

(43) International Publication Date
12 October 2017 (12.10.2017)

- (51) International Patent Classification:
A61B 17/32 (2006.01) *A61B 17/29* (2006.01)
- (21) International Application Number:
PCT/US2017/025952
- (22) International Filing Date:
4 April 2017 (04.04.2017)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
15/089,748 4 April 2016 (04.04.2016) US
- (71) Applicant: ETHICON LLC [US/US]; #475 Street C, Suite 401, Los Frailes Industrial Park, Guaynabo, 00969 (PR).
- (72) Inventors: HIBNER, John A.; 4545 Creek Road, Cincinnati, Ohio 45242 (US). BYRUM, Randal T.; 4545 Creek Road, Cincinnati, Ohio 45242 (US). TELLIO, Karalyn R.; 4545 Creek Road, Cincinnati, Ohio 45242 (US). GROENE, David C.; 4545 Creek Road, Cincinnati, Ohio 45242 (US). DICKERSON, Benjamin D.; 4545 Creek Road, Cincinnati, Ohio 45242 (US).
- (74) Agents: SHIRTZ, Joseph F. et al.; JOHNSON & JOHNSON, One Johnson & Johnson Plaza, New Brunswick, New Jersey 08933 (US).
- (81) Designated States (*unless otherwise indicated, for every kind of national protection available*): AE, AG, AL, AM,

AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

- (84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:

- *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*
- *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

- *with international search report (Art. 21(3))*

[Continued on next page]

(54) Title: SURGICAL INSTRUMENT WITH SELECTIVELY LOCKED ARTICULATION ASSEMBLY

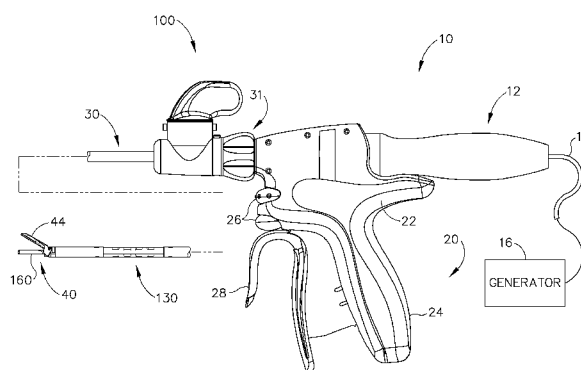


Fig. 1

(57) Abstract: An apparatus for operating on tissue includes a body (22) assembly, a shaft assembly (30), an acoustic waveguide (180), an articulation section (130), an articulation control assembly (100), an end effector (40), and an articulation lock. A portion of the articulation section (130) encompasses a flexible portion (166) of the waveguide (180). The articulation includes a first member (161) and a second member (162) that is longitudinally translatable relative to the first member. The articulation control assembly (100) is configured to move relative to the shaft assembly (30) in order to longitudinally translate the second member (162) relative to the first member (161). The end effector (40) includes an ultrasonic blade (160) in acoustic communication with the waveguide (180). The articulation lock is configured to prevent movement of the articulation control assembly (100) relative to the shaft assembly (30).



-
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

SURGICAL INSTRUMENT WITH SELECTIVELY LOCKED ARTICULATION ASSEMBLY

BACKGROUND

[0001] A variety of surgical instruments include an end effector having a blade element that vibrates at ultrasonic frequencies to cut and/or seal tissue (e.g., by denaturing proteins in tissue cells). These instruments include piezoelectric elements that convert electrical power into ultrasonic vibrations, which are communicated along an acoustic waveguide to the blade element. The precision of cutting and coagulation may be controlled by the surgeon's technique and adjusting the power level, blade edge, tissue traction and blade pressure.

[0002] Examples of ultrasonic surgical instruments include the HARMONIC ACE® Ultrasonic Shears, the HARMONIC WAVE® Ultrasonic Shears, the HARMONIC FOCUS® Ultrasonic Shears, and the HARMONIC SYNERGY® Ultrasonic Blades, all by Ethicon Endo-Surgery, Inc. of Cincinnati, Ohio. Further examples of such devices and related concepts are disclosed in U.S. Pat. No. 5,322,055, entitled "Clamp Coagulator/Cutting System for Ultrasonic Surgical Instruments," issued June 21, 1994, the disclosure of which is incorporated by reference herein; U.S. Pat. No. 5,873,873, entitled "Ultrasonic Clamp Coagulator Apparatus Having Improved Clamp Mechanism," issued February 23, 1999, the disclosure of which is incorporated by reference herein; U.S. Pat. No. 5,980,510, entitled "Ultrasonic Clamp Coagulator Apparatus Having Improved Clamp Arm Pivot Mount," filed October 10, 1997, the disclosure of which is incorporated by reference herein; U.S. Pat. No. 6,325,811, entitled "Blades with Functional Balance Asymmetries for use with Ultrasonic Surgical Instruments," issued December 4, 2001, the disclosure of which is incorporated by reference herein; U.S. Pat. No. 6,773,444, entitled "Blades with Functional Balance Asymmetries for Use with Ultrasonic Surgical Instruments," issued August 10, 2004, the disclosure of which is incorporated by reference herein; U.S. Pat. No. 6,783,524, entitled "Robotic Surgical

Tool with Ultrasound Cauterizing and Cutting Instrument,” issued August 31, 2004, the disclosure of which is incorporated by reference herein; U.S. Pat. No. 8,461,744, entitled “Rotating Transducer Mount for Ultrasonic Surgical Instruments,” issued June 11, 2013, the disclosure of which is incorporated by reference herein; U.S. Pat. No. 8,591,536, entitled “Ultrasonic Surgical Instrument Blades,” issued November 26, 2013, the disclosure of which is incorporated by reference herein; and U.S. Pat. No. 8,623,027, entitled “Ergonomic Surgical Instruments,” issued January 7, 2014, the disclosure of which is incorporated by reference herein.

[0003] Still further examples of ultrasonic surgical instruments are disclosed in U.S. Pub. No. 2006/0079874, entitled “Tissue Pad for Use with an Ultrasonic Surgical Instrument,” published April 13, 2006, the disclosure of which is incorporated by reference herein; U.S. Pub. No. 2007/0191713, entitled “Ultrasonic Device for Cutting and Coagulating,” published August 16, 2007, the disclosure of which is incorporated by reference herein; U.S. Pub. No. 2007/0282333, entitled “Ultrasonic Waveguide and Blade,” published December 6, 2007, the disclosure of which is incorporated by reference herein; U.S. Pub. No. 2008/0200940, entitled “Ultrasonic Device for Cutting and Coagulating,” published August 21, 2008, the disclosure of which is incorporated by reference herein; U.S. Pub. No. 2009/0105750, entitled “Ergonomic Surgical Instruments,” published April 23, 2009, the disclosure of which is incorporated by reference herein; U.S. Pub. No. 2010/0069940, entitled “Ultrasonic Device for Fingertip Control,” published March 18, 2010, the disclosure of which is incorporated by reference herein; and U.S. Pub. No. 2011/0015660, entitled “Rotating Transducer Mount for Ultrasonic Surgical Instruments,” published January 20, 2011, the disclosure of which is incorporated by reference herein; and U.S. Pub. No. 2012/0029546, entitled “Ultrasonic Surgical Instrument Blades,” published February 2, 2012, the disclosure of which is incorporated by reference herein.

[0004] Some ultrasonic surgical instruments may include a cordless transducer such as that disclosed in U.S. Pub. No. 2012/0112687, entitled “Recharge System for Medical Devices,” published May 10, 2012, the disclosure of which is incorporated by reference

herein; U.S. Pub. No. 2012/0116265, entitled “Surgical Instrument with Charging Devices,” published May 10, 2012, the disclosure of which is incorporated by reference herein; and/or U.S. Pat. App. No. 61/410,603, filed November 5, 2010, entitled “Energy-Based Surgical Instruments,” the disclosure of which is incorporated by reference herein.

[0005] Additionally, some ultrasonic surgical instruments may include an articulating shaft section and/or a bendable ultrasonic waveguide. Examples of such ultrasonic surgical instruments are disclosed in U.S. Pat. No. 5,897,523, entitled “Articulating Ultrasonic Surgical Instrument,” issued April 27, 1999, the disclosure of which is incorporated by reference herein; U.S. Pat. No. 5,989,264, entitled “Ultrasonic Polyp Snare,” issued November 23, 1999, the disclosure of which is incorporated by reference herein; U.S. Pat. No. 6,063,098, entitled “Articulate Ultrasonic Surgical Apparatus,” issued May 16, 2000, the disclosure of which is incorporated by reference herein; U.S. Pat. No. 6,090,120, entitled “Articulating Ultrasonic Surgical Instrument,” issued July 18, 2000, the disclosure of which is incorporated by reference herein; U.S. Pat. No. 6,454,782, entitled “Actuation Mechanism for Surgical Instruments,” issued September 24, 2002, the disclosure of which is incorporated by reference herein; U.S. Pat. No. 6,589,200, entitled “Articulating Ultrasonic Surgical Shears,” issued July 8, 2003, the disclosure of which is incorporated by reference herein; U.S. Pat. No. 6,752,815, entitled “Method and Waveguides for Changing the Direction of Longitudinal Vibrations,” issued June 22, 2004, the disclosure of which is incorporated by reference herein; U.S. Pat. No. 7,135,030, entitled “Articulating Ultrasonic Surgical Shears,” issued November 14, 2006; U.S. Pat. No. 7,621,930, entitled “Ultrasound Medical Instrument Having a Medical Ultrasonic Blade,” issued November 24, 2009, the disclosure of which is incorporated by reference herein; U.S. Pub. No. 2014/0005701, published January 2, 2014, entitled “Surgical Instruments with Articulating Shafts,” the disclosure of which is incorporated by reference herein; U.S. Pub. No. 2014/005703, entitled “Surgical Instruments with Articulating Shafts,” published January 2, 2014, the disclosure of which is incorporated by reference herein; U.S. Pub. No. 2014/0114334, entitled “Flexible Harmonic Waveguides/Blades for Surgical Instruments,” published April 24, 2014, the disclosure of which is incorporated by reference herein; U.S. Pub. No. 2015/0080924, entitled

“Articulation Features for Ultrasonic Surgical Instrument,” published March 19, 2015, the disclosure of which is incorporated by reference herein; and U.S. Pat. App. No. 14/258,179, entitled “Ultrasonic Surgical Device with Articulating End Effector,” filed April 22, 2014, the disclosure of which is incorporated by reference herein.

[0006] While several surgical instruments and systems have been made and used, it is believed that no one prior to the inventors has made or used the invention described in the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] While the specification concludes with claims which particularly point out and distinctly claim this technology, it is believed this technology will be better understood from the following description of certain examples taken in conjunction with the accompanying drawings, in which like reference numerals identify the same elements and in which:

[0008] FIG. 1 depicts a side elevational view of an exemplary ultrasonic surgical instrument;

[0009] FIG. 2 depicts a perspective view of an articulation section of a shaft assembly and an end effector of the surgical instrument of FIG. 1;

[00010] FIG. 3 depicts an exploded perspective view of an articulation section of the shaft assembly of FIG. 2;

[00011] FIG. 4 depicts a cross-sectional side view of the shaft assembly and end effector of FIG. 2;

[00012] FIG. 5 depicts a top plan view of the shaft assembly and end effector of FIG. 2;

[00013] FIG. 6A depicts a cross-sectional top view of the shaft assembly and end effector of FIG. 2 in a straight configuration;

[00014] FIG. 6B depicts a cross-sectional top view of the shaft assembly and end effector of FIG. 2 in a first articulated configuration;

- [00015] FIG. 6C depicts a cross-sectional top view of the shaft assembly and end effector of FIG. 2 in a second articulated configuration;
- [00016] FIG. 7 depicts a partially exploded perspective view of an articulation control assembly of the instrument of FIG. 1;
- [00017] FIG. 8 depicts a perspective view of an alternative rotatable knob that may be readily incorporated into the surgical instrument of FIG. 1;
- [00018] FIG. 9 depicts a side elevational view of an alternative shaft assembly that may be readily incorporated into the surgical instrument of FIG. 1;
- [00019] FIG. 10A depicts a side cross-sectional view of the rotatable knob of FIG. 8 and the shaft assembly of FIG. 9 incorporated into the surgical instrument of FIG. 1, where the instrument is in a non-clamping configuration;
- [00020] FIG. 10B depicts a side cross-sectional view of the rotatable knob of FIG. 8 and the shaft assembly of FIG. 9 incorporated into the surgical instrument of FIG. 1, where the instrument is in a clamping configuration;
- [00021] FIG. 11A depicts a side elevational view of the rotatable knob of FIG. 8 and the shaft assembly of FIG. 9 incorporated into the surgical instrument of FIG. 1, with half the body omitted for clarity, where the instrument is in a non-clamping configuration;
- [00022] FIG. 11B depicts a side elevational view of the rotatable knob of FIG. 8 and the shaft assembly of FIG. 9 incorporated into the surgical instrument of FIG. 1, with half the body omitted for clarity, where the instrument is in a clamping configuration;
- [00023] FIG. 12 depicts a perspective view of an alternative handle assembly and another alternative shaft assembly that may be readily incorporated into the instrument of FIG. 1;
- [00024] FIG. 13 depicts a perspective view of the alternative knob of the shaft assembly of FIG. 12;
- [00025] FIG. 14 depicts an exploded perspective view of the shaft assembly and handle assembly of FIG. 12;

- [00026] FIG. 15A depicts a side cross-sectional view of the shaft assembly and handle assembly of FIG. 12, where the articulation and rotations features are in a locked position;
- [00027] FIG. 15B depicts a side cross-sectional view of the shaft assembly and handle assembly of FIG. 12, where the articulation and rotation features are in an unlocked position;
- [00028] FIG. 15C depicts a side cross-sectional view of the shaft assembly and handle assembly of FIG. 12, where the articulation and rotation features are in the unlocked position and the end effector is in the first articulated position shown in FIG. 6B; and
- [00029] FIG. 15D depicts a side cross-sectional view of the shaft assembly and handle assembly of FIG. 12, where the articulation and rotation features are in the unlocked position and the end effector is in the second articulated position shown in FIG. 6C.
- [00030] The drawings are not intended to be limiting in any way, and it is contemplated that various embodiments of the technology may be carried out in a variety of other ways, including those not necessarily depicted in the drawings. The accompanying drawings incorporated in and forming a part of the specification illustrate several aspects of the present technology, and together with the description serve to explain the principles of the technology; it being understood, however, that this technology is not limited to the precise arrangements shown.

DETAILED DESCRIPTION

- [00031] The following description of certain examples of the technology should not be used to limit its scope. Other examples, features, aspects, embodiments, and advantages of the technology will become apparent to those skilled in the art from the following description, which is by way of illustration, one of the best modes contemplated for carrying out the technology. As will be realized, the technology described herein is capable of other different and obvious aspects, all without departing from the technology.

Accordingly, the drawings and descriptions should be regarded as illustrative in nature and not restrictive.

[00032] It is further understood that any one or more of the teachings, expressions, embodiments, examples, etc. described herein may be combined with any one or more of the other teachings, expressions, embodiments, examples, etc. that are described herein. The following-described teachings, expressions, embodiments, examples, etc. should therefore not be viewed in isolation relative to each other. Various suitable ways in which the teachings herein may be combined will be readily apparent to those of ordinary skill in the art in view of the teachings herein. Such modifications and variations are intended to be included within the scope of the claims.

[00033] For clarity of disclosure, the terms “proximal” and “distal” are defined herein relative to a human or robotic operator of the surgical instrument. The term “proximal” refers the position of an element closer to the human or robotic operator of the surgical instrument and further away from the surgical end effector of the surgical instrument. The term “distal” refers to the position of an element closer to the surgical end effector of the surgical instrument and further away from the human or robotic operator of the surgical instrument.

[00034] I. Exemplary Ultrasonic Surgical Instrument

[00035] FIG. 1 shows an exemplary ultrasonic surgical instrument (10). At least part of instrument (10) may be constructed and operable in accordance with at least some of the teachings of any of the various patents, patent application publications, and patent applications that are cited herein. As described therein and as will be described in greater detail below, instrument (10) is operable to cut tissue and seal or weld tissue (e.g., a blood vessel, etc.) substantially simultaneously.

[00036] Instrument (10) of the present example comprises a handle assembly (20), a shaft assembly (30), and an end effector (40). Handle assembly (20) comprises a body (22) including a pistol grip (24) and a pair of buttons (26). Handle assembly (20) also includes a trigger (28) that is pivotable toward and away from pistol grip (24). It should

be understood, however, that various other suitable configurations may be used, including but not limited to a scissor grip configuration. End effector (40) includes an ultrasonic blade (160) and a pivoting clamp arm (44). Clamp arm (44) is coupled with trigger (28) such that clamp arm (44) is pivotable toward ultrasonic blade (160) in response to pivoting of trigger (28) toward pistol grip (24); and such that clamp arm (44) is pivotable away from ultrasonic blade (160) in response to pivoting of trigger (28) away from pistol grip (24). Various suitable ways in which clamp arm (44) may be coupled with trigger (28) will be apparent to those of ordinary skill in the art in view of the teachings herein. In some versions, one or more resilient members are used to bias clamp arm (44) and/or trigger (28) to the open position shown in FIG. 1.

[00037] An ultrasonic transducer assembly (12) extends proximally from body (22) of handle assembly (20). Transducer assembly (12) is coupled with a generator (16) via a cable (14), such that transducer assembly (12) receives electrical power from generator (16). Piezoelectric elements in transducer assembly (12) convert that electrical power into ultrasonic vibrations. Generator (16) may include a power source and control module that is configured to provide a power profile to transducer assembly (12) that is particularly suited for the generation of ultrasonic vibrations through transducer assembly (12). By way of example only, generator (16) may comprise a GEN04 or GEN11 sold by Ethicon Endo-Surgery, Inc. of Cincinnati, Ohio. In addition or in the alternative, generator (16) may be constructed in accordance with at least some of the teachings of U.S. Pub. No. 2011/0087212, entitled “Surgical Generator for Ultrasonic and Electrosurgical Devices,” published April 14, 2011, the disclosure of which is incorporated by reference herein. It should also be understood that at least some of the functionality of generator (16) may be integrated into handle assembly (20), and that handle assembly (20) may even include a battery or other on-board power source such that cable (14) is omitted. Still other suitable forms that generator (16) may take, as well as various features and operabilities that generator (16) may provide, will be apparent to those of ordinary skill in the art in view of the teachings herein.

[00038] A. Exemplary End Effector and Acoustic Drivetrain

[00039] As best seen in FIGS. 2-4, end effector (40) of the present example comprises clamp arm (44) and ultrasonic blade (160). Clamp arm (44) includes a clamp pad (46) that is secured to the underside of clamp arm (44), facing blade (160). Clamp pad (46) may comprise polytetrafluoroethylene (PTFE) and/or any other suitable material(s). Clamp arm (44) is pivotally secured to a distally projecting tongue (43) of an upper distal shaft element (172), which is fixedly secured within a distal portion of a distal outer sheath (33). Clamp arm (44) is operable to selectively pivot toward and away from blade (160) to selectively clamp tissue between clamp arm (44) and blade (160). A pair of arms (156) extend transversely from clamp arm (44) and are pivotally secured to a lower distal shaft element (170), which is slidably disposed within the distal portion of distal outer sheath (33).

