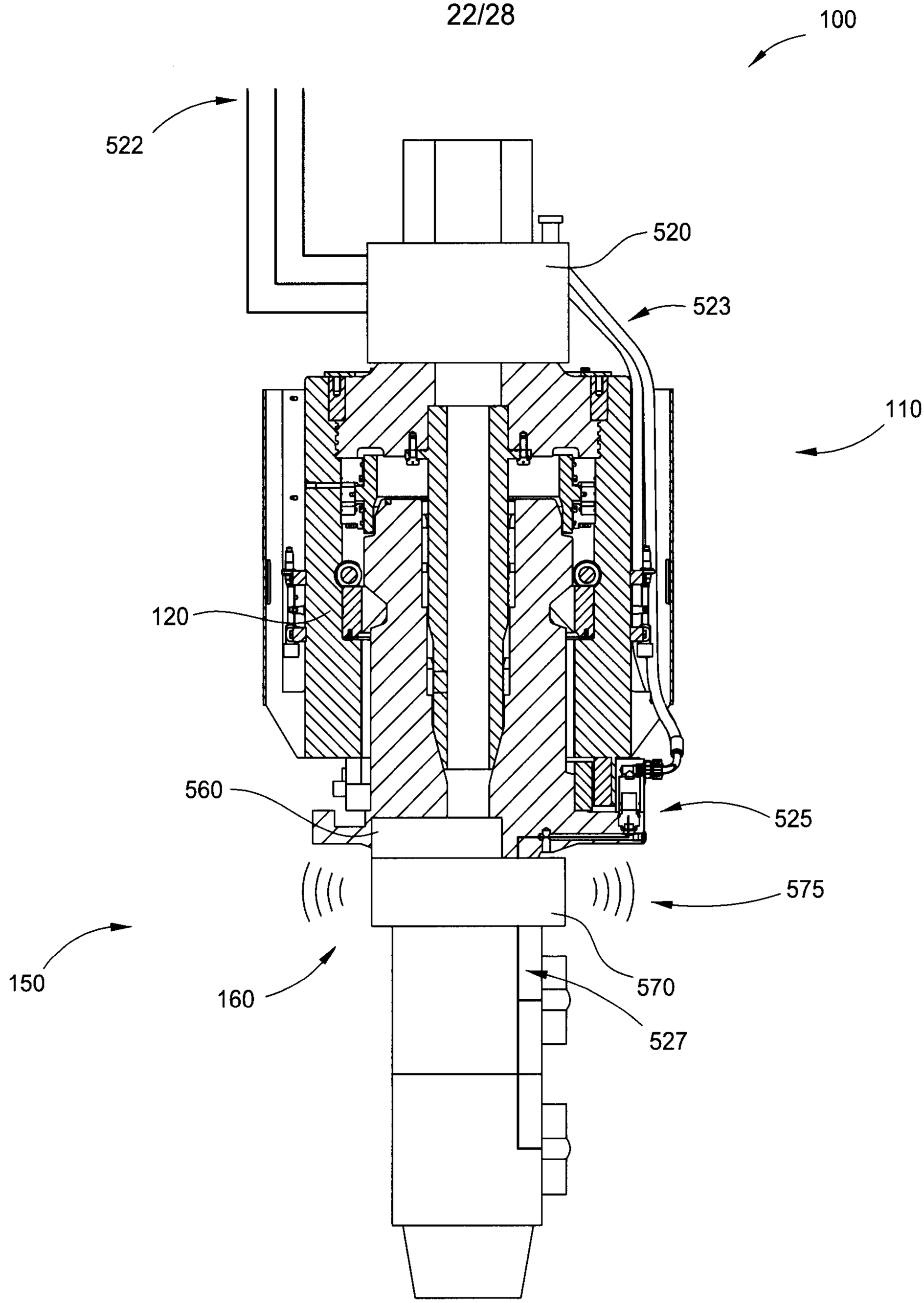


FIG. 17