[00040] In some examples a cable (not shown) may be secured to lower distal shaft element (170). Such a cable may be operable to translate longitudinally relative to an articulation section (130) of shaft assembly (30) to selectively pivot clamp arm (44) toward and away from blade (160). In further examples, the cable is coupled with trigger (28) such that the cable translates proximally in response to pivoting of trigger (28) toward pistol grip (24), and such that clamp arm (44) thereby pivots toward blade (160) in response to pivoting of trigger (28) toward pistol grip (24). In addition, the cable may translate distally in response to pivoting of trigger (28) away from pistol grip (24), such that clamp arm (44) pivots away from blade (160) in response to pivoting of trigger (28) away from pistol grip (24). Alternatively, the cable may be secured to proximal outer sheath (32). Proximal outer sheath (32) may be coupled with trigger (28) such that the cable and outer sheath (32) translates proximally in response to pivoting of trigger (28) toward pistol grip (24); and such that clamp arm (44) thereby pivots toward blade (160) in response to pivoting of trigger (28) toward pistol grip (24). In addition, the cable and outer sheath (32) may translate distally in response to pivoting of trigger (28) away from pistol grip (24), such that clamp arm (44) pivots away from blade (160) in response to pivoting of trigger (28) away from pistol grip (24). Clamp arm (44) may be biased toward the open position, such that (at least in some instances) the operator may effectively open clamp arm (44) by releasing a grip on trigger (28).

[00041] Blade (160) of the present example is operable to vibrate at ultrasonic frequencies in order to effectively cut through and seal tissue, particularly when the tissue is being compressed between clamp pad (46) and blade (160). Blade (160) is positioned at the distal end of an acoustic drivetrain. This acoustic drivetrain includes transducer assembly (12) and an acoustic waveguide (180). Acoustic waveguide (180) comprises a flexible portion (166). Transducer assembly (12) includes a set of piezoelectric discs (not shown) located proximal to a horn (not shown) of waveguide (180). The piezoelectric discs are operable to convert electrical power into ultrasonic vibrations, which are then transmitted along waveguide (180), including flexible portion (166) of waveguide (180) to blade (160) in accordance with known configurations and techniques. By way of example only, this portion of the acoustic drivetrain may be configured in accordance with various teachings of various references that are cited herein.

[00042] As best seen in FIG. 3, flexible portion (166) of waveguide (180) includes a distal flange (136), a proximal flange (138), and a narrowed section (164) located between flanges (136, 138). In the present example, flanges (136, 138) are located at positions corresponding to nodes associated with resonant ultrasonic vibrations communicated through flexible portion (166) of waveguide (180) (i.e. locations where the vibrational amplitude is minimal). Narrowed section (164) is configured to allow flexible portion (166) of waveguide (180) to flex without significantly affecting the ability of flexible portion (166) of waveguide (180) to transmit ultrasonic vibrations. By way of example only, narrowed section (164) may be configured in accordance with one or more teachings of U.S. Pub. No. 2014/0005701 and/or U.S. Pub. No. 2014/0114334, the disclosures of which are incorporated by reference herein. It should be understood that waveguide (180) may be configured to amplify mechanical vibrations transmitted through waveguide (180). Furthermore, waveguide (180) may include features operable to control the gain of the longitudinal vibrations along waveguide (180) and/or features to tune waveguide (180) to the resonant frequency of the system. Various suitable ways in which waveguide (180) may be mechanically and acoustically coupled with transducer assembly (12) will be apparent to those of ordinary skill in the art in view of the teachings herein.

[00043] Those of ordinary skill in the art will understand that, as a matter of physics, the distal end of blade (160) is located at a position corresponding to an anti-node associated with resonant ultrasonic vibrations communicated through flexible portion (166) of waveguide (180). When transducer assembly (12) is energized, the distal end of blade (160) is configured to move longitudinally in the range of, for example, approximately 10 to 500 microns peak-to-peak, and in some instances in the range of about 20 to about 200 microns at a predetermined vibratory frequency f_0 of, for example, 55.5 kHz. When transducer assembly (12) of the present example is activated, these mechanical oscillations are transmitted through waveguide (180) to reach blade (160), thereby providing oscillation of blade (160) at the resonant ultrasonic frequency. Thus, when tissue is secured between blade (160) and clamp pad (46), the ultrasonic oscillation of blade (160) may simultaneously sever the tissue and denature the proteins in adjacent tissue cells, thereby providing a coagulative effect with relatively little thermal spread.

[00044] In some versions, end effector (40) is operable to apply radiofrequency (RF) electrosurgical energy to tissue in addition to applying ultrasonic energy to tissue. By way of example only, end effector (40) may be configured and operable in accordance with at least some of the teachings of U.S. Pub. No. 2015/0141981, entitled “Ultrasonic Surgical Instrument with Electrosurgical Feature,” published May 21, 2015, the disclosure of which is incorporated by reference herein; and/or U.S. Patent No. 8,663,220, entitled “Ultrasonic Electrosurgical Instruments,” issued March 4, 2014, the disclosure of which is incorporated by reference herein.

[00045] Other suitable configurations for an acoustic transmission assembly and transducer assembly (12) will be apparent to one of ordinary skill in the art in view of the teachings herein. Similarly, other suitable configurations for end effector (40) will be apparent to those of ordinary skill in the art in view of the teachings herein.

[00046] B. Exemplary Shaft Assembly and Articulation Section

[00047] Shaft assembly (30) of the present example extends distally from handle assembly (20). As shown in FIGS. 2-6C, shaft assembly (30) includes distal outer sheath (33) and

a proximal outer sheath (32) that enclose clamp arm (44) drive features and the above-described acoustic transmission features. Shaft assembly (30) further includes an articulation section (130), which is located at a distal portion of shaft assembly (30), with end effector (40) being located distal to articulation section (130). As shown in FIG. 1, a knob (31) is secured to a proximal portion of proximal outer sheath (32). Knob (31) is rotatable relative to body (22), such that shaft assembly (30) is rotatable about the longitudinal axis defined by outer sheath (32), relative to handle assembly (20). Such rotation may provide rotation of end effector (40), articulation section (130), and shaft assembly (30) unitarily. Of course, rotatable features may simply be omitted if desired.

[00048] Articulation section (130) is operable to selectively position end effector (40) at various lateral deflection angles relative to a longitudinal axis defined by outer sheath (32). Articulation section (130) may take a variety of forms. By way of example only, articulation section (130) may be configured in accordance with one or more teachings of U.S. Pub. No. 2012/0078247, the disclosure of which is incorporated by reference herein. As another merely illustrative example, articulation section (130) may be configured in accordance with one or more teachings of U.S. Pub. No. 2014/0005701 and/or U.S. Pub. No. 2014/0114334, the disclosures of which are incorporated by reference herein. Various other suitable forms that articulation section (130) may take will be apparent to those of ordinary skill in the art in view of the teachings herein.

[00049] As best seen in FIGS. 2-6CB articulation section (130) of this example comprises a set of three outer rings (133) and a pair of ribbed body portions (132, 134), with a pair of articulation bands (140, 142) extending along respective channels (135, 137) defined between interior surfaces of outer rings (133) and exterior surfaces of ribbed body portions (132, 134). Ribbed body portions (132, 134) are longitudinally positioned between flanges (136, 138) of flexible portion (166) of waveguide (180). In some versions, ribbed body portions (132, 134) snap together about flexible portion (166) of waveguide (180). Ribbed body portions (132, 134) are configured to flex with flexible portion (166) of waveguide (180) when articulation section (130) bends to achieve an articulated state.

[00050] FIG. 3 shows ribbed body portions (132, 134) in greater detail. In the present example, ribbed body portions (132, 134) are formed of a flexible plastic material, though it should be understood that any other suitable material may be used. Ribbed body portion (132) comprises a set of three ribs (150) that are configured to promote lateral flexing of ribbed body portion (132). Of course, any other suitable number of ribs (150) may be provided. Ribbed body portion (132) also defines a channel (135) that is configured to receive articulation band (140) while allowing articulation band (140) to slide relative to ribbed body portion (132). Similarly, ribbed body portion (134) comprises a set of three ribs (152) that are configured to promote lateral flexing of ribbed body portion (134). Of course, any other suitable number of ribs (152) may be provided. Ribbed body portion (134) also defines a channel (137) that is configured to receive articulation band (142) while allowing articulation band (142) to slide relative to ribbed body portion (137).

[00051] As best seen in FIG. 5, ribbed body portions (132, 134) are laterally interposed between articulation bands (140, 142) and flexible portion (166) of waveguide (180). Ribbed body portions (132, 134) mate with each other such that they together define an internal passage sized to accommodate flexible portion (166) of waveguide (180) without contacting waveguide (180). In addition, when ribbed body portions (132, 134) are coupled together, a pair of complementary distal notches (131A, 131B) formed in ribbed body portions (132, 134) align to receive a pair of inwardly projecting resilient tabs (38) of distal outer sheath (33). This engagement between tabs (38) and notches (131A, 131B) longitudinally secures ribbed body portions (132, 134) relative to distal outer sheath (33). Similarly, when ribbed body portions (132, 134) are coupled together, a pair of complementary proximal notches (139A, 139B) formed in ribbed body portions (132, 134) align to receive a pair of inwardly projecting resilient tabs (37) of proximal outer sheath (32). This engagement between tabs (37) and notches (139A, 139B) longitudinally secures ribbed body portions (132, 134) relative to proximal outer sheath (32). Of course, any other suitable kinds of features may be used to couple ribbed body portions (132, 134) with proximal outer sheath (32) and/or distal outer sheath (33).

[00052] The distal ends of articulation bands (140, 142) are unitarily secured to upper distal shaft element (172). When articulation bands (140, 142) translate longitudinally in an opposing fashion, this will cause articulation section (130) to bend, thereby laterally deflecting end effector (40) away from the longitudinal axis of shaft assembly (30) from a straight configuration as shown in FIG. 6A to a first articulated configuration as shown in FIG. 6B or a second articulated configuration as shown in FIG. 6C. In particular, end effector (40) will be articulated toward the articulation band (140, 142) that is being pulled proximally. During such articulation, the other articulation band (140, 142) may be pulled distally by upper distal shaft element (172). Alternatively, the other articulation band (140, 142) may be driven distally by an articulation control. Ribbed body portions (132, 134) and narrowed section (164) are all sufficiently flexible to accommodate the above-described articulation of end effector (40). Furthermore, flexible acoustic waveguide (166) is configured to effectively communicate ultrasonic vibrations from waveguide (180) to blade (160) even when articulation section (130) is in an articulated state as shown in FIGS. 6B-6C.

[00053] As best seen in FIG. 3, each flange (136, 138) of waveguide (180) includes a respective pair of opposing flats (192, 196). Flats (192, 196) are oriented along vertical planes that are parallel to a vertical plane extending through narrowed section (164) of flexible portion (166). Flats (192, 196) are configured to provide clearance for articulation bands (140, 142). In particular, flats (196) of proximal flange (138) accommodate articulation bands (140, 142) between proximal flange (138) and the inner diameter of proximal outer sheath (32); while flats (192) of distal flange (136) accommodate articulation bands (140, 142) between distal flange (136) and the inner diameter of distal outer sheath (33). Of course, flats (192, 196) could be substituted with a variety of features, including but not limited to slots, channels, etc., with any suitable kind of profile (e.g., square, flat, round, etc.). In the present example, flats (192, 196) are formed in a milling process, though it should be understood that any other suitable process(es) may be used. Various suitable alternative configurations and methods of forming flats (192, 196) will be apparent to those of ordinary skill in the art in view of the teachings herein. It should also be understood that waveguide (180) may include flats

formed in accordance with at least some of the teachings of U.S. Pub. No. 2013/0289592, entitled "Ultrasonic Device for Cutting and Coagulating," published October 31, 2013, the disclosure of which is incorporated by reference herein.

[00054] In the present example, outer rings (133) are located at longitudinal positions corresponding to ribs (150, 152), such that three rings (133) are provided for three ribs (150, 152). Articulation band (140) is laterally interposed within channel (135) between rings (133) and ribbed body portion (132); while articulation band (142) is laterally interposed within channel (137) between rings (133) and ribbed body portion (134). Rings (133) are configured to keep articulation bands (140, 142) in a parallel relationship, particularly when articulation section (130) is in a bent configuration (e.g., similar to the configuration shown in FIGS. 6B-6C). In other words, when articulation band (140) is on the inner diameter of a curved configuration presented by a bent articulation section (130), rings (133) may retain articulation band (140) such that articulation band (140) follows a curved path that complements the curved path followed by articulation band (142). It should be understood that channels (135, 137) are sized to accommodate respective articulation bands (140, 142) in such a way that articulation bands (140, 142) may still freely slide through articulation section (130), even with rings (133) being secured to ribbed body portions (150, 152). It should also be understood that rings (133) may be secured to ribbed body portions (132, 134) in various ways, including but not limited to interference fitting, adhesives, welding, etc.

[00055] When articulation bands (140, 142) are translated longitudinally in an opposing fashion, a moment is created and applied to a distal end of distal outer sheath (33) via upper distal shaft element (172). This causes articulation section (130) and narrowed section (164) of flexible portion (166) of waveguide (180) to articulate, without transferring axial forces in articulation bands (140, 142) to waveguide (180). It should be understood that one articulation band (140, 142) may be actively driven distally while the other articulation band (140, 142) is passively permitted to retract proximally. As another merely illustrative example, one articulation band (140, 142) may be actively driven proximally while the other articulation band (140, 142) is passively permitted to

advance distally. As yet another merely illustrative example, one articulation band (140, 142) may be actively driven distally while the other articulation band (140, 142) is actively driven proximally. Various suitable ways in which articulation bands (140, 142) may be driven will be apparent to those of ordinary skill in the art in view of the teachings herein.

[00056] As best seen in FIG. 7, an articulation control assembly (100) is secured to a proximal portion of outer sheath (32). Articulation control assembly (100) comprises a housing (110) and a rotatable knob (120). Housing (110) comprises a pair of perpendicularly intersecting cylindrical portions (112, 114). Knob (120) is rotatably disposed within a first hollow cylindrical portion (112) of housing (110) such that knob (120) is operable to rotate within cylindrical portion (112) of housing (110). Shaft assembly (30) is slidably and rotatably disposed within a second cylindrical portion (114). Shaft assembly (30) comprises a pair of translatable members (161, 162), both of which extend slidably and longitudinally through the proximal portion of outer sheath (32). Translatable members (161, 162) are longitudinally translatable within second cylindrical portion (114) between a distal position and a proximal position. Translatable members (161, 162) are mechanically coupled with respective articulation bands (140, 142) such that longitudinal translation of translatable member (161) causes longitudinal translation of articulation band (140), and such that longitudinal translation of translatable member (162) causes longitudinal translation of articulation band (142).

[00057] Knob (120) comprises a pair of pins (122, 124) extending downwardly from a bottom surface of knob (120). Pins (122, 124) extend into second cylindrical portion (114) of housing (110) and are rotatably and slidably disposed within a respective pair of channels (163, 165) formed in top surfaces of translatable members (161, 162). Channels (163, 165) are positioned on opposite sides of an axis of rotation of knob (120), such that rotation of knob (120) about that axis causes opposing longitudinal translation of translatable members (161, 162). For instance, rotation of knob (120) in a first direction causes distal longitudinal translation of translatable member (161) and articulation band (140), and proximal longitudinal translation of translatable member (162) and articulation

band (142); and rotation of knob (120) in a second direction causes proximal longitudinal translation of translatable member (161) and articulation band (140), and distal longitudinal translation of translatable member (162) and articulation band (142). Thus, it should be understood that rotation of rotation knob (120) causes articulation of articulation section (130).

[00058] Housing (110) of articulation control assembly (100) comprises a pair of set screws (111, 113) extending inwardly from an interior surface of first cylindrical portion (112). With knob (120) rotatably disposed within first cylindrical portion (112) of housing (110), set screws (111, 113) are slidably disposed within a pair of arcuate channels (121, 123) formed in knob (120). Thus, it should be understood that rotation of knob (120) will be limited by movement of set screws (111, 113) within channels (121). Set screws (111, 113) also retain knob (120) in housing (110), preventing knob (120) from traveling vertically within first cylindrical portion (112) of housing (110).

[00059] An interior surface of first cylindrical portion (112) of housing (110) comprises a first angular array of teeth (116) and a second angular array of teeth (118) formed in an interior surface of first cylindrical portion (112). Rotation knob (120) comprises a pair of outwardly extending engagement members (126, 128) that are configured to engage teeth (116, 118) of first cylindrical portion (112) in a detent relationship to thereby selectively lock knob (120) in a particular rotational position. The engagement of engagement members (126, 128) with teeth (116, 118) may be overcome by a user applying sufficient rotational force to knob (120); but absent such force, the engagement will suffice to maintain the straight or articulated configuration of articulation section (130). It should therefore be understood that the ability to selectively lock knob (120) in a particular rotational position lock will enable an operator to selectively lock articulation section (130) in a particular deflected position relative to the longitudinal axis defined by outer sheath (32).

[00060] In addition to or in lieu of the foregoing, articulation section (130) and/or articulation control assembly (100) may be constructed and/or operable in accordance

with at least some of the teachings of U.S. Pat. App. No. 14/688,458, entitled “Ultrasonic Surgical Instrument with Rigidizing Articulation Drive Members,” filed on April 16, 2015. Alternatively, articulation section (130) and/or articulation control assembly (100) may be constructed and/or operable in any other suitable fashion.

[00061] II. Exemplary Articulation Section Locking Features

[00062] In some instances, it may be desirable to selectively lock articulation section (130) in various articulation angles. In other words, it may be desirable to selectively prevent further deflection of end effector (40) relative to the longitudinal axis defined by proximal outer sheath (32). Locking articulation section (130) may prevent a user from inadvertently articulating (or de-articulating) end effector (40) during use of instrument (10) in a surgical procedure. In some instances, it may also be desirable to simultaneously or independently lock rotatable features, such as knob (31) described above. A user may thus be prevented from inadvertently rotating shaft assembly (30) about the longitudinal axis defined by outer sheath (32) during use of instrument (10) in a surgical procedure.

[00063] A. Locking Features Associated with Trigger Closure

[00064] FIGS. 8-11B show an alternative rotatable knob (220), alternative shaft assembly (230), and alternative trigger (228) that may be readily incorporated into instrument (10). Knob (220) is substantially similar to knob (120), with the differences described below. Knob (220) includes an arcuate channel (221), engagement member (226), pins (222, 224), and set screws (211, 213); which are substantially similar to arcuate channel (121), engagement member (126), pins (122, 124), and set screws (111, 113), respectively, described above. Also similar to knob (120), knob (220) is rotatably disposed within a first hollow cylindrical portion (112) of housing (110) such that knob (220) is operable to rotate within cylindrical portion (112) of housing (110). Pins (222, 224) extend into second cylindrical portion (114) of housing (110) and are rotatably and slidably disposed within a respective pair of channels (263, 265) formed in top surfaces of translatable members (261, 262). Channels (263, 265) are positioned on opposite sides of an axis of

rotation of knob (220), such that rotation of knob (220) about that axis causes opposing longitudinal translation of translatable members (261, 262).

[00065] Unlike knob (120) described above, knob (220) of the present example also includes an annular array of distally presented teeth (225). As will be described in greater detail below, teeth (225) of knob (220) may selectively lock with portions of shaft assembly (230) in order to help lock articulation of end effector (40).

[00066] Shaft assembly (230) is substantially similar to shaft assembly (30) described above, with differences described below. Shaft assembly (230) includes a proximal outer shaft (232), translatable members (261, 262), a pair of channels (263, 265), and a waveguide (280); all of which are substantially similar to proximal outer shaft (32), translatable members (161, 162), channels (163, 165), and waveguide (180), respectively, as described above. It should be understood that translatable members (261, 262) and waveguide (280) will be attached to articulation section (130) and end effector (40) in substantially the same manner as translatable members (161, 162) and waveguide (180) described above. Therefore, translatable members (261, 262) may be mechanically coupled with articulation bands (140, 142) while waveguide (280) may transition into narrowed section (164) and ultrasonic blade (160); similar to that seen in FIG. 3. Also similar to shaft assembly (30), a proximal portion of outer sheath (232) may be connected to knob (31) such that shaft assembly (230) is rotatable about the longitudinal axis defined by outer sheath (232), relative to handle assembly (20). Of course, rotatable features may simply be omitted if desired.

[00067] Shaft assembly (230) includes a radial mounting ring (236) with an annular array of pins (238) projecting from the exterior of mounting ring (236). Mounting ring (236) is fixed to proximal outer shaft (232). As previously described above for proximal outer shaft (32) and trigger (28), proximal outer shaft (232) is coupled with trigger (228) such that outer sheath (232) translates proximally in response to pivoting of trigger (228) toward pistol grip (24). As shown in FIGS. 10A-10B, pins (328) project from the exterior of mounting ring (236) in such a manner that the top pin (238) will mesh with distal facing teeth (225) when trigger (228) is pivoted toward pistol grip (24).

[00068] Additionally, as seen in FIGS. 11A-11B, trigger (228) includes a lever (240), a pin (241), and a pivot (242). Lever (240) is pivotally fixed to handle assembly (22) via pivot (242). Pin (241) is attached to the end of lever (240) opposite of trigger (28). As shown in FIGS. 11A-11B, as trigger (228) is pivoted toward pistol grip (24), lever (240) rotates about pivot (242) until trigger (228) completes a range of pivotal motion. When trigger (228) is fully closed against pistol grip (24), pin (241) is configured to mesh against splines (231) of proximal outer sheath (232). In some other versions, pin (241) may reach a position where pin (241) meshes with splines (231) before trigger (228) actually reaches pistol grip (24).

[00069] It should be understood from the foregoing that, when trigger (228) completes a full range of pivotal motion, top pin (238) meshes against distal facing teeth (225) while pin (242) simultaneously meshes against splines (2310) of proximal outer sheath (232). With pin (241) meshing against splines (231), the rotational position of shaft assembly (230) about the longitudinal axis defined by proximal outer shaft (232) is locked. Additionally, with top pin (238) meshing against distal facing teeth (225), rotation knob (220) is rotationally fixed relative to first hollow cylindrical portion (112). Thus, pins (222, 224) are rotationally fixed, such that translatable members (261, 262) are longitudinally fixed. With translatable members (261, 262) being mechanically coupled to articulation bands (140, 142), articulation bands (140, 142) are also longitudinally fixed. Therefore, the articulated position of end effector (40) is fixed (regardless of whether articulation section (130) is in a straight configuration or a bent configuration). In other words, when trigger (228) completes a full range of pivotal motion, the rotational position of proximal outer sheath (232) and the articulated position (40) of end effector (40) are both locked. This prevents end effector (40) from inadvertently rotating about the longitudinal axis or deflecting laterally relative to the longitudinal axis when clamp arm (44) is in a closed position. This will further prevent inadvertent damage to tissue clamped between clamp arm (44) and blade (160) that might otherwise occur if end effector (40) is inadvertently rotated about the longitudinal axis or deflected laterally relative to the longitudinal axis.

[00070] B. Locking Features with Biased Engagement

[00071] FIGS. 12-15D show an articulation control assembly (300), a conical lock (310), a knob (331), a handle assembly (320), and a shaft assembly (330) that may be readily incorporated into instrument (10) described above. Handle assembly (320) is substantially similar to handle assembly (20) described above, with the differences described below. In particular, handle assembly (320) includes a body (322) and a button (326) that are substantially similar to body (22) and button (26) described above. However, handle assembly (320) also includes an articulation finger wheel (325). As will be described in greater detail below, articulation finger wheel (325) is capable of selectively controlling articulation control assembly (300) to articulate end effector (40) relative to a longitudinal axis (L2) defined by a proximal outer sheath (332) of shaft assembly (330). By way of example only, finger wheel (325) may be operable to drive articulation of end effector (40) in accordance with at least some of the teachings of U.S. Patent App. No. 14/688,663, entitled “Ultrasonic Surgical Instrument with Opposing Thread Drive for End Effector Articulation,” filed April 16, 2015, the disclosure of which is incorporated by reference herein.

[00072] Shaft assembly (330) includes a waveguide (380), a pair of translating members (361, 362), and a proximal outer shaft (332). Waveguide (380) is substantially similar to waveguide (180, 280) mentioned above. A proximal end of waveguide (380) extends through knob (331), articulation drive shaft (370), and conical lock (310) into handle assembly (320). Translating member (361) is substantially similar to translating member (161, 261) mentioned above, with differences described below. Additionally, translating member (362) is substantially similar to translating member (162, 262) described above, with differences described below. Therefore, translatable members (361, 362) may be mechanically coupled with articulation bands (140, 142) while waveguide (280) may transition into narrowed section (164) and ultrasonic blade (160); similar to that seen in FIG. 3. However, instead of defining channels (163, 165, 263, 265), translatable members (361, 362) are fixed to a respective translating gear drive (363, 365). As will be described in greater detail below, translating gear drives (363, 365) are configured as lead

screws with threading that mesh with a selected portion of articulation control assembly (300) in order to translate translating members (361, 362) to articulate end effector (40) relative to longitudinal axis (L2) defined by proximal outer sheath (332) of shaft assembly (330).

[00073] Waveguide (380) is housed within translating members (361, 362), while translating members (361, 362) are housed within proximal outer shaft (332). Proximal outer shaft (332) defines slots (334) for translating drive gears (363, 365) to protrude from in order to mate with articulation drive shaft (370), as will be described below.

[00074] Knob (331) is substantially similar to knob (31, 231) described above in that a proximal portion of outer sheath (332) may be connected to knob (331) such that knob (331) may rotate shaft assembly (330) about longitudinal axis (L2) defined by outer sheath (332). Knob (331) includes a proximal sleeve (346), a radial protrusion (354), a proximal exterior surface (352), a first annular wall (348), a second annular wall (350), a pair of biasing springs (356, 358), and a pair of unlocking pins (340) slidably housed within respective pin slots (341). Knob (331) defines a cavity (344) that partially houses articulation drive shaft (370) and conical rotation lock (310). Knob (331) also defines a pair of locking slots (342) extending from proximal exterior wall (342) into cavity (344). Biasing spring (358) is housed within first annular wall (348) of knob (331) while biasing spring (356) is housed within second annular wall (350) of knob (331). As will be described in greater detail below, unlocking pins (340) may be pressed inwardly to enable unitary rotation of knob (331) and shaft assembly (330) about longitudinal axis (L2) defined by proximal outer shaft (332); and to enable translation of translating members (361, 362) to articulate end effector (40) relative to longitudinal axis (L2).

[00075] Articulation control assembly (300) includes an articulation drive shaft (370), a drive shaft (315) unitarily connected to articulation finger wheel (325), and a bevel gear (335) unitarily fixed to the other end of drive shaft (315). Articulation finger wheel (325) is rotatably fixed to body (322) via pin (311). Pin (311) defines axis (L1), which articulation finger wheel (325), drive shaft (315) and bevel gear (335) rotate about. Articulation drive shaft (370) includes a hollow shaft (372), a bevel gear (375), and a

rotating drive gear (374). Articulation drive shaft (370) also defines a hollow portion (379) that partially houses proximal outer shaft (332), waveguide (380), and translating members (361, 362). Bevel gear (375) is fixed to a proximal end of hollow shaft (372) while rotating drive gear (374) is fixed to a distal end of hollow shaft (372). Bevel gears (335, 375) are configured to mesh with each other such that rotation of bevel gear (335) about axis (L1) causes rotation of bevel gear (375) about axis (L2). Because bevel gear (375) is unitarily fixed to hollow shaft (372) and rotating drive gear (374), rotation of bevel gear (375) also rotates hollow shaft (372) and rotating drive gear (374) in the same direction. Therefore, rotation of finger wheel (325) about axis (L1) causes rotation of rotating drive gear (374) about axis (L2).

[00076] As seen in FIGS. 15A-15D, rotating drive gear (374) includes a pair of opposed-pitch threading (376, 377) and an external annular step surface (378). Opposed-pitch threading (376, 377) faces toward hollow portion (379). It should be understood that if threading (376) has a right-handed pitch orientation, threading (377) would have a left-handed pitch orientation or vice versa. Translating drive gear (363) meshes with threading (377) while translating drive gear (365) meshes with threading (376). It should be understood that translating drive gears (363, 365) are mechanically grounded with proximal outer shaft (332). Therefore, rotation of rotating drive gear (374) relative to proximal outer shaft (332) actuates translating members (361, 362) via meshing of translating drive gears (363, 365) and respective threading (377, 376). Due to the opposing orientation of threading (376, 377), rotation of rotating drive member (374) in a first direction will actuate translating drive gear (365) and translating member (362) in a distal direction while simultaneously translating drive gear (363) and translating member (361) in a distal direction as shown in FIG. 15C. This position may correspond with the articulated state of end effector (40) shown in FIG. 6B. Also, rotation of rotating drive member (374) in a second direction will actuate translating driver gear (365) and translating member (362) in a proximal direction while simultaneously translating driver gear (363) and translating member (361) in a distal direction as shown in FIG. 15D. This position may correspond with the articulated state of end effector (40) shown in FIG. 6C.

[00077] Conical rotation lock (310) includes a pair of proximally presented tabs (312), an intermediate portion (317), a conical portion (316), and a distal end (319) having an internal step (318). As shown in FIG. 15A, spring (348) is located between first annular wall (348) and distal end (319) to impart a biasing force on conical lock (310) so that proximally presented tabs (312) extend through locking slots (342). A portion of body (322) is located between proximal exterior surface (352) and radial protrusion (354) of knob (331). Proximally presented tabs (312) extend through locking slots (342) to make contact with the portion of body (322) located between proximal exterior surface (352) and radial protrusion (342). The contact between proximally presented tabs (312) and body (322) provides a frictional braking force preventing rotation on conical lock (310). The frictional braking force travels through spring (358) to first annular wall (348) of knob (331). Alternatively, some other kind of feature(s) may be provided to couple knob (331) with conical lock (310). In either case, the frictional braking force between distally presented tabs (312) and body (322) prevents rotation of knob (331) about longitudinal axis (L2). Knob (331) and shaft assembly (330) are thus effectively locked in rotational position when conical lock (310) is in the proximal position shown in FIG. 15A. In some versions, body (322) includes an annular array of recesses that are configured to receive proximally presented tabs (312), thereby providing an enhanced braking effect when conical rotation lock is in the proximal position shown in FIG. 15A.

[00078] Additionally, as shown in FIG. 15A, spring (356) is located between second annular wall (350) and a distal end of rotating drive gear (374) to impart a biasing force on rotating drive gear (374) so that annular step surface (378) contacts internal step (318) of conical lock (310). The proximal bias of rotating drive gear (374) creates a frictional braking force between the complementary threading (376, 377) of rotating drive gear (374) and the threading of translating drive gears (365, 363), respectively. This frictional braking force is sufficient to inhibit rotation of articulation drive shaft (370) about longitudinal axis (L2). Therefore, a user may be prevented from rotating articulation finger wheel (325) about pin (311) if bevel gears (335, 375) are meshed. In other words, the frictional braking force provided by the proximal bias of rotating driver gear (374)

acts as an articulation lock for articulation control assembly (300) when knob (331) is in the position shown in FIG. 15A.

[00079] Alternatively, the proximal bias of rotating drive gear (374) may place bevel gear (375) in a proximal position such that bevel gear (375) does not mesh with bevel gear (335). Thus, rotation of articulation finger wheel (325) about axis (L1) would not rotate articulation drive shaft (370) about axis (L2), such that articulation control assembly (300) would effectively be inoperable when knob (331) is in the position shown in FIG. 15A.

[00080] As previously mentioned, unlocking pins (340) are slidably housed within pin slots (341). Conical portion (316) of conical lock (310) is located directly under the bottom of unlocking pins (340). As shown between FIG. 15A and FIG. 15B, unlocking pins (340) may be pressed inwardly to make contact with conical portion (316) of conical lock (310). The inward motion of unlocking pins (340) imparts a camming force on conical portion (316) of conical lock (310). The camming force imparted on conical lock (310) may overcome the biasing forces provided springs (348, 350). Therefore, conical lock (310) travels in the distal direction. When this occurs, proximally presented pins (312) of conical lock (310) no longer make contact with the portion of body (322) located between proximal exterior surface (352) and radial protrusion (354) of knob (331). In other words, conical lock (310) and body (322) no longer impart a frictional braking force on knob (331). With no frictional braking force imparted on knob (331), knob (331) and shaft assembly (330) are free to rotate about longitudinal axis (L2).

[00081] It should be understood that rotation of knob (331) in the position shown in FIG. 15B also rotates translating members (361, 362) and translating drive gears (363, 365). However, contact between internal step (318) of conical lock (310) and annular step surface (378) of rotating drive gear (374) imparts a frictional force such that articulation drive shaft (370) unitarily rotates with conical lock (310) and knob (331). Therefore, there is no effective rotation between translating drive gears (363, 365) and rotating drive gear (374). Thus, rotation of knob (331) and shaft assembly (330) in the position shown

in FIG. 15B do not cause any unintentional articulation of end effector (40). However, it should be understood that if a user holds articulation finger wheel (325) while rotation knob (331) and shaft assembly (330) are in the position shown in FIG. 15B, the friction force between internal step (318) of conical lock (310) and annular step surface (378) will be overcome, leading to rotation between translating drive gears (363, 365) and rotation drive gear (374), and therefore articulation of end effector (40).

[00082] Additionally, when unlocking pins (340) force conical lock (310) in the distal direction as shown in FIG. 15B, internal step (318) of conical lock (310) contacts annular step surface (378) of rotating drive gear (374) to force articulation drive shaft (370) in the distal direction. Thus, complementary threading (376, 377) of rotating drive gear (374) and the threading of translating drive gears (365, 363), respectively, are aligned. This alignment eliminates the frictional braking force between complementary threading (376, 377) of rotating drive gear (374) and threading of translating drive gears (365, 363), respectively. A user may then rotate articulation finger wheel (325) about axis (L1) to rotate articulation drive shaft (370) about longitudinal axis (L2). A user may therefore no longer be prevented from rotating articulation finger wheel (325) about pin (311) when bevel gears (335, 375) are meshed. In other words, articulation control assembly (300) is in an unlocked configuration when conical lock (310) is in the position shown in FIG. 15B.

[00083] Alternatively, the distal movement of rotating drive gear (374) may place bevel gear (375) in a distal position such that bevel gear (375) and bevel gear (35) mesh. Then, rotation of articulation finger wheel (325) about axis (L1) would rotate articulation drive shaft (370) about axis (L2), therefore effectively unlocking articulation control assembly (300) when knob (331) is in the position shown in FIG. 15B.

[00084] As shown in FIG. 15C, a user may rotate articulation finger wheel (325) in a first direction about axis (L1) while holding knob (331), leading to rotation of drive shaft (315) and bevel gear (335) about axis (L1). Due to bevel gear (335) meshing with bevel gear (375), bevel gear (375) and the rest of articulation drive shaft (370) rotate about

longitudinal axis (L2) in a first direction. Because a user is preventing rotation of knob (331), rotation of drive shaft (370) leads to rotation of rotating drive gear (374) in the first direction relative to proximal outer shaft (332). Due to the opposed-pitch threading (376, 377) meshing with translating drive gears (365, 363) respectively, translating drive gear (365) and translating member (362) actuate in a distal direction while translating driver gear (363) and translating member (361) simultaneously actuate in a proximal direction. This position may correspond with the articulated state of end effector (40) shown in FIG. 6B.

[00085] Alternatively, as shown in FIG. 15D, a user may rotate articulation finger wheel (325) in a second direction about axis (L1) while holding knob (331), leading to drive shaft (315) and bevel gear (335) rotating about axis (L1). Due to bevel gear (335) meshing with bevel gear (375), bevel gear (375) and the rest of articulation drive shaft (370) rotate about longitudinal axis (L2) in a second direction. Because a user is preventing rotation of knob (331), rotation of drive shaft (370) leads to rotation of rotating drive gear (374) in the second direction relative to proximal outer shaft (332). Due to the opposed-pitch threading (376, 377) meshing with translating drive gears (365, 363) respectively, translating drive gear (365) and translating member (362) actuate in a proximal direction while translating driver gear (363) and translating member (361) simultaneously actuate in a distal direction. This position may correspond with the articulated state of end effector (40) shown in FIG. 6C.

[00086] When a user releases unlocking pins (340), springs (348, 350) resiliently return articulation drive shaft (370) and conical lock (310) back into the position shown in FIG. 15A, thereby preventing rotation of knob (331) and shaft assembly (330) about longitudinal axis (L2), and also preventing articulation of end effector (40) through rotation of articulation control assembly (300).

[00087] Therefore, a user may selectively unlock the rotation features of knob (331) and shaft assembly (330) while unlocking the articulation features of articulation control assembly (300) by pushing unlocking pins (340) inwardly. A user may then rotate knob

(331) and shaft assembly (330) to a desired rotation position relative to longitudinal axis (L2) and simultaneously articulate end effector (40) to a desired articulated position. Once user releases unlocking pins (340), knob (331), shaft assembly (330), and end effector (40) will remain in the desired positions until unlocking pins (340) are pushed inwardly again.

[00088] In the foregoing example, conical lock (310) is configured to transition between a first state (proximal position) and a second state (distal position). In the first state, conical lock (310) is configured to simultaneously lock rotation of shaft assembly (330) about the longitudinal axis (L2) and articulation of end effector (40). In the second state, conical lock (310) is configured to simultaneously unlock rotation of shaft assembly (330) about the longitudinal axis (L2) and articulation of end effector (40). In some other versions, separate components or features are used to lock/unlock rotation of shaft assembly (330) about the longitudinal axis (L2) and articulation of end effector (40). For instance, a first locking feature may selectively lock/unlock rotation of shaft assembly (330) about the longitudinal axis (L2); while a second locking feature may selectively lock/unlock articulation of end effector (40). In such versions, a single control feature (e.g., button, slider, lever, etc.) may be used to simultaneously actuate the first and second locking features. Alternatively, the first and second locking features may be actuated independently (e.g., by respective first and second control features). Various suitable ways in which these alternative versions may be provided will be apparent to those of ordinary skill in the art in view of the teachings herein.