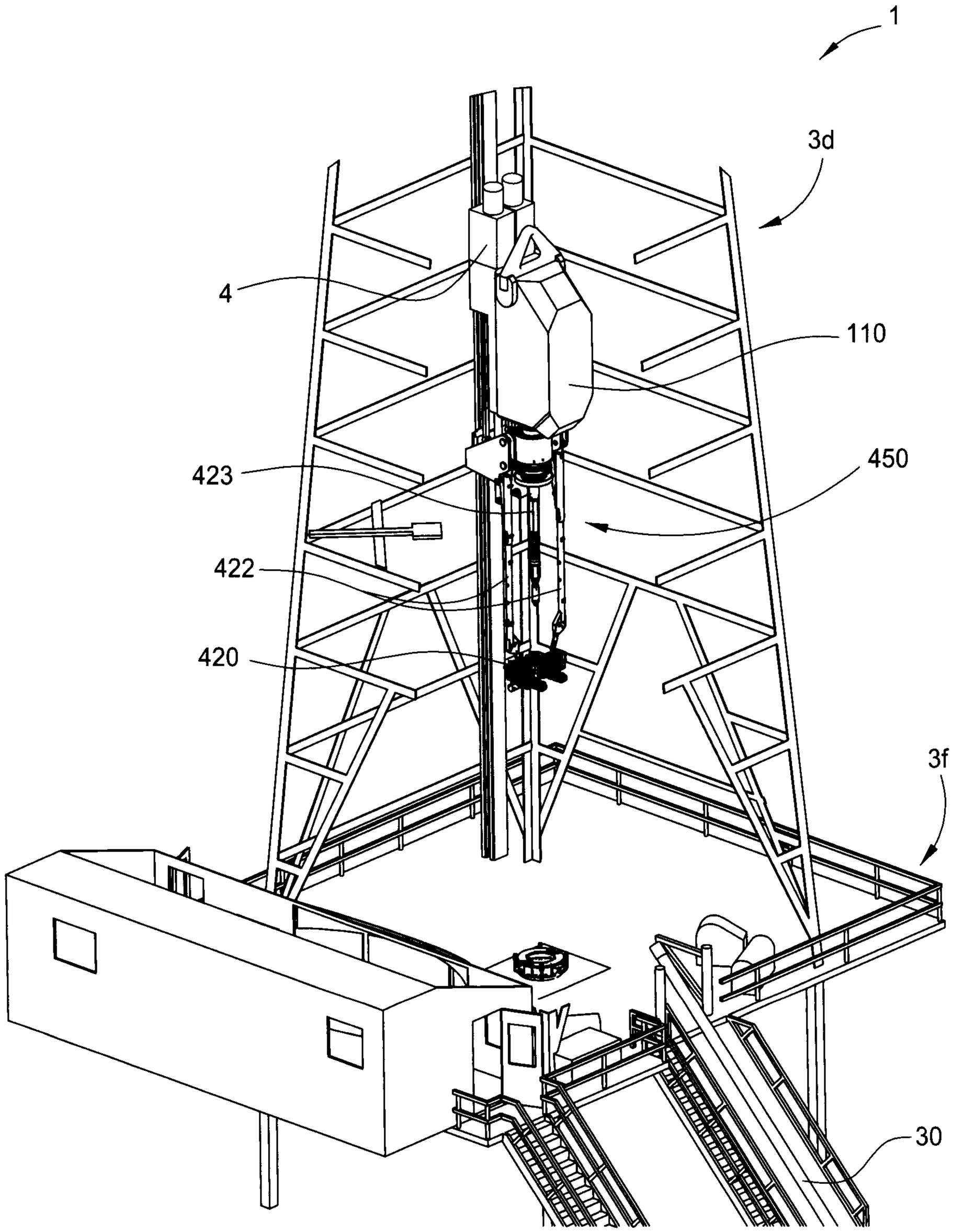


FIG. 18A

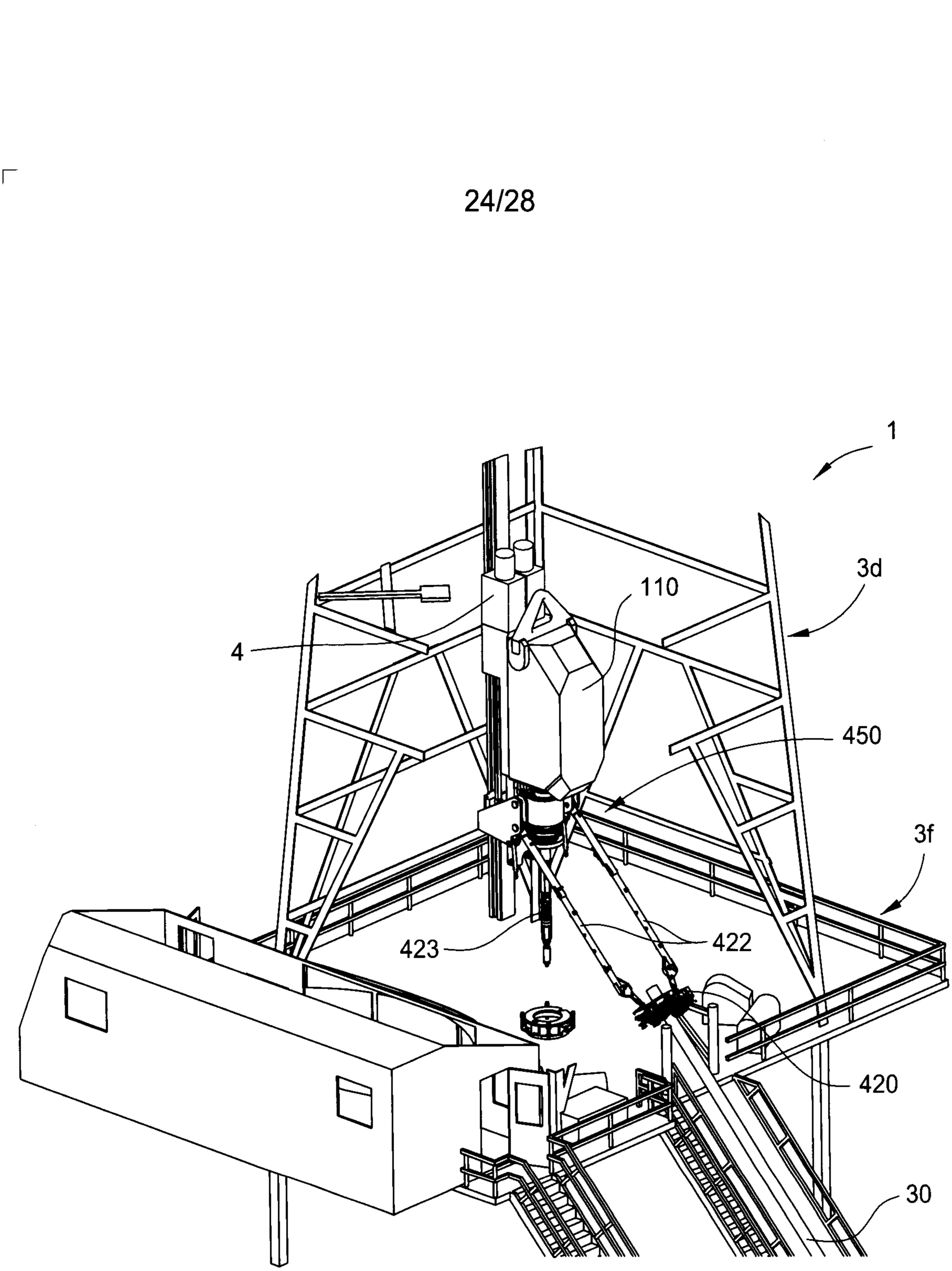


FIG. 18B