[00089] III. Exemplary Combinations

[00090] The following examples relate to various non-exhaustive ways in which the teachings herein may be combined or applied. It should be understood that the following examples are not intended to restrict the coverage of any claims that may be presented at any time in this application or in subsequent filings of this application. No disclaimer is intended. The following examples are being provided for nothing more than merely illustrative purposes. It is contemplated that the various teachings herein may be

arranged and applied in numerous other ways. It is also contemplated that some variations may omit certain features referred to in the below examples. Therefore, none of the aspects or features referred to below should be deemed critical unless otherwise explicitly indicated as such at a later date by the inventors or by a successor in interest to the inventors. If any claims are presented in this application or in subsequent filings related to this application that include additional features beyond those referred to below, those additional features shall not be presumed to have been added for any reason relating to patentability.

[00091] Example 1

[00092] An apparatus for operating on tissue, the apparatus comprising: (a) a body assembly; (b) a shaft assembly extending distally from the body assembly, wherein the shaft assembly defines a longitudinal axis; (c) an acoustic waveguide, wherein the waveguide comprises a flexible portion; (d) an articulation section coupled with the shaft assembly, wherein a portion of the articulation section encompasses the flexible portion of the waveguide, wherein the articulation section further comprises: (i) a first member, and (ii) a second member, wherein the second member is longitudinally translatable relative to the first member; (e) an articulation control assembly configured to move relative to the shaft assembly in order to longitudinally translate the second member relative to the first member; (f) an end effector comprising an ultrasonic blade in acoustic communication with the waveguide; and (g) an articulation lock, wherein the articulation lock is configured to prevent movement of the articulation control assembly relative to the shaft assembly.

[00093] Example 2

[00094] The apparatus of Example 1, wherein the shaft assembly comprises an outer sheath configured to translate from a first position to a second position, wherein articulation lock comprises: (i) a plurality of teeth located on the articulation control assembly, and (ii) a pin fixed to an outer sheath of the shaft assembly, wherein the pin is

configured to mesh with the plurality of teeth when the outer sheath is in the second position.

[00095] Example 3

[00096] The apparatus of Example 2, wherein the body assembly further comprises a trigger, wherein the trigger is configured to pivot toward or away from the body assembly from a first pivotal position to a second pivotal position.

[00097] Example 4

[00098] The apparatus of Example 3, wherein the trigger is configured to translate the outer sheath from the first position to the second position in response to the trigger pivoting from the first pivotal position to the second pivotal position.

[00099] Example 5

[000100] The apparatus of Example 4, wherein the apparatus further comprises a knob rotatably connected to the body assembly, wherein the knob is configured to rotate the shaft assembly about the longitudinal axis.

[000101] Example 6

[000102] The apparatus of any one or more of Examples 4 through 5, wherein the outer sheath further comprises a splined proximal portion extending into the body assembly.

[000103] Example 7

[000104] The apparatus of Example 6, wherein the trigger further comprises a lever with a pin, wherein the pin is configured to mesh with the splined proximal portion when the trigger is in the second pivotal position.

[000105] Example 8

[000106] The apparatus of any one or more of Examples 1 through 7, wherein the articulation control assembly further comprises a rotating drive gear comprising a left-handed threading and a right-handed threading.

[000107] Example 9

[000108] The apparatus of Example 8, wherein the first member further comprises a first translating drive gear coupled to the left-handed threading of the rotating drive gear, wherein the second member further comprises a second translating drive gear coupled to the right handed threading of the rotating drive gear.

[000109] Example 10

[000110] The apparatus of Example 9, wherein the articulation lock further comprises a first biasing element in contact with the articulation control assembly, wherein the first biasing element is configured to bias articulation control assembly to a first position to prevent movement of the articulation control assembly relative to the shaft assembly.

[000111] Example 11

[000112] The apparatus of Example 10, wherein the first biasing element is configured to impart a frictional braking force between the left-handed threading of the rotating drive gear and the first translating drive gear of the first member to prevent movement of the articulation control assembly relative to the shaft assembly.

[000113] Example 12

[000114] The apparatus of any one or more of Examples 10 through 11, wherein the articulation lock further comprises a conical locking member, wherein the conical locking member is configured to actuate from a third position to a fourth position such that articulation control assembly actuates from the first position to a second position, wherein the articulation control assembly is configured to move relative to the shaft assembly in the second position.

[000115] Example 13

[000116] The apparatus of Example 12, wherein the conical locking member is in contact with a second biasing element, wherein the second biasing element is configured to bias the conical locking member to the third position.

[000117] Example 14

[000118] The apparatus of Example 13, wherein the apparatus further comprises knob rotatably connected to the body assembly, wherein the knob is configured to rotate the shaft assembly about the longitudinal axis, wherein the knob houses the conical locking member.

[000119] Example 15

[000120] The apparatus of Example 14, wherein the conical locking member is configured to prevent the knob from rotating the shaft assembly about the longitudinal axis in the third position.

[000121] Example 16

[000122] The apparatus of Example 15, wherein the knob comprises an unlocking pin, wherein the unlocking pin is configured to actuate the conical locking member from the third position to the fourth position.

[000123] Example 17

[000124] The apparatus of any one or more of Examples 15 through 16, wherein conical locking member is further configured to lock the articulation control assembly in the third position.

[000125] Example 18

[000126] An apparatus for operating on tissue, the apparatus comprising: (a) a body assembly; (b) a shaft extending distally from the body assembly, wherein the shaft

defines a longitudinal axis; (c) an articulation section coupled with the shaft; (d) an end effector coupled with the articulation section, wherein the end effector comprises a working element configured to engage tissue; (e) an articulation drive assembly operable to drive articulation of the articulation section to thereby deflect the end effector from the longitudinal axis, wherein the articulation drive assembly comprises: (i) a first translating driver, and (ii) a second translating driver; and (f) an articulation lock assembly configured to engage the articulation drive assembly to fix the first translating driver relative to the second translating driver.

[000127] Example 19

[000128] The apparatus of Example 18, wherein the articulation lock is biased fix the first translating driver relative to the second translating driver.

[000129] Example 20

[000130] An apparatus for operating on tissue, the apparatus comprising: (a) a body assembly; (b) a shaft extending distally from the body assembly, wherein the shaft defines a longitudinal axis; (c) an articulation section coupled with the shaft; (d) an end effector coupled with the articulation section; (e) a knob rotatably coupled to the body assembly, wherein the knob is configured to rotate the shaft, the articulation section, and the end effector about the longitudinal axis; (e) a first pair of translating members, wherein the first pair of translating members is operable to actuate the articulation section to thereby deflect the end effector from the longitudinal axis; (f) a drive assembly in communication with the first pair of translating members, wherein the drive assembly is configured to translate the first pair of translating members to actuate the articulation section; and (g) a lock assembly, wherein the lock assembly is configured to simultaneously prevent rotation a knob about the longitudinal axis and translation of the first pair of translating members.

[000131] IV. Miscellaneous

[000132] It should be understood that any of the versions of instruments described herein may include various other features in addition to or in lieu of those described above. By way of example only, any of the instruments described herein may also include one or more of the various features disclosed in any of the various references that are incorporated by reference herein. It should also be understood that the teachings herein may be readily applied to any of the instruments described in any of the other references cited herein, such that the teachings herein may be readily combined with the teachings of any of the references cited herein in numerous ways. Moreover, those of ordinary skill in the art will recognize that various teachings herein may be readily applied to electrosurgical instruments, stapling instruments, and other kinds of surgical instruments. Other types of instruments into which the teachings herein may be incorporated will be apparent to those of ordinary skill in the art.

[000133] It should be appreciated that any patent, publication, or other disclosure material, in whole or in part, that is said to be incorporated by reference herein is incorporated herein only to the extent that the incorporated material does not conflict with existing definitions, statements, or other disclosure material set forth in this disclosure. As such, and to the extent necessary, the disclosure as explicitly set forth herein supersedes any conflicting material incorporated herein by reference. Any material, or portion thereof, that is said to be incorporated by reference herein, but which conflicts with existing definitions, statements, or other disclosure material set forth herein will only be incorporated to the extent that no conflict arises between that incorporated material and the existing disclosure material.

[000134] Versions of the devices described above may have application in conventional medical treatments and procedures conducted by a medical professional, as well as application in robotic-assisted medical treatments and procedures. By way of example only, various teachings herein may be readily incorporated into a robotic surgical system such as the DAVINCI™ system by Intuitive Surgical, Inc., of Sunnyvale, California. Similarly, those of ordinary skill in the art will recognize that various teachings herein may be readily combined with various teachings of U.S. Pat. No. 6,783,524, entitled

“Robotic Surgical Tool with Ultrasound Cauterizing and Cutting Instrument,” published August 31, 2004, the disclosure of which is incorporated by reference herein.

[000135] Versions described above may be designed to be disposed of after a single use, or they can be designed to be used multiple times. Versions may, in either or both cases, be reconditioned for reuse after at least one use. Reconditioning may include any combination of the steps of disassembly of the device, followed by cleaning or replacement of particular pieces, and subsequent reassembly. In particular, some versions of the device may be disassembled, and any number of the particular pieces or parts of the device may be selectively replaced or removed in any combination. Upon cleaning and/or replacement of particular parts, some versions of the device may be reassembled for subsequent use either at a reconditioning facility, or by a user immediately prior to a procedure. Those skilled in the art will appreciate that reconditioning of a device may utilize a variety of techniques for disassembly, cleaning/replacement, and reassembly. Use of such techniques, and the resulting reconditioned device, are all within the scope of the present application.

[000136] By way of example only, versions described herein may be sterilized before and/or after a procedure. In one sterilization technique, the device is placed in a closed and sealed container, such as a plastic or TYVEK bag. The container and device may then be placed in a field of radiation that can penetrate the container, such as gamma radiation, x-rays, or high-energy electrons. The radiation may kill bacteria on the device and in the container. The sterilized device may then be stored in the sterile container for later use. A device may also be sterilized using any other technique known in the art, including but not limited to beta or gamma radiation, ethylene oxide, or steam.

[000137] Having shown and described various embodiments of the present invention, further adaptations of the methods and systems described herein may be accomplished by appropriate modifications by one of ordinary skill in the art without departing from the scope of the present invention. Several of such potential modifications have been mentioned, and others will be apparent to those skilled in the art. For instance, the examples, embodiments, geometrics, materials, dimensions, ratios, steps, and the like

discussed above are illustrative and are not required. Accordingly, the scope of the present invention should be considered in terms of the following claims and is understood not to be limited to the details of structure and operation shown and described in the specification and drawings.

I/We claim:

1. An apparatus for operating on tissue, the apparatus comprising:
 - (a) a body assembly;
 - (b) a shaft assembly extending distally from the body assembly, wherein the shaft assembly defines a longitudinal axis;
 - (c) an acoustic waveguide, wherein the waveguide comprises a flexible portion;
 - (d) an articulation section coupled with the shaft assembly, wherein a portion of the articulation section encompasses the flexible portion of the waveguide, wherein the articulation section further comprises:
 - (i) a first member, and
 - (ii) a second member, wherein the second member is longitudinally translatable relative to the first member;
 - (e) an articulation control assembly configured to move relative to the shaft assembly in order to longitudinally translate the second member relative to the first member;
 - (f) an end effector comprising an ultrasonic blade in acoustic communication with the waveguide; and
 - (g) an articulation lock, wherein the articulation lock is configured to prevent movement of the articulation control assembly relative to the shaft assembly.
2. The apparatus of claim 1, wherein the shaft assembly comprises an outer sheath configured to translate from a first position to a second position, wherein articulation lock comprises:
 - (i) a plurality of teeth located on the articulation control assembly, and
 - (ii) a pin fixed to an outer sheath of the shaft assembly, wherein the pin is configured to mesh with the plurality of teeth when the outer

sheath is in the second position.

3. The apparatus of claim 2, wherein the body assembly further comprises a trigger, wherein the trigger is configured to pivot toward or away from the body assembly from a first pivotal position to a second pivotal position.

4. The apparatus of claim 3, wherein the trigger is configured to translate the outer sheath from the first position to the second position in response to the trigger pivoting from the first pivotal position to the second pivotal position.

5. The apparatus of claim 4, wherein the apparatus further comprises a knob rotatably connected to the body assembly, wherein the knob is configured to rotate the shaft assembly about the longitudinal axis.

6. The apparatus of claim 4, wherein the outer sheath further comprises a splined proximal portion extending into the body assembly.

7. The apparatus of claim 6, wherein the trigger further comprises a lever with a pin, wherein the pin is configured to mesh with the splined proximal portion when the trigger is in the second pivotal position.

8. The apparatus of claim 1, wherein the articulation control assembly further comprises a rotating drive gear comprising a left-handed threading and a right-handed threading.

9. The apparatus of claim 8, wherein the first member further comprises a first translating drive gear coupled to the left-handed threading of the rotating drive gear, wherein the second member further comprises a second translating drive gear coupled to the right handed threading of the rotating drive gear.

10. The apparatus of claim 9, wherein the articulation lock further comprises a first

biasing element in contact with the articulation control assembly, wherein the first biasing element is configured to bias articulation control assembly to a first position to prevent movement of the articulation control assembly relative to the shaft assembly.

11. The apparatus of claim 10, wherein the first biasing element is configured to impart a frictional braking force between the left-handed threading of the rotating drive gear and the first translating drive gear of the first member to prevent movement of the articulation control assembly relative to the shaft assembly.

12. The apparatus of claim 10, wherein the articulation lock further comprises a conical locking member, wherein the conical locking member is configured to actuate from a third position to a fourth position such that articulation control assembly actuates from the first position to a second position, wherein the articulation control assembly is configured to move relative to the shaft assembly in the second position.

13. The apparatus of claim 12, wherein the conical locking member is in contact with a second biasing element, wherein the second biasing element is configured to bias the conical locking member to the third position.

14. The apparatus of claim 13, wherein the apparatus further comprises knob rotatably connected to the body assembly, wherein the knob is configured to rotate the shaft assembly about the longitudinal axis, wherein the knob houses the conical locking member.

15. The apparatus of claim 14, wherein the conical locking member is configured to prevent the knob from rotating the shaft assembly about the longitudinal axis in the third position.

16. The apparatus of claim 15, wherein the knob comprises an unlocking pin, wherein the unlocking pin is configured to actuate the conical locking member from the third position to the fourth position.

17. The apparatus of claim 15, wherein conical locking member is further configured to lock the articulation control assembly in the third position.

18. An apparatus for operating on tissue, the apparatus comprising:

- (a) a body assembly;
- (b) a shaft extending distally from the body assembly, wherein the shaft defines a longitudinal axis;
- (c) an articulation section coupled with the shaft;
- (d) an end effector coupled with the articulation section, wherein the end effector comprises a working element configured to engage tissue;
- (e) an articulation drive assembly operable to drive articulation of the articulation section to thereby deflect the end effector from the longitudinal axis, wherein the articulation drive assembly comprises:
 - (i) a first translating driver, and
 - (ii) a second translating driver; and
- (f) an articulation lock assembly configured to engage the articulation drive assembly to fix the first translating driver relative to the second translating driver.

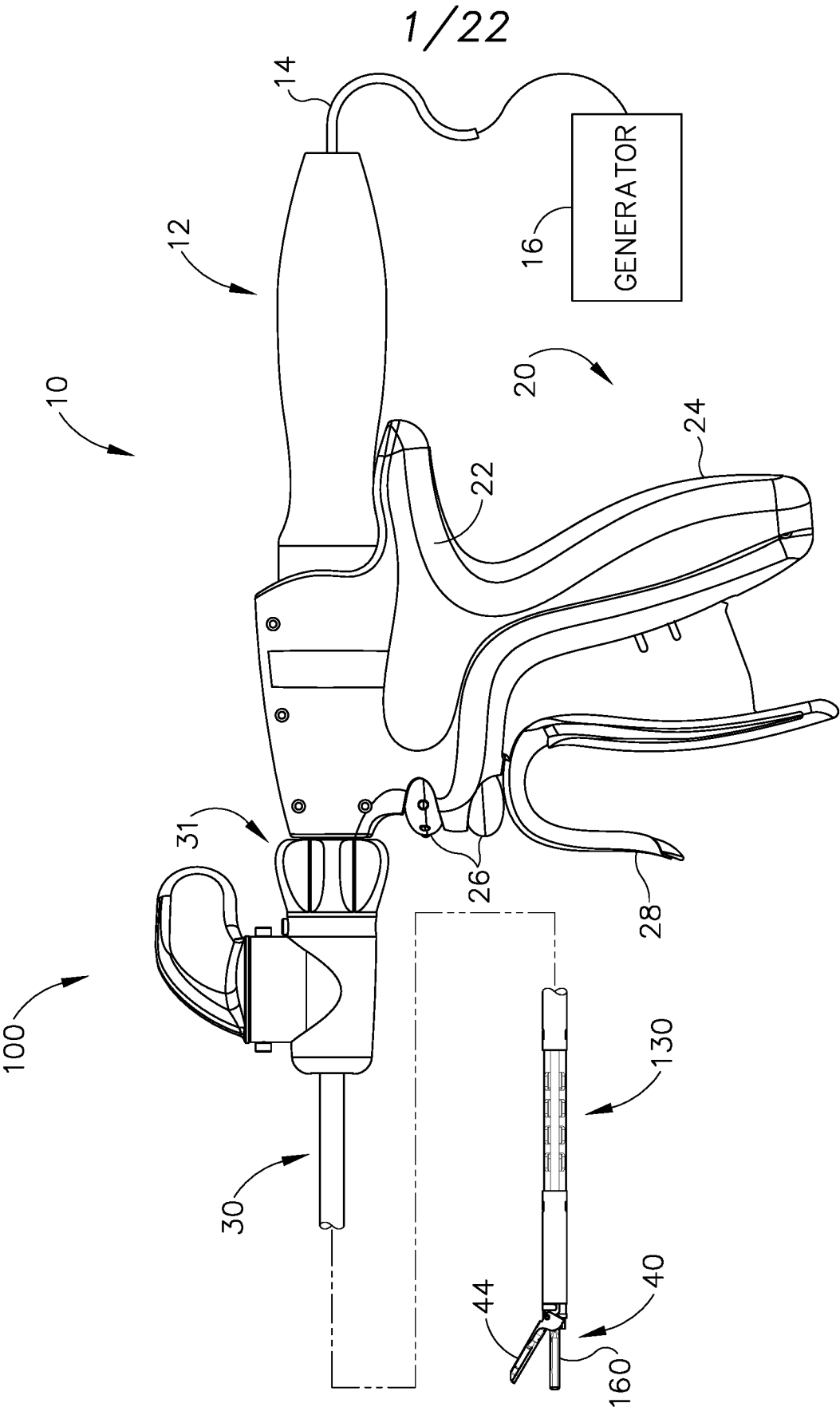
19. The apparatus of claim 18, wherein the articulation lock is biased fix the first translating driver relative to the second translating driver.