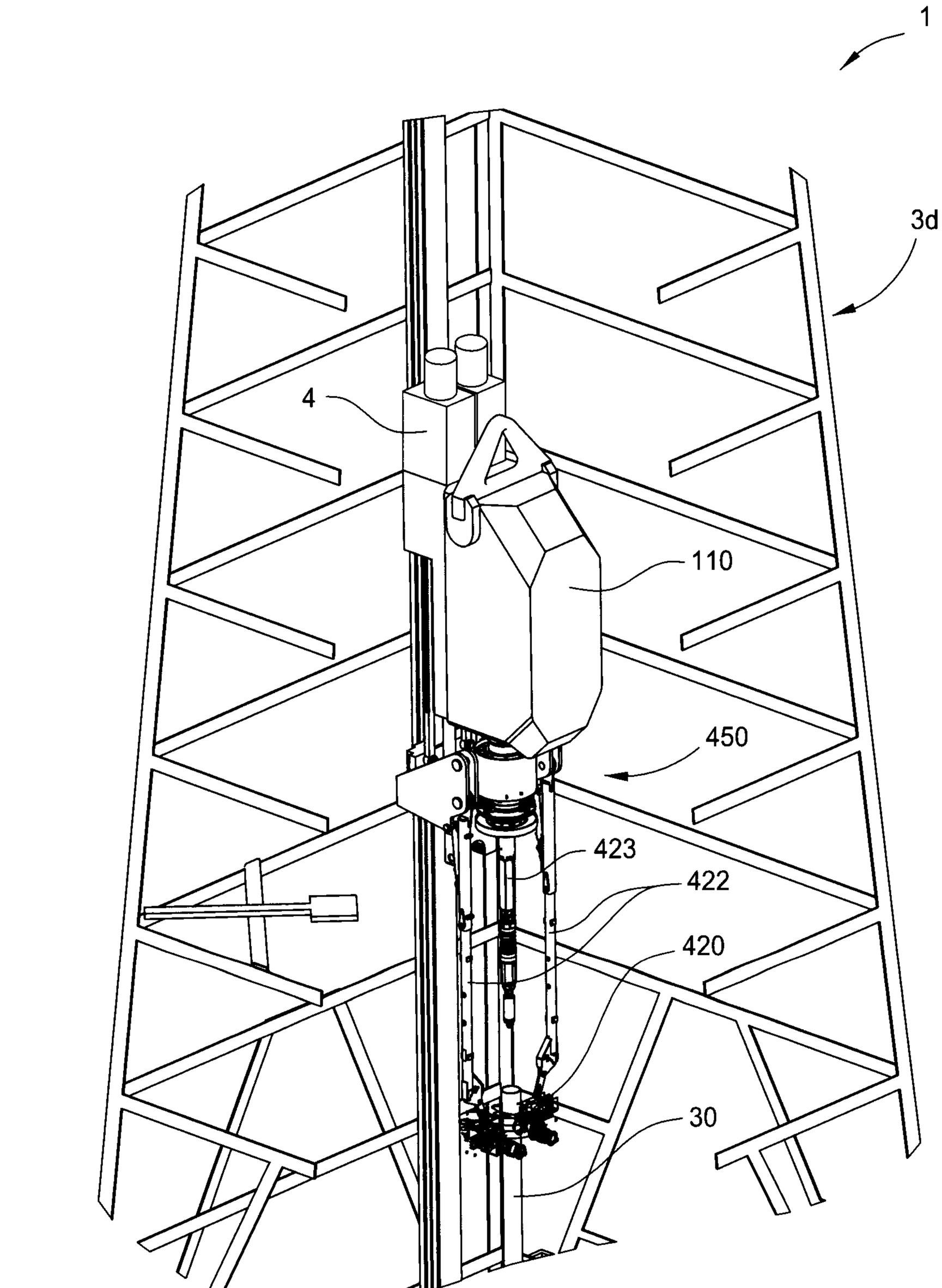


FIG. 18C

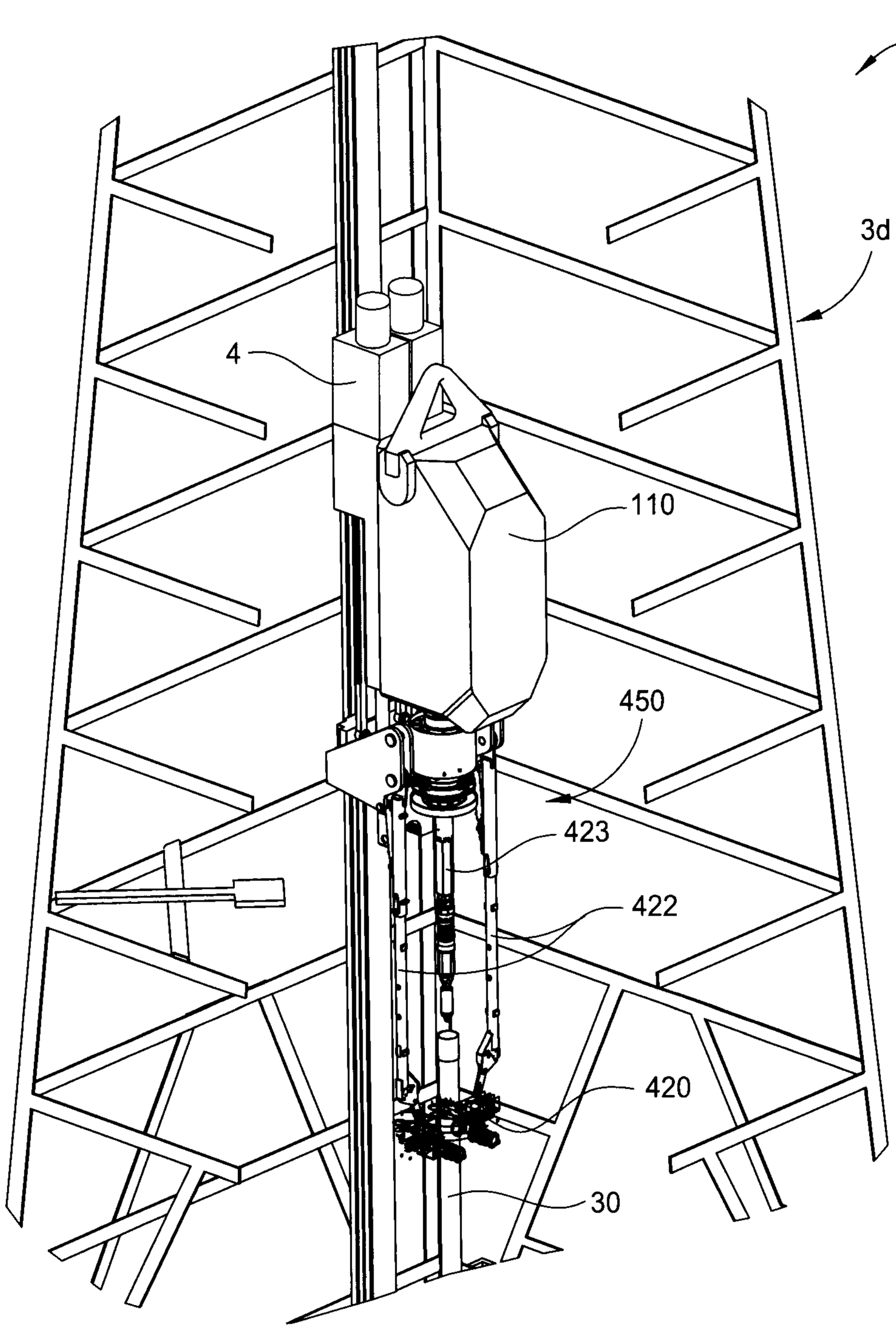