20. An apparatus for operating on tissue, the apparatus comprising:

- (a) a body assembly;
- (b) a shaft extending distally from the body assembly, wherein the shaft defines a longitudinal axis;
- (c) an articulation section coupled with the shaft;
- (d) an end effector coupled with the articulation section;
- (e) a knob rotatably coupled to the body assembly, wherein the knob is

configured to rotate the shaft, the articulation section, and the end effector about the longitudinal axis;

- (e) a first pair of translating members, wherein the first pair of translating members is operable to actuate the articulation section to thereby deflect the end effector from the longitudinal axis;
- (f) a drive assembly in communication with the first pair of translating members, wherein the drive assembly is configured to translate the first pair of translating members to actuate the articulation section; and
- (g) a lock assembly, wherein the lock assembly is configured to simultaneously prevent rotation a knob about the longitudinal axis and translation of the first pair of translating members.



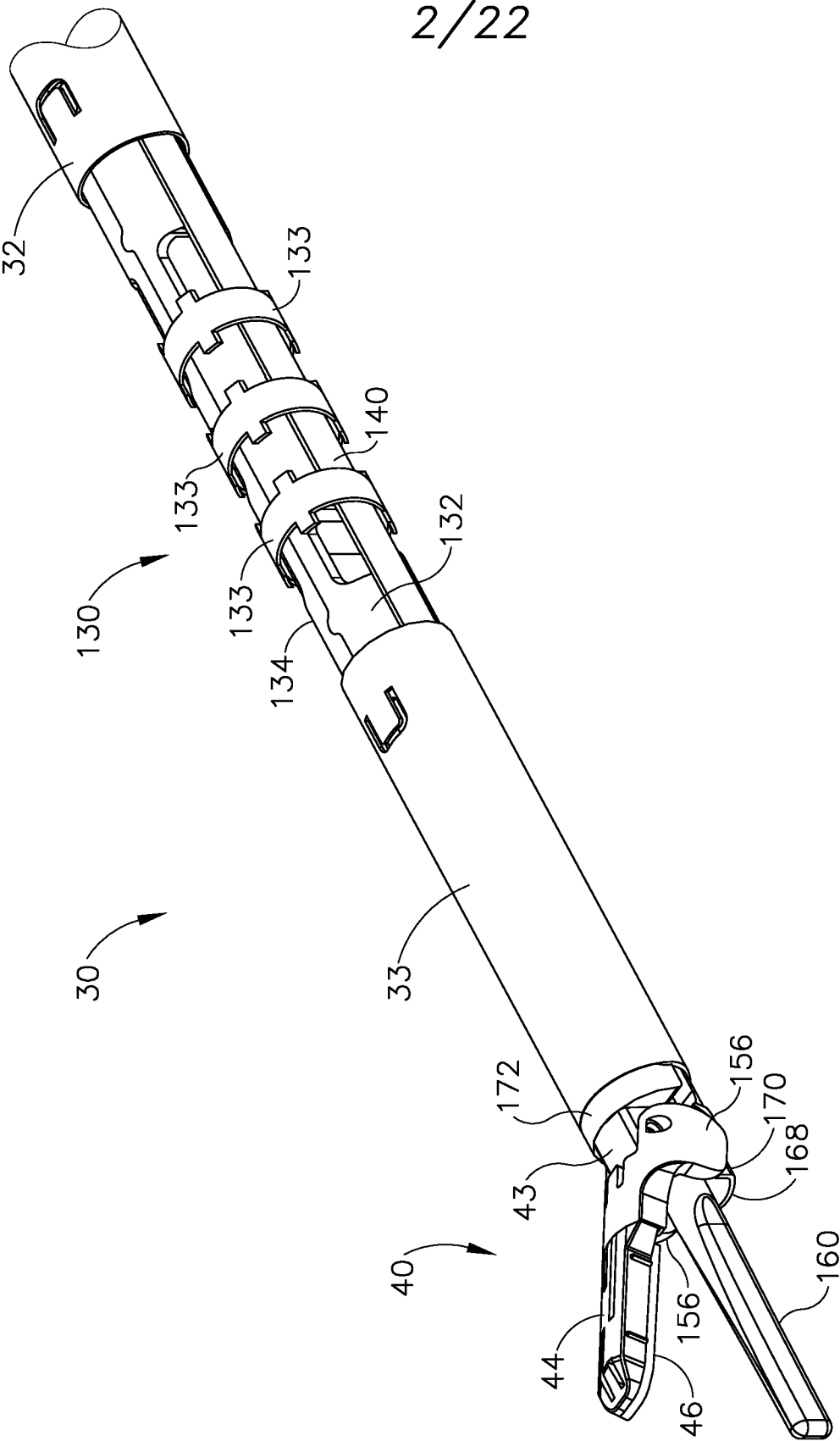


Fig. 2

3/22

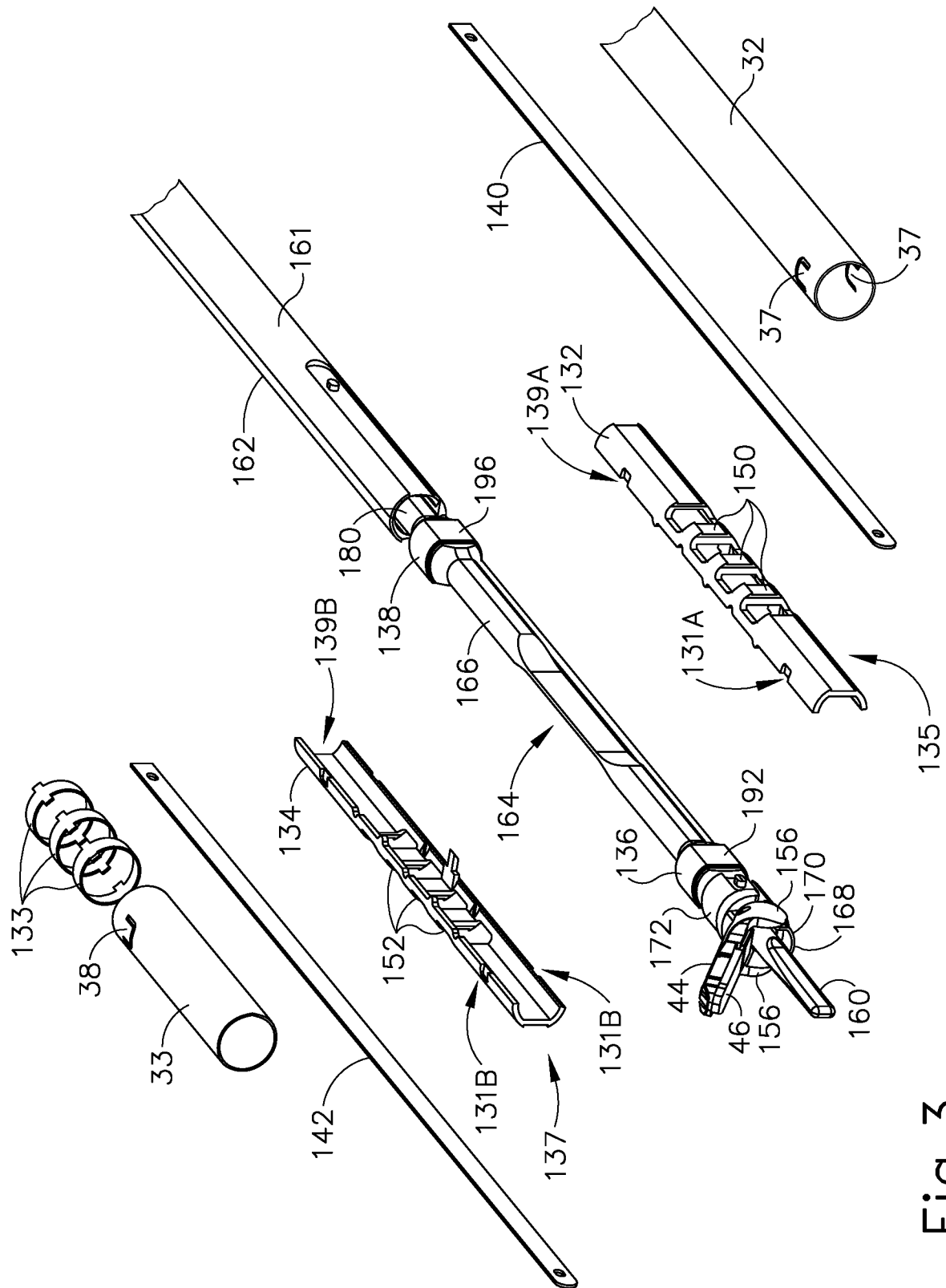


Fig. 3

4/22

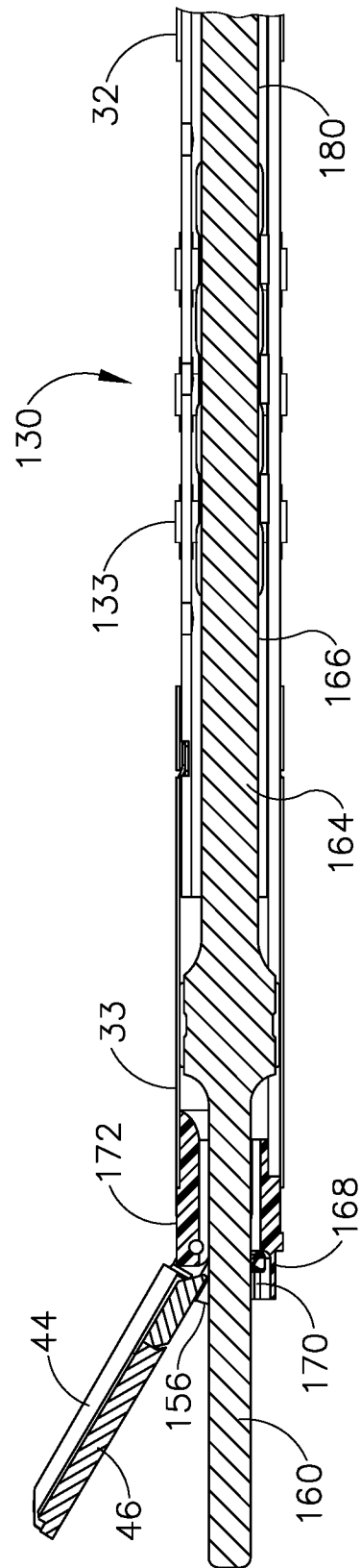


Fig. 4

5/22

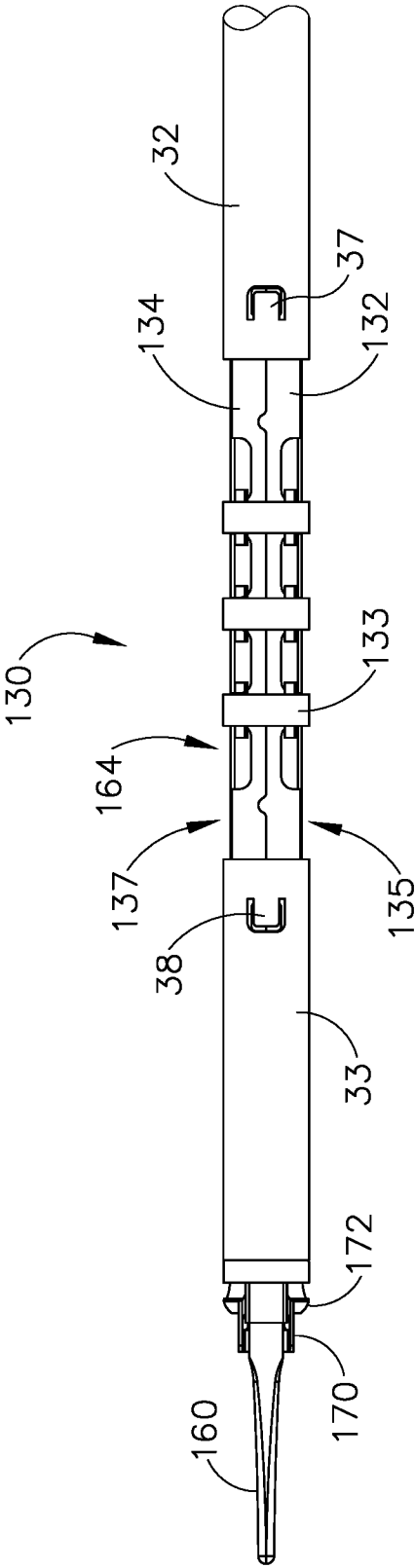


Fig.5

6/22

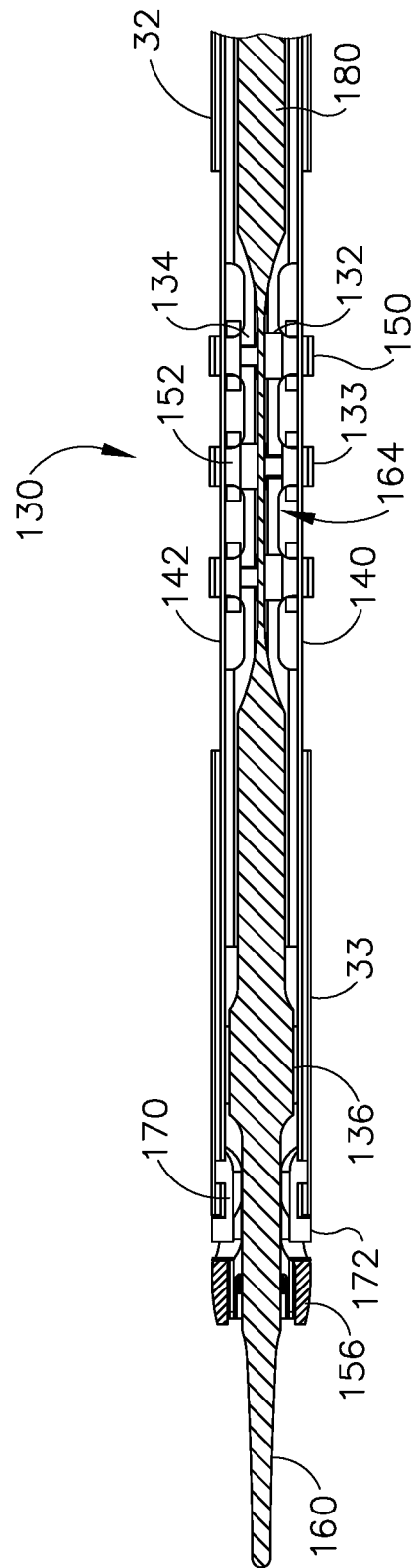


Fig. 6A

7/22

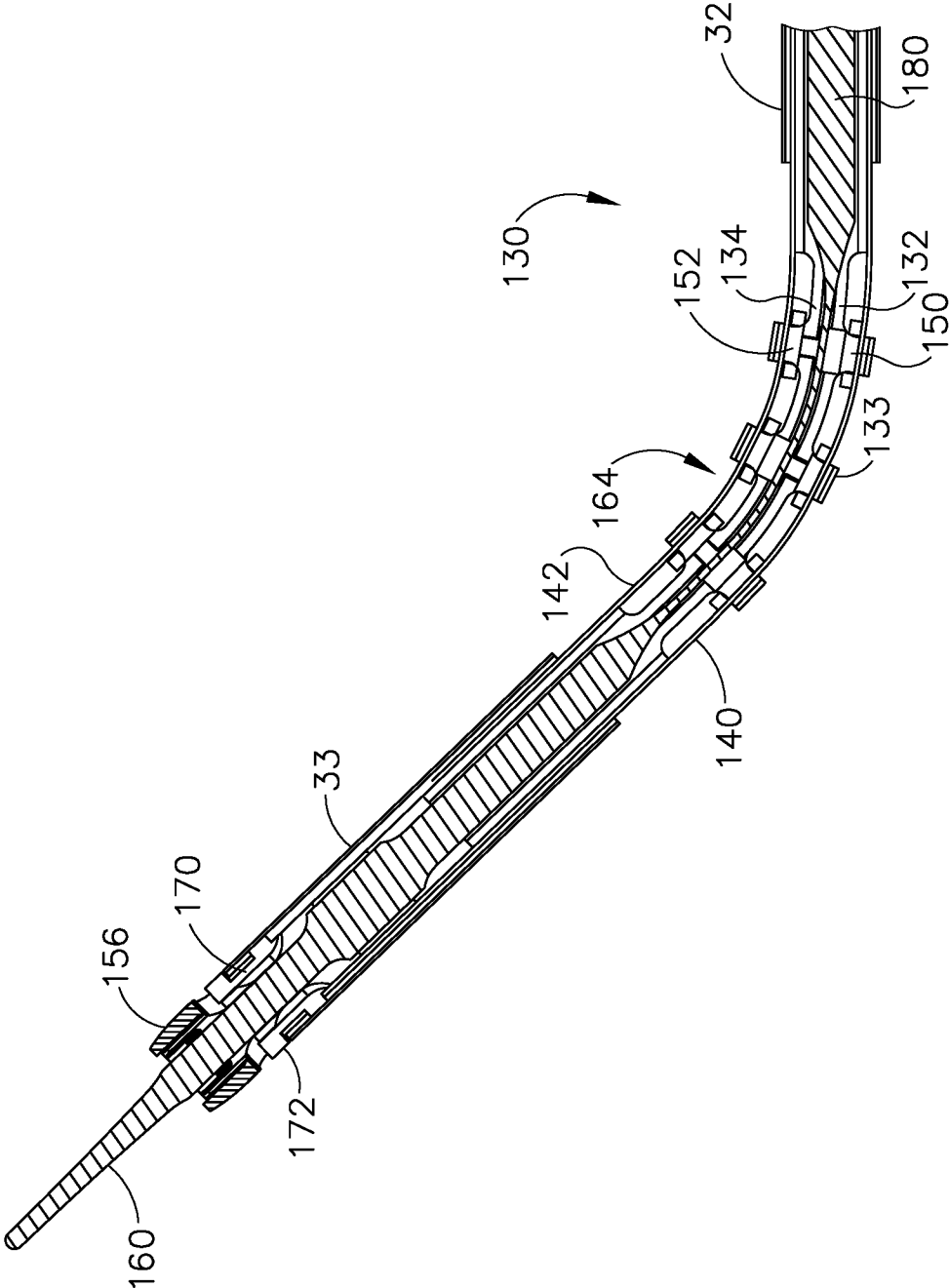


Fig. 6B

8/22

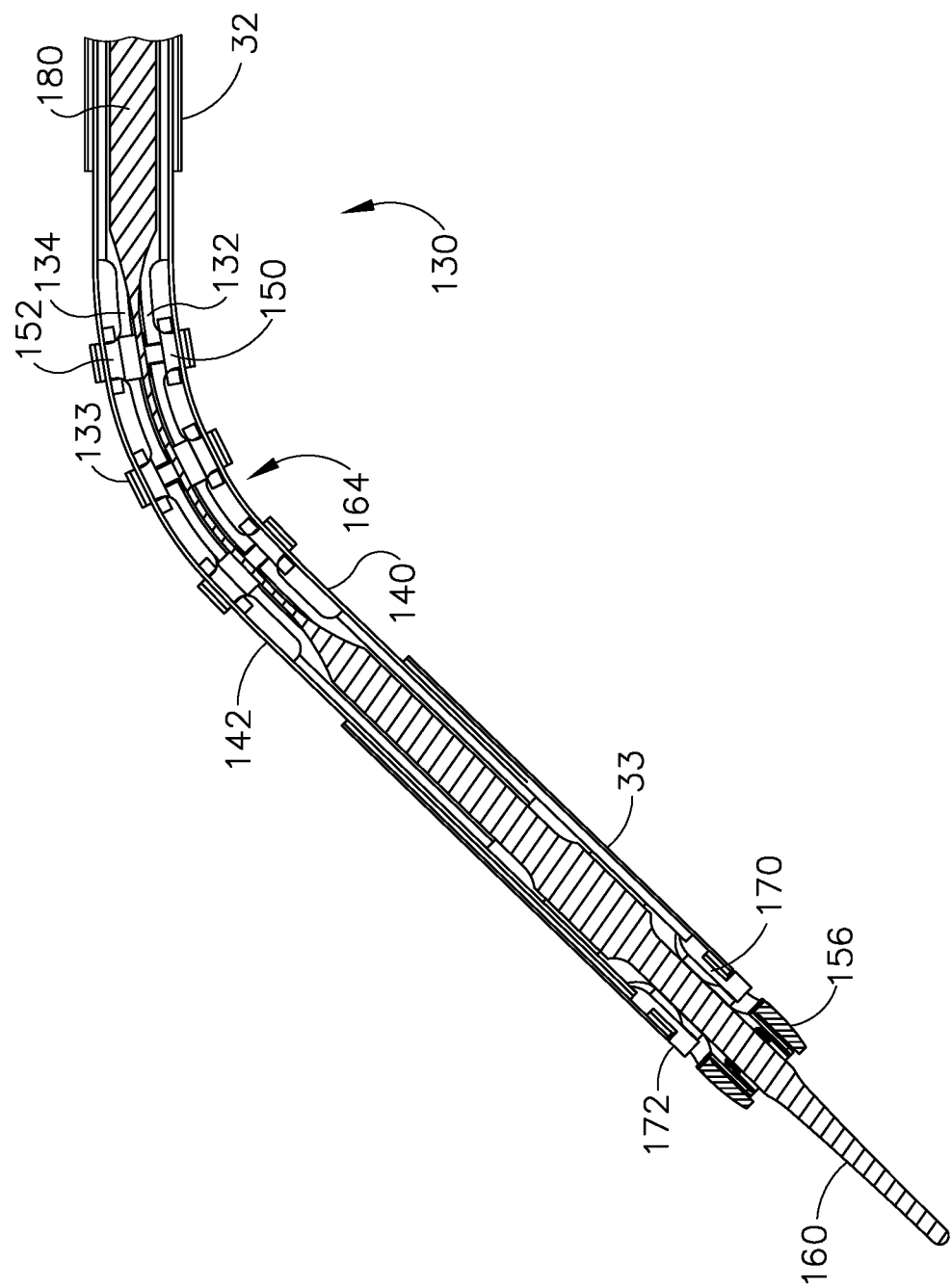


Fig. 6C

9/22

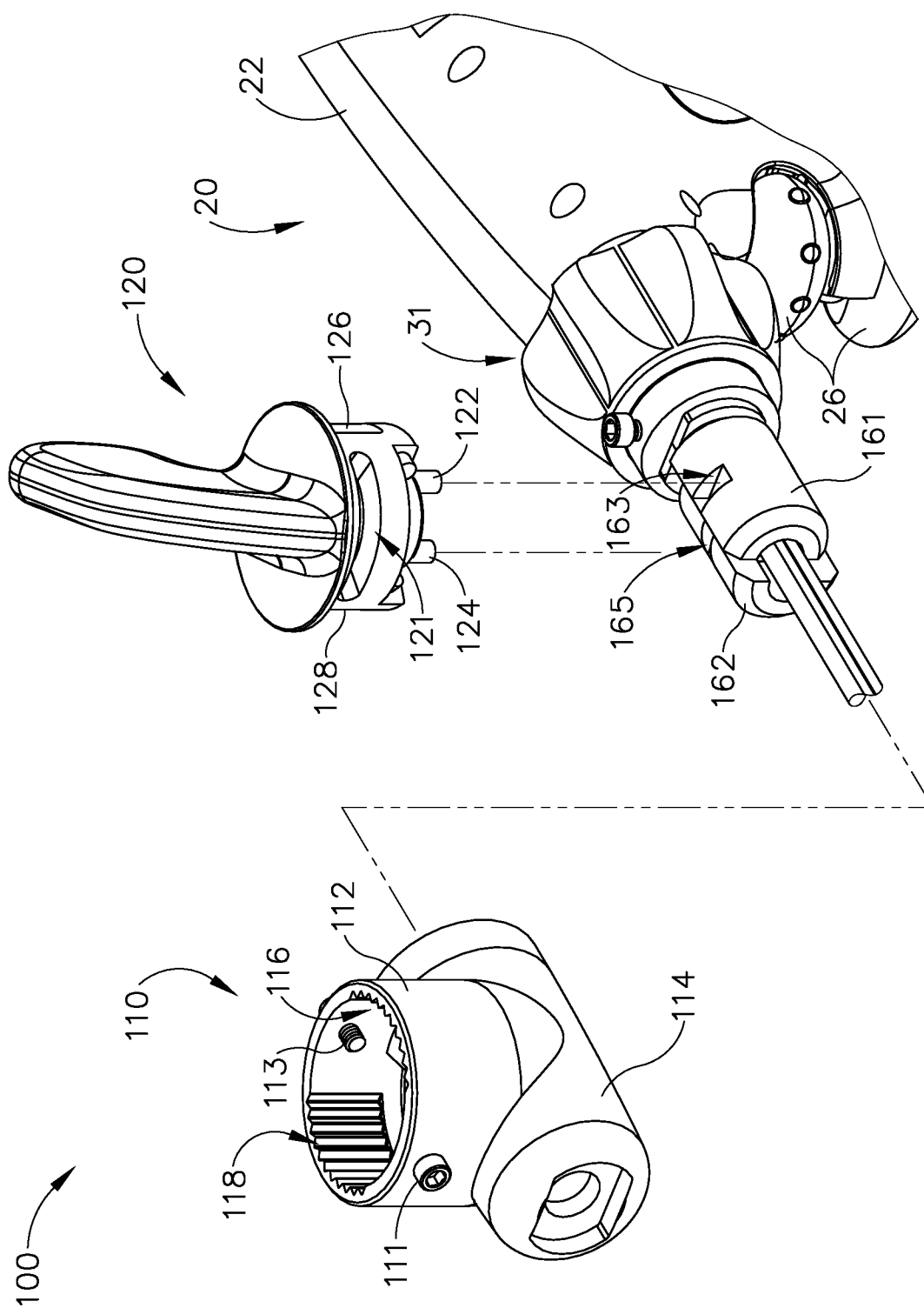


Fig. 7

10/22

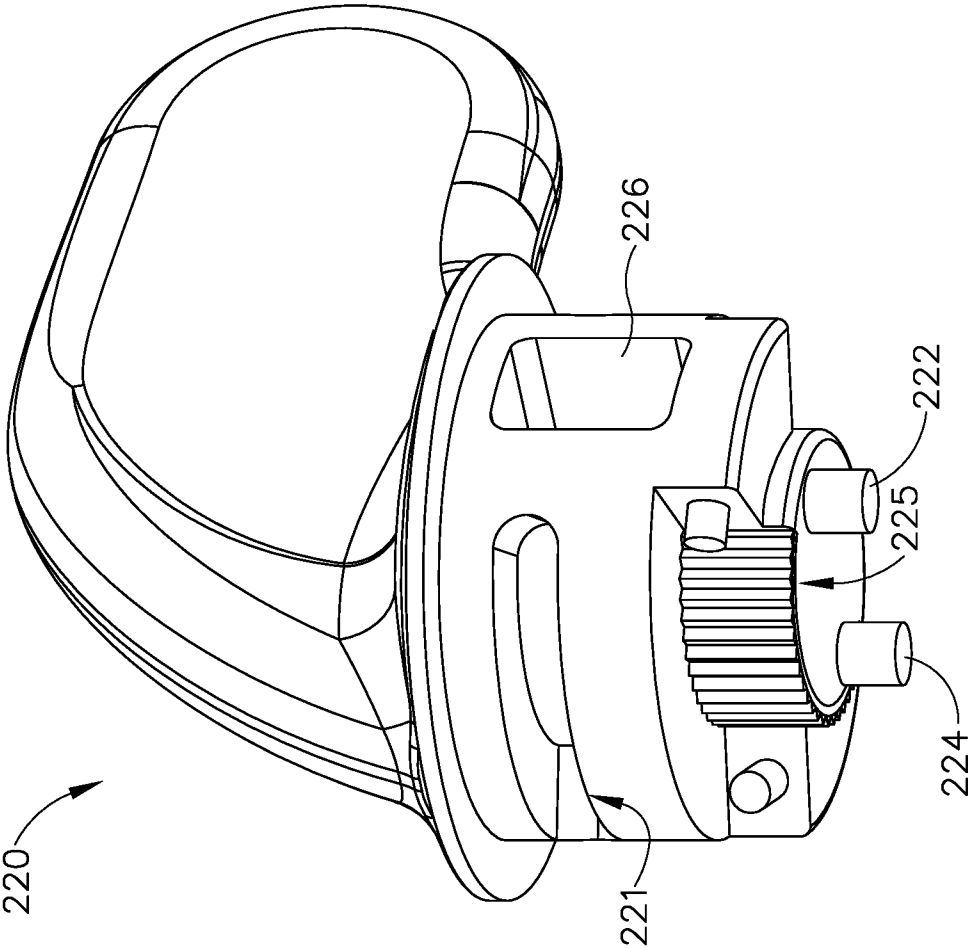


Fig.8

11/22

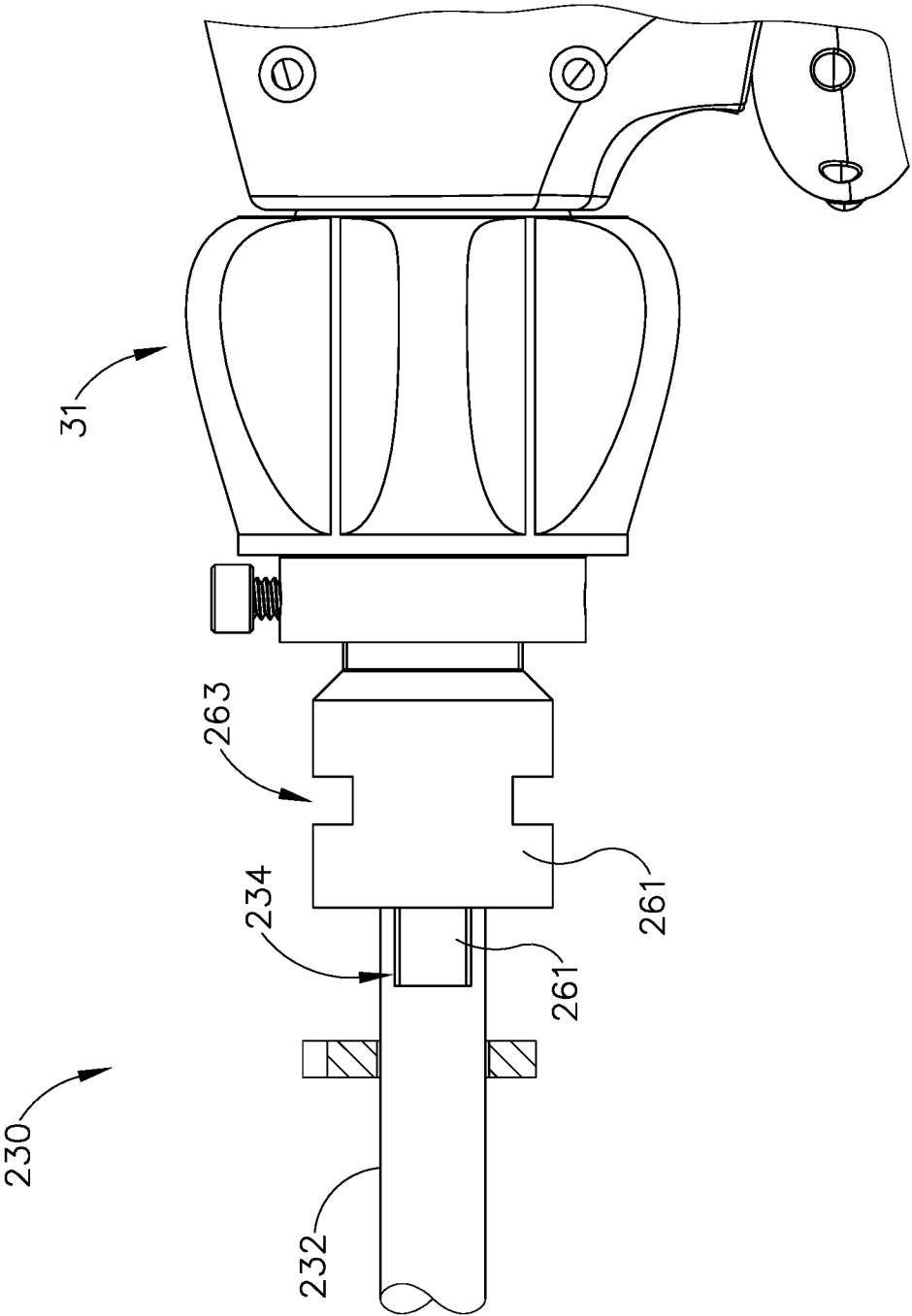


Fig. 9

12/22

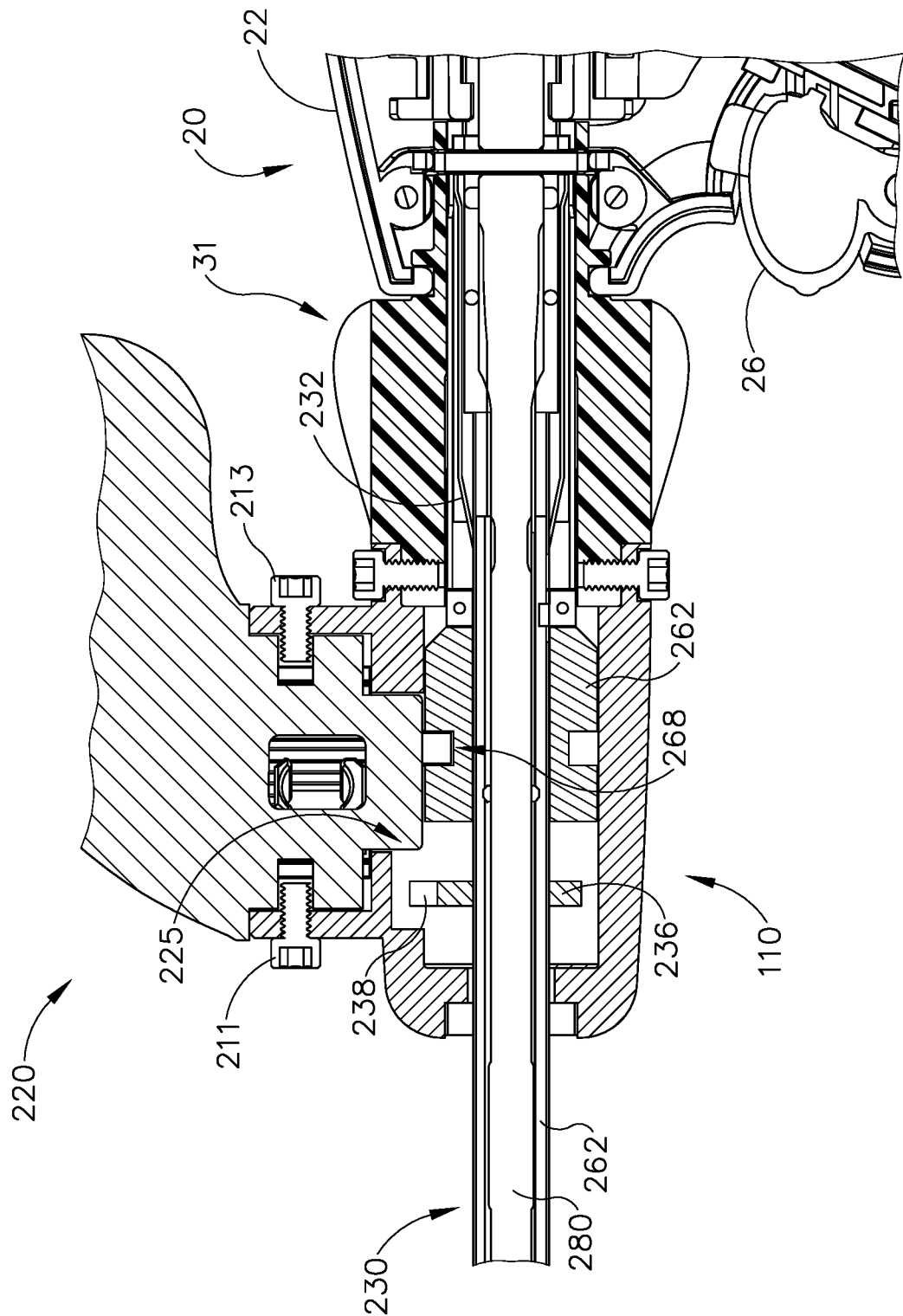


Fig. 10A

13/22

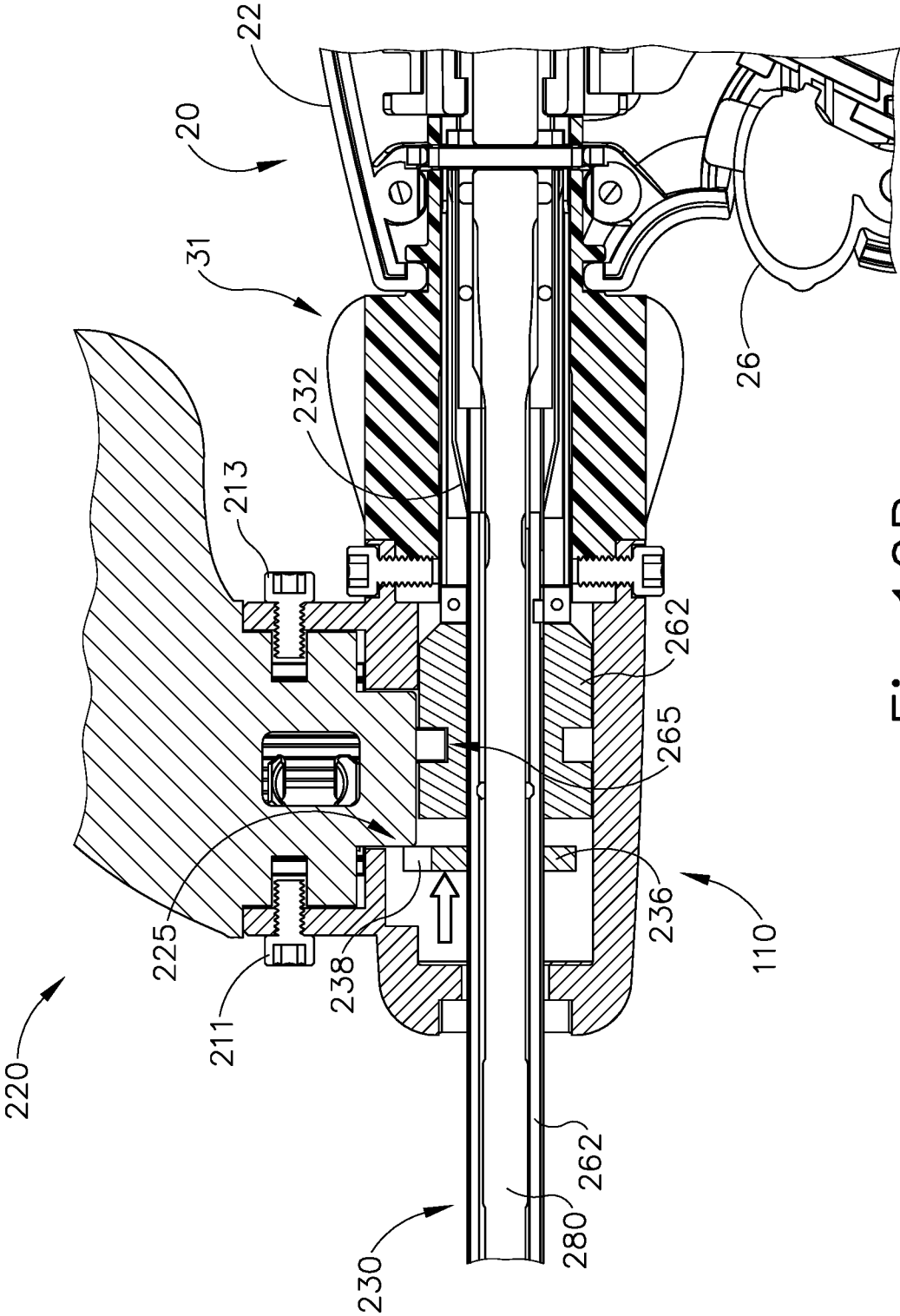


Fig.10B

14/22

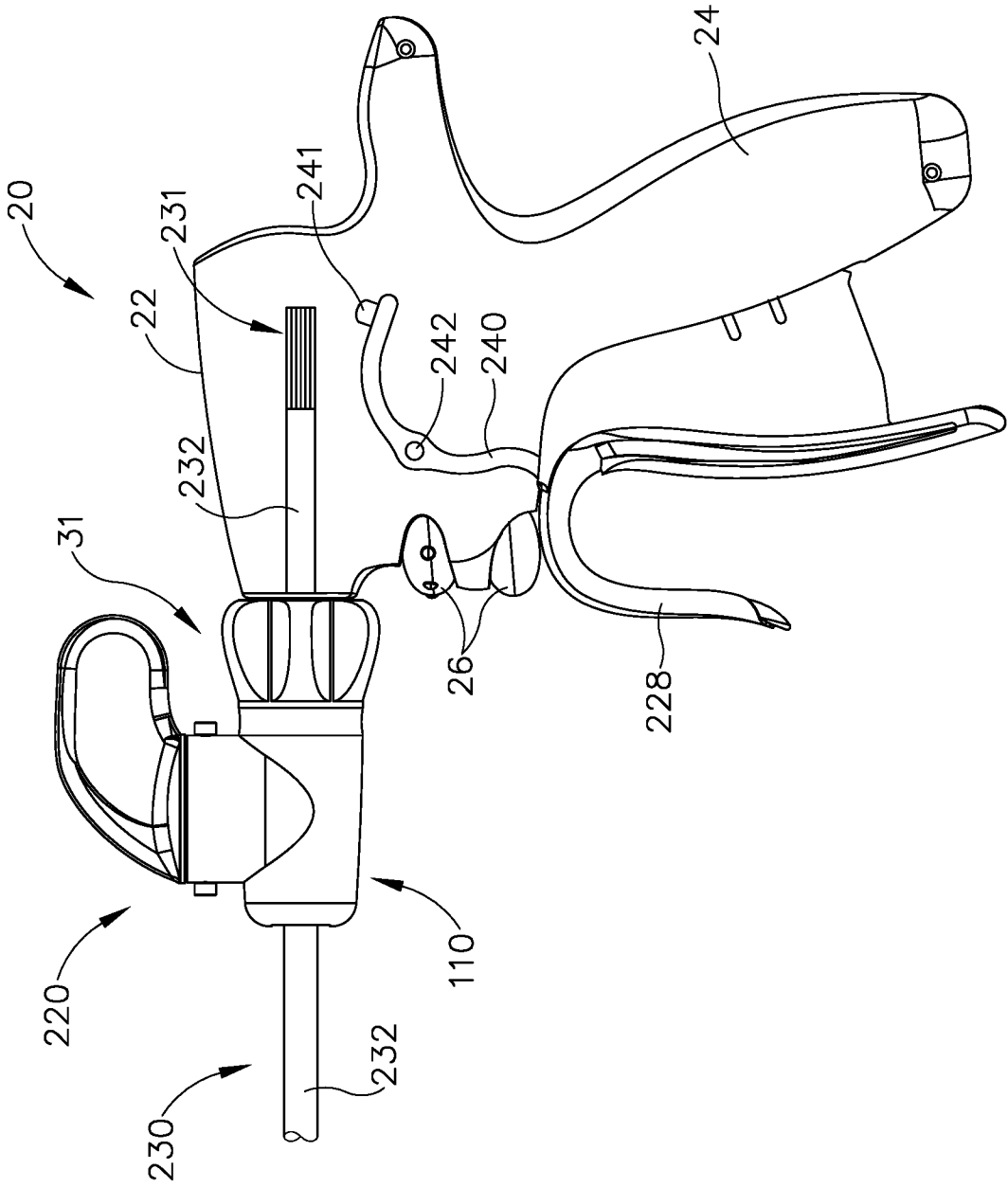