FIG. 18D

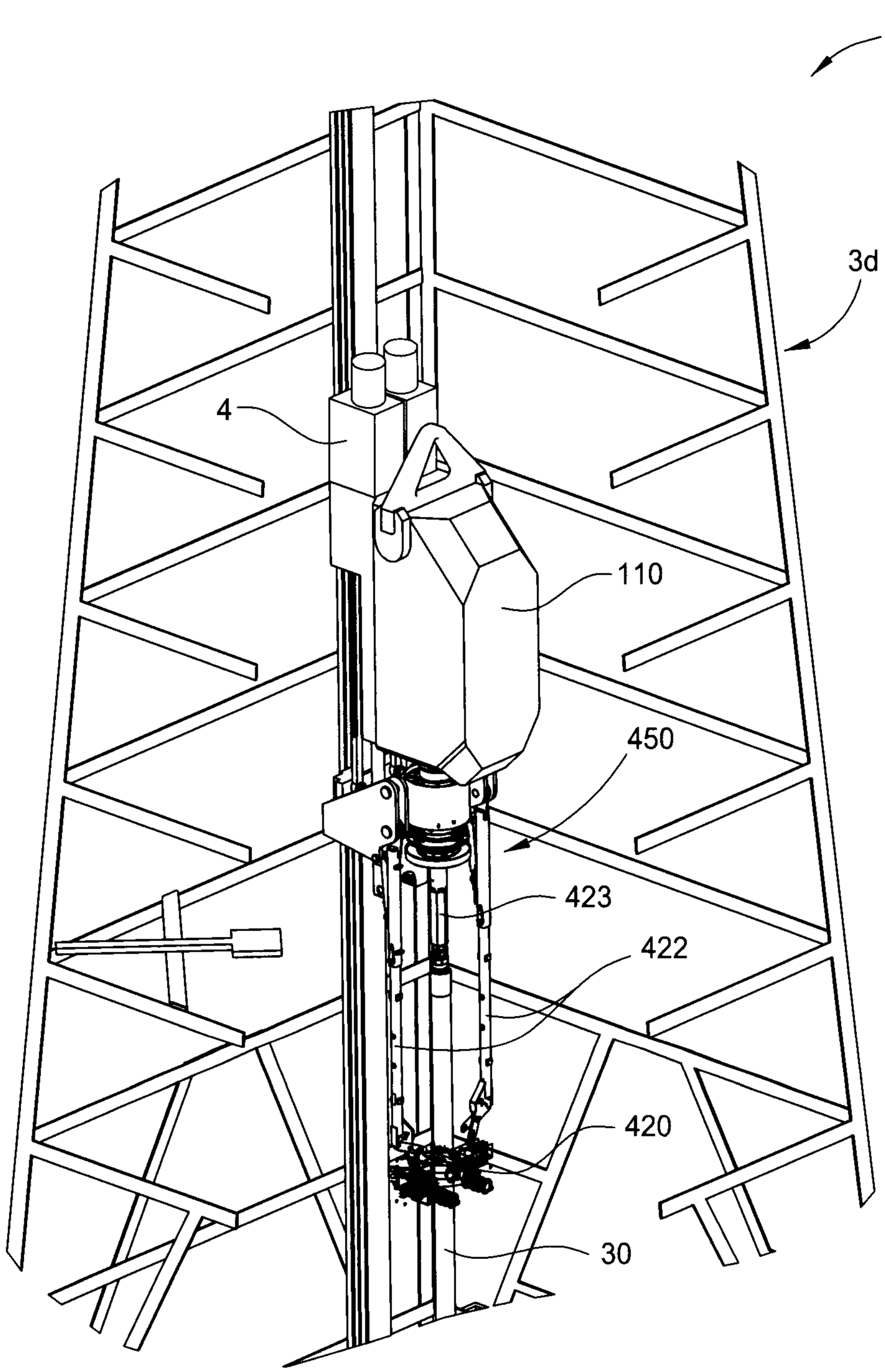