Fig. 11A

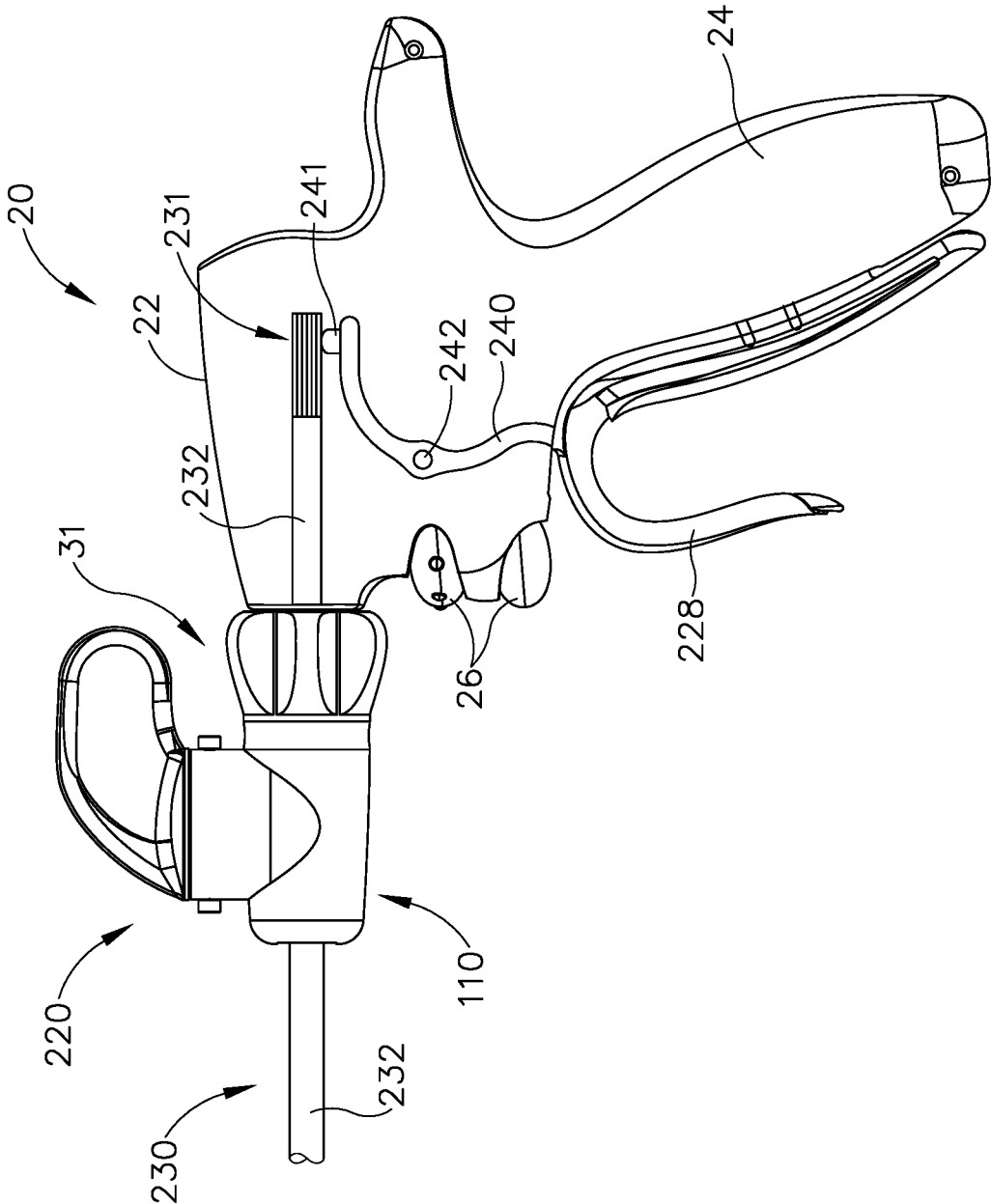


Fig.11B

16/22

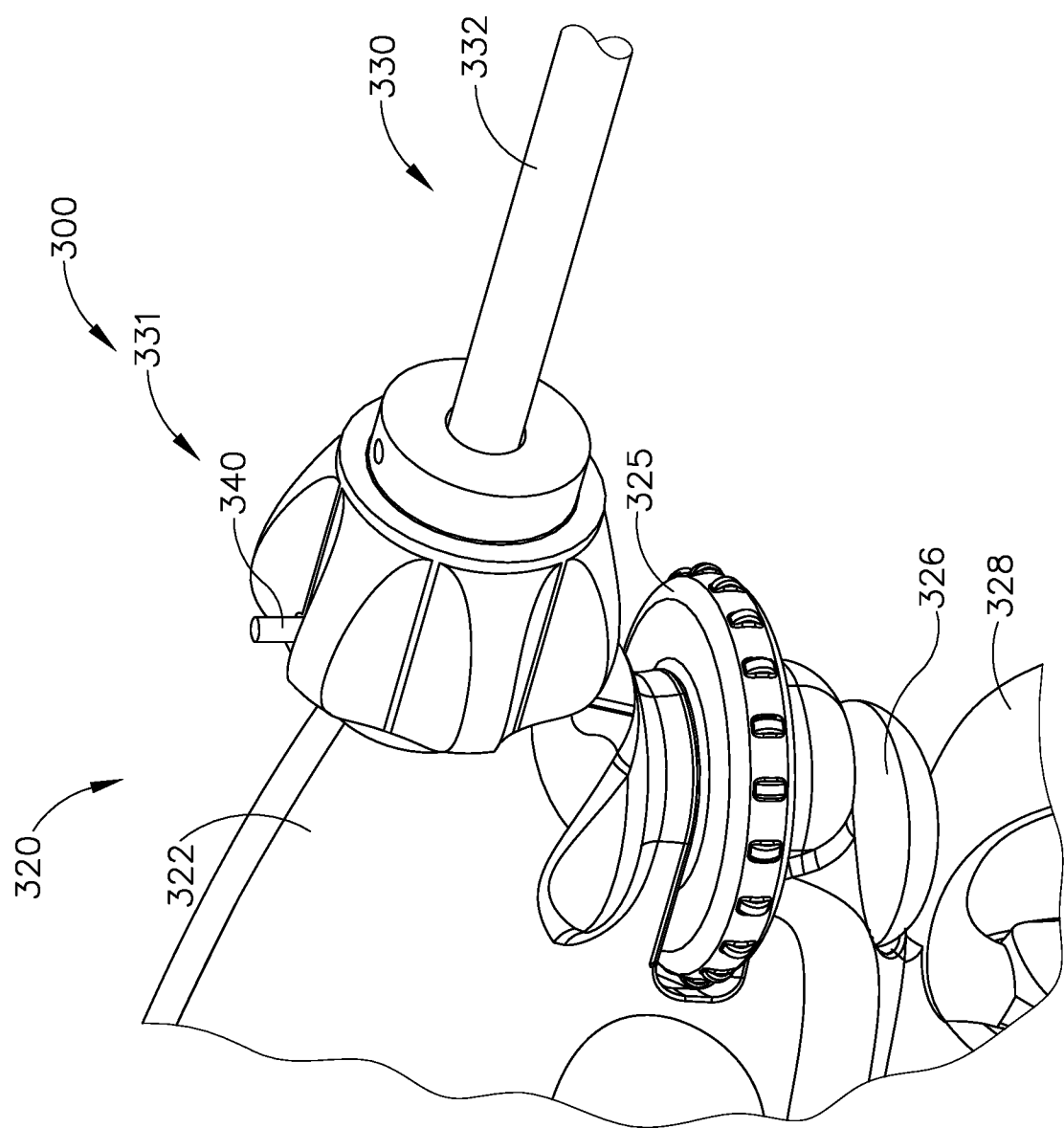


Fig.12

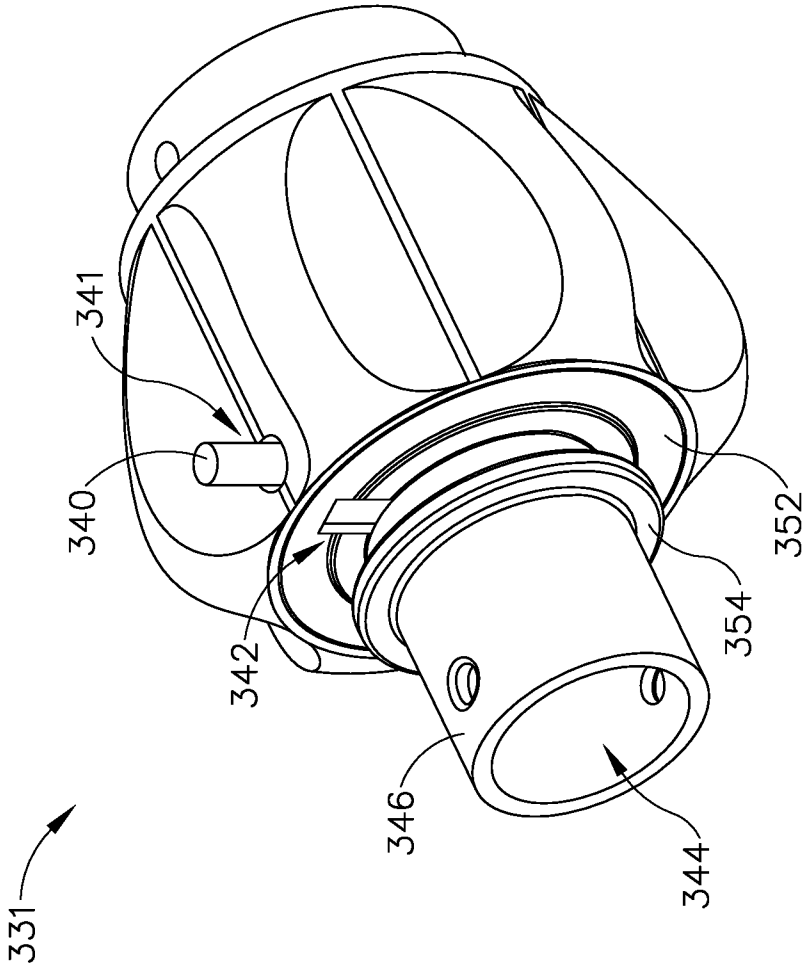


Fig. 13

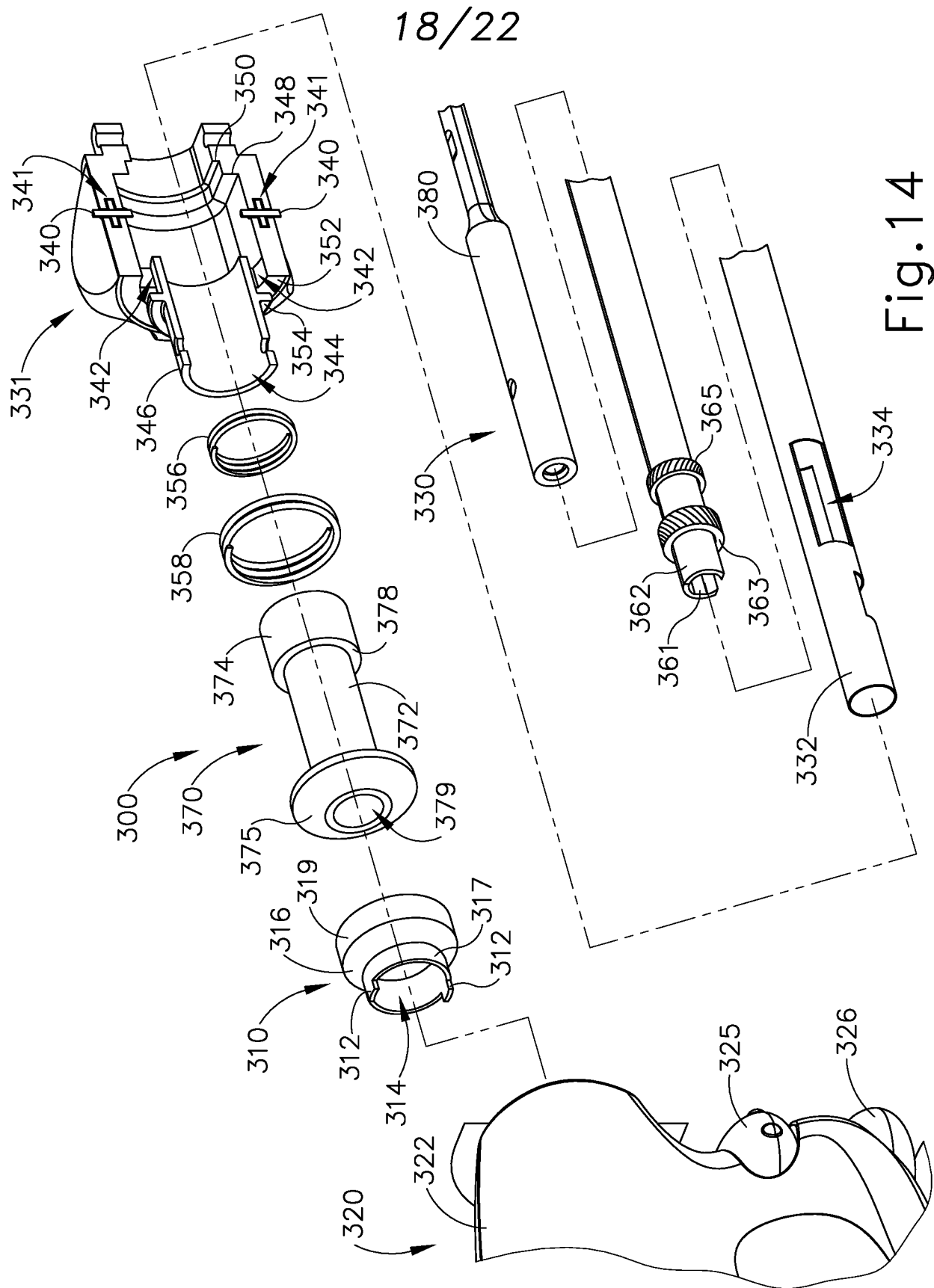


Fig. 14

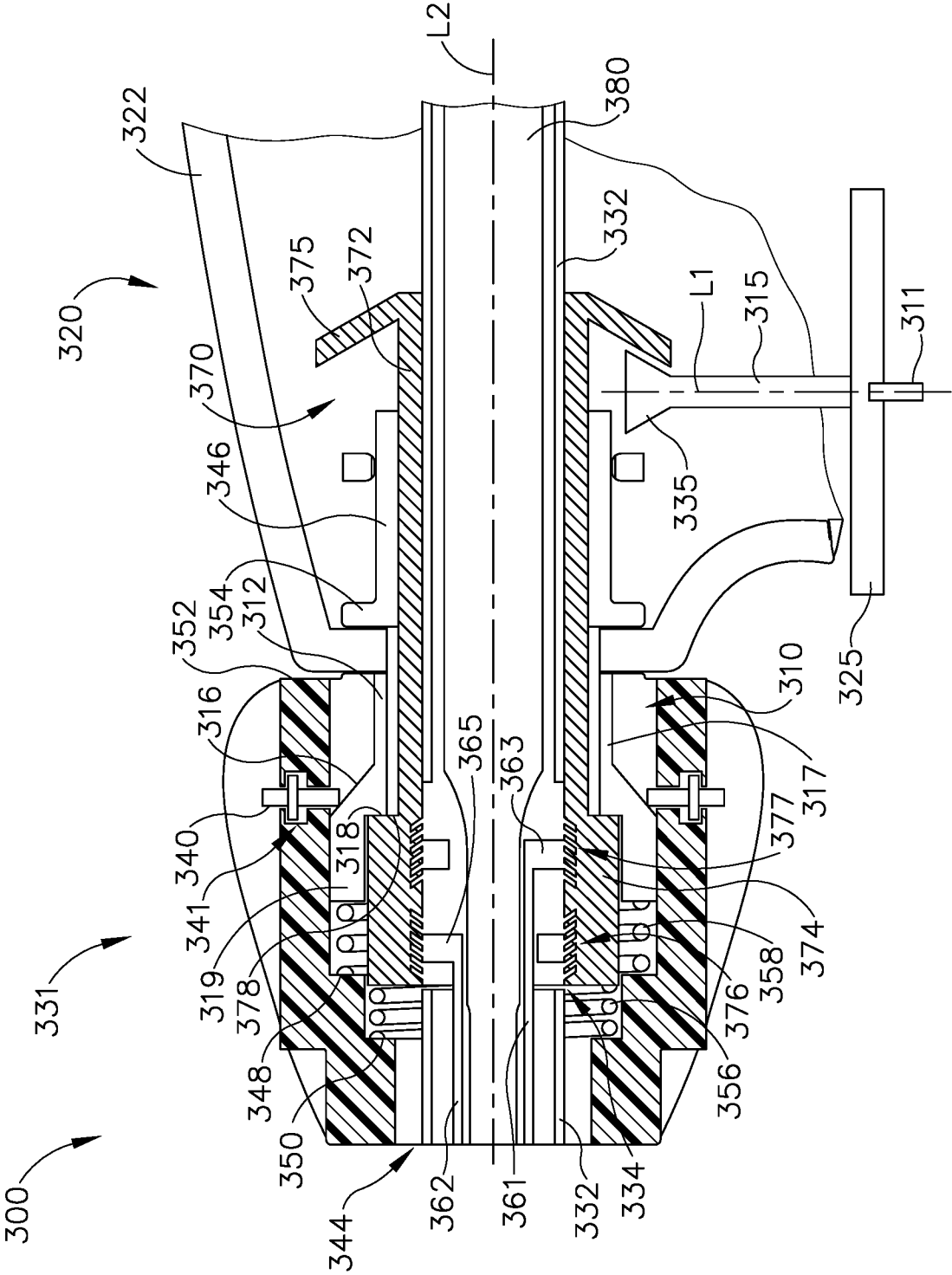


Fig. 15A

21/22

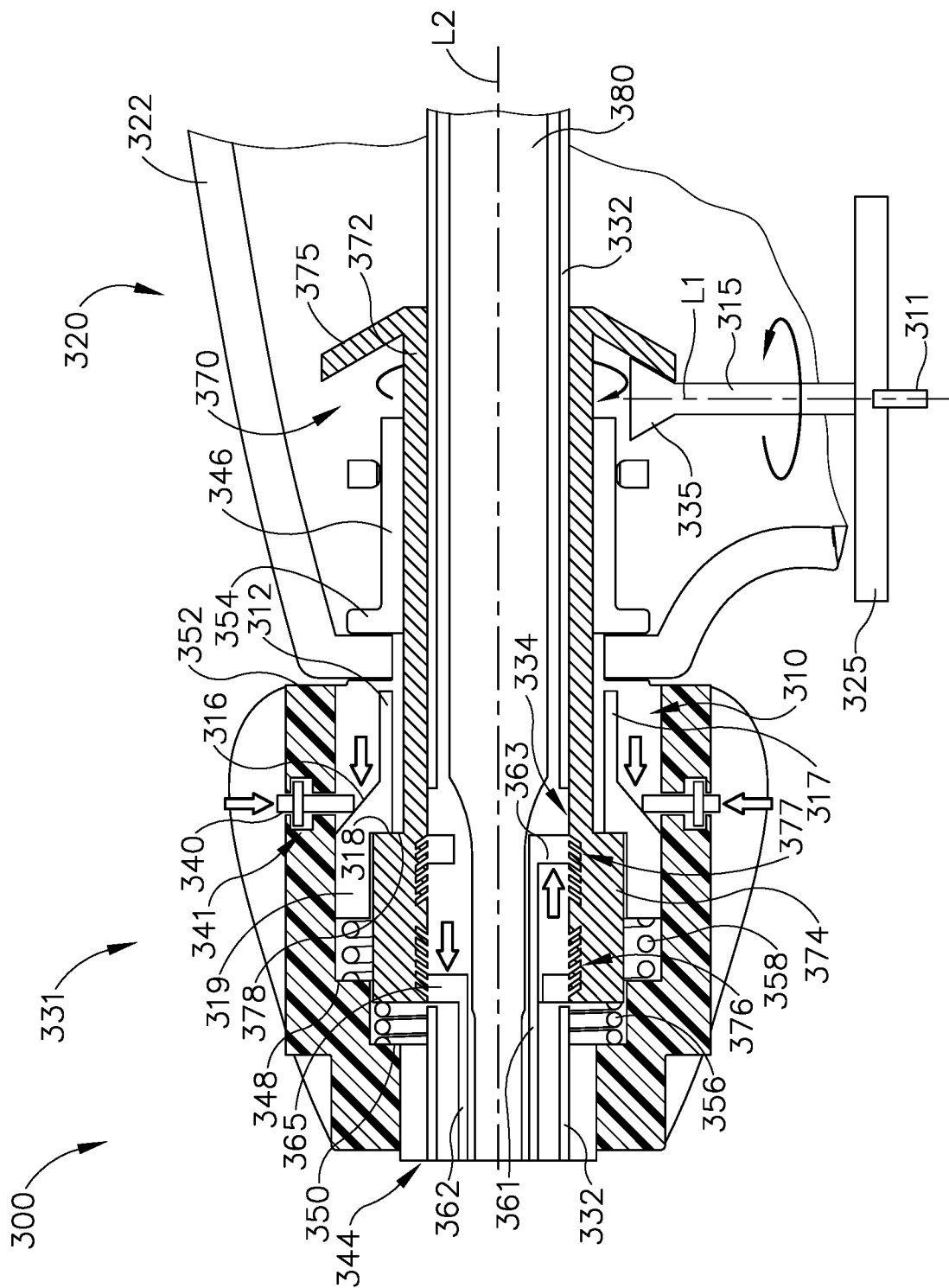


Fig. 15C

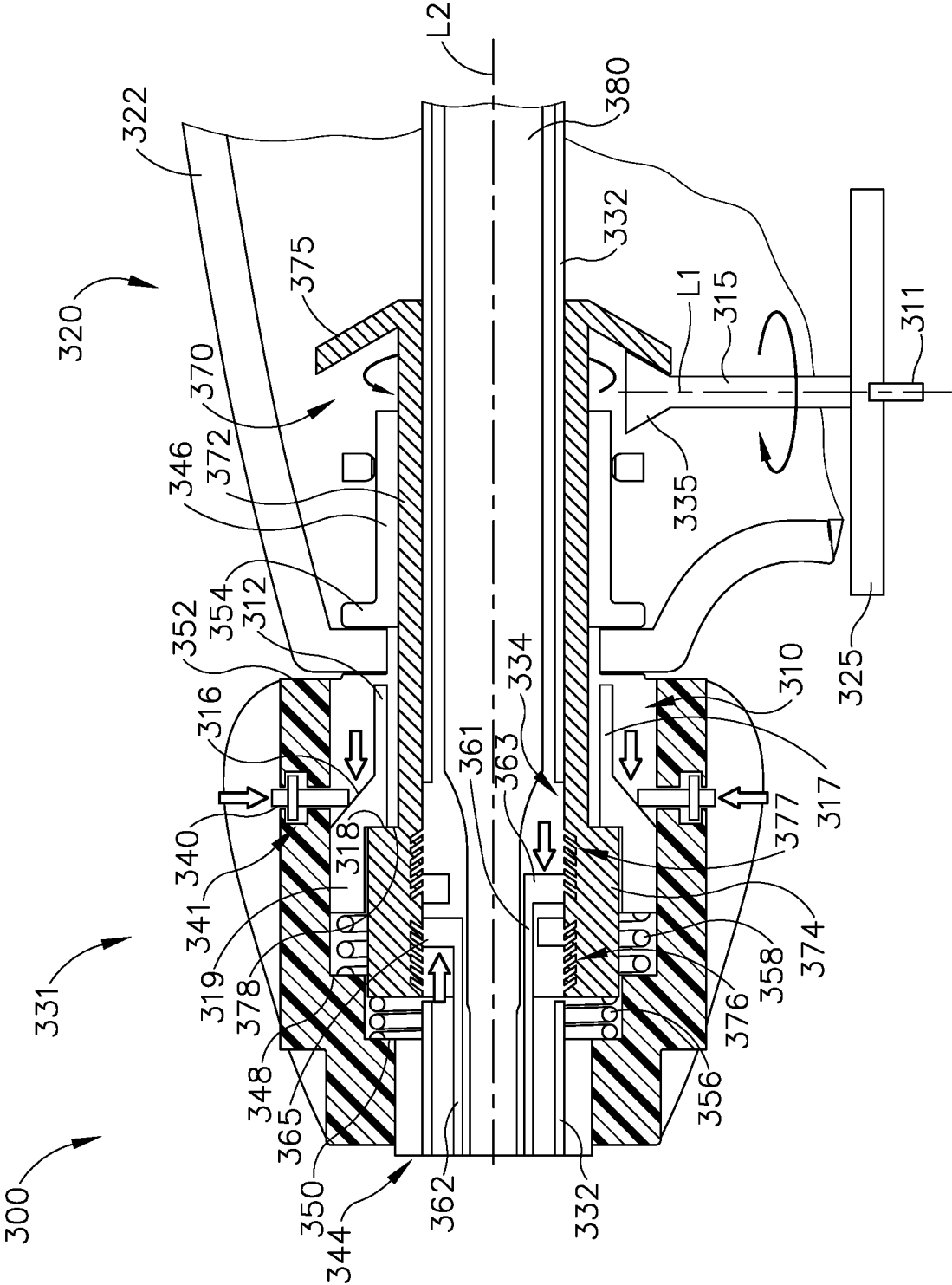


Fig.15D

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/025952

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B17/32 A61B17/29
ADD.

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
A61B

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y A	US 2015/320437 A1 (WORRELL BARRY C [US] ET AL) 12 November 2015 (2015-11-12) figures 1, 9, 91A-94B, 101A-101B, 141-144, 153-155 paragraph [0413] - paragraph [0417] paragraph [0614] - paragraph [0626] paragraph [0650] - paragraph [0658] paragraph [0742] - paragraph [0746] paragraph [0803] - paragraph [0806] figures 229-245C paragraph [0972] - paragraph [0996] -----	1,8-10, 18,19 11-17 2-7
X Y	WO 2012/040432 A1 (ETHICON ENDO SURGERY INC [US]; WORRELL BARRY C [US]; BOURDREAUX CHAD B) 29 March 2012 (2012-03-29) figures 8-15 paragraph [00072] paragraph [000101] - paragraph [000104] ----- -/-	1-3,18, 19 4-6



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search

12 September 2017

Date of mailing of the international search report

22/09/2017

Name and mailing address of the ISA/

European Patent Office, P.B. 5818 Patentlaan 2
NL - 2280 HV Rijswijk
Tel. (+31-70) 340-2040,
Fax: (+31-70) 340-3016

Authorized officer

Emirdag, Eda

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2017/025952

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X A	US 2010/193566 A1 (SCHEIB CHARLES J [US] ET AL) 5 August 2010 (2010-08-05) figures 16-19 paragraph [0088] - paragraph [0090] -----	1-3, 18-20 8-17