FIG. 18E

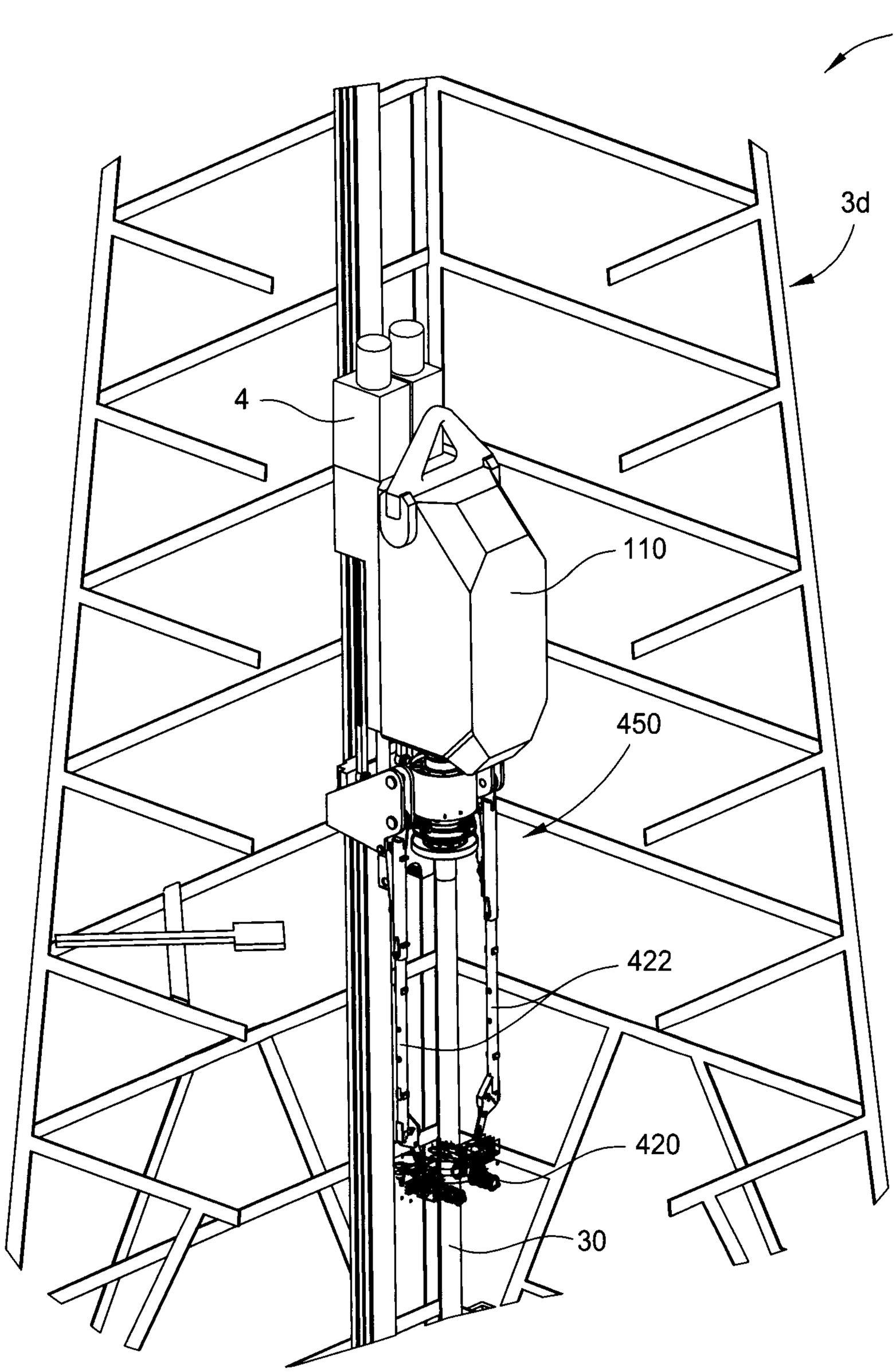
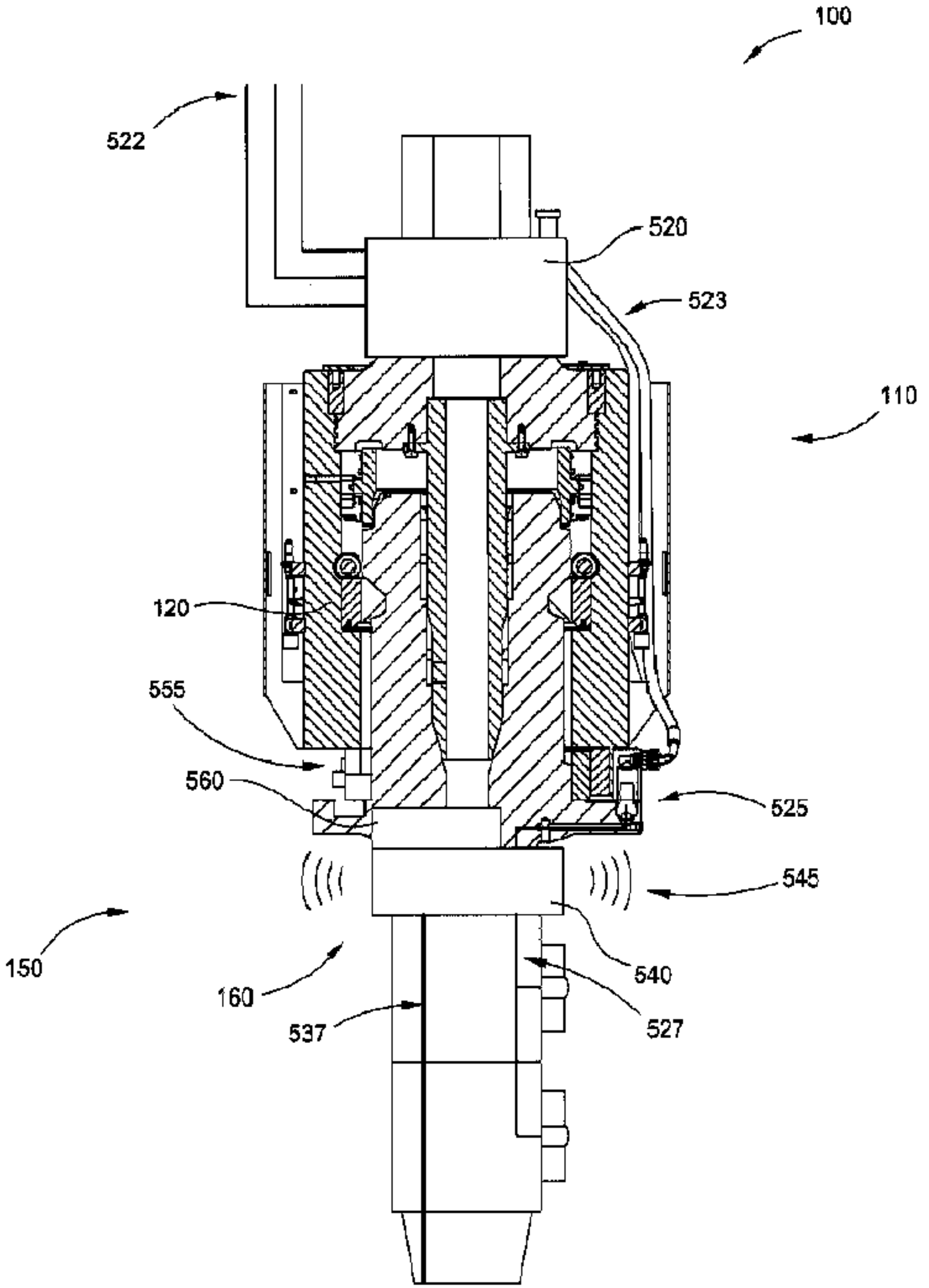


FIG. 18F


100
522
520
523
110
120
555
560
525
545
150
160
540
537
527