Y	US 2015/351854 A1 (HEGEMAN DAVID ELIAS [US] ET AL) 10 December 2015 (2015-12-10) figures 35, 36 paragraph [0110] - paragraph [0112] -----	4-6
X Y	EP 2 090 236 A2 (ETHICON ENDO SURGERY INC [US]) 19 August 2009 (2009-08-19) figures 35-46, 70, 71 paragraph [0182] - paragraph [0192] paragraph [0209] - paragraph [0211] -----	20 11-17
X A	EP 0 621 009 A1 (ETHICON INC [US]) 26 October 1994 (1994-10-26) figures 5, 6 column 8, line 36 - column 11, line 12 -----	20 8-17
X A	US 2007/287993 A1 (HINMAN CAMERON D [US] ET AL) 13 December 2007 (2007-12-13) figures 15, 16 paragraph [0062] - paragraph [0065] -----	20 8-17

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2017/025952

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☒ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-7, 18, 19

Locking with the trigger

2. claims: 8-17, 20

Locking with the knob

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2017/025952

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2015320437	A1	12-11-2015	NONE
WO 2012040432	A1	29-03-2012	AU 2011305198 A1 14-03-2013
			AU 2011305205 A1 14-03-2013
			AU 2011305395 A1 14-03-2013
			AU 2011305397 A1 14-03-2013
			BR 112013006851 A2 14-06-2016
			BR 112013006855 A2 14-06-2016
			BR 112013008673 A2 21-06-2016
			CA 2811337 A1 29-03-2012
			CA 2812146 A1 29-03-2012
			CA 2812150 A1 29-03-2012
			CA 2812157 A1 29-03-2012
			CN 103118615 A 22-05-2013
			CN 103118616 A 22-05-2013
			CN 103118617 A 22-05-2013
			CN 103281979 A 04-09-2013
			EP 2618760 A1 31-07-2013
			EP 2618761 A1 31-07-2013
			EP 2618764 A2 31-07-2013
			EP 2618765 A2 31-07-2013
			JP 5878176 B2 08-03-2016
			JP 5886294 B2 16-03-2016
			JP 5893630 B2 23-03-2016
			JP 5931071 B2 08-06-2016
			JP 2013540002 A 31-10-2013
			JP 2013540003 A 31-10-2013
			JP 2013541372 A 14-11-2013
			JP 2013543396 A 05-12-2013
			KR 20130108367 A 02-10-2013
			KR 20130111559 A 10-10-2013
			KR 20130112035 A 11-10-2013
			KR 20130120466 A 04-11-2013
			RU 2013118584 A 27-10-2014
			RU 2013118684 A 27-10-2014
			RU 2013118694 A 27-10-2014
			RU 2013118706 A 27-10-2014
			US 2012074200 A1 29-03-2012
			US 2012074201 A1 29-03-2012
			US 2012078243 A1 29-03-2012
			US 2012078244 A1 29-03-2012
			WO 2012040430 A1 29-03-2012
			WO 2012040432 A1 29-03-2012
			WO 2012040593 A2 29-03-2012
			WO 2012040600 A2 29-03-2012
US 2010193566	A1	05-08-2010	AU 2010210793 A1 25-08-2011
			BR PI1007927 A2 23-02-2016
			CA 2751663 A1 12-08-2010
			CN 102368961 A 07-03-2012
			EP 2393429 A2 14-12-2011
			JP 5607077 B2 15-10-2014
			JP 2012516754 A 26-07-2012
			RU 2011136633 A 10-03-2013
			US 2010193566 A1 05-08-2010
			WO 2010090938 A2 12-08-2010
US 2015351854	A1	10-12-2015	US 2015351854 A1 10-12-2015

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2017/025952

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
		US 2017165018 A1	15-06-2017
EP 2090236	A2 19-08-2009	BR PI0901423 A2	16-11-2010
		CN 101507643 A	19-08-2009
		EP 2090236 A2	19-08-2009
		JP 5474365 B2	16-04-2014
		JP 2009189824 A	27-08-2009
		RU 2009105060 A	20-08-2010
		US 2009206130 A1	20-08-2009
		US 2011068148 A1	24-03-2011
		US 2014353359 A1	04-12-2014
		US 2015374367 A1	31-12-2015
EP 0621009	A1 26-10-1994	AT 155989 T	15-08-1997
		AU 6055394 A	27-10-1994
		CA 2121533 A1	21-10-1994
		DE 69404526 D1	04-09-1997
		DE 69404526 T2	18-12-1997
		EP 0621009 A1	26-10-1994
		ES 2105517 T3	16-10-1997
		JP H08206120 A	13-08-1996
		US 5374277 A	20-12-1994
US 2007287993	A1 13-12-2007	EP 2026700 A2	25-02-2009
		JP 5484900 B2	07-05-2014
		JP 5701339 B2	15-04-2015
		JP 2009539567 A	19-11-2009
		JP 2013176651 A	09-09-2013
		US 2007287993 A1	13-12-2007
		WO 2007146894 A2	21-12-2007