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Houser et al.

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(54) **SURGICAL INSTRUMENTS**

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(Continued)

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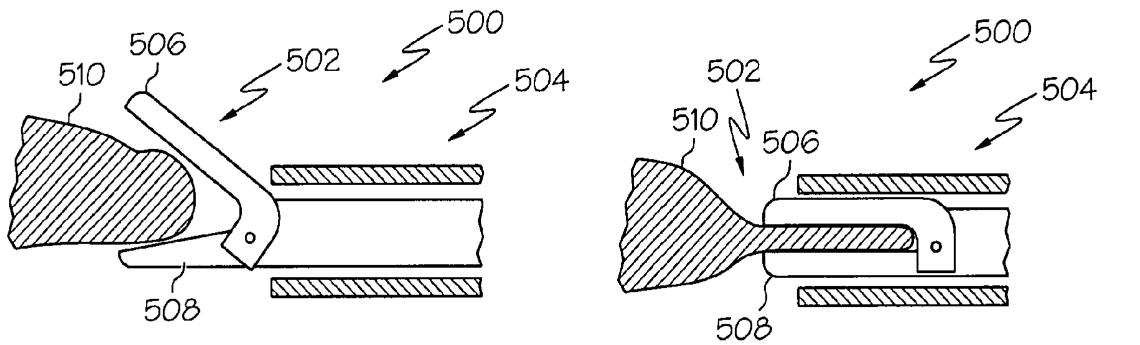
(57) **ABSTRACT**

A surgical device is disclosed including a surgical instrument and an outer sheath surrounding the surgical instrument. The surgical instruments includes an end effector including a first jaw member and a second jaw member. At least one of the first jaw member or the second jaw member is pivotable toward the other to grasp tissue. The outer sheath is slidable relative to the surgical instrument along a longitudinal axis between a first position, wherein the first jaw member and the second jaw member are positioned within the outer sheath proximal to a distal portion of the outer sheath, and a second positon, wherein the first iaw member and the second iaw member are positioned outside the outer sheath distal to the distal portion of the outer sheath. The distal portion of the outer sheath is configured to clamp tissue.

21 Claims, 35 Drawing Sheets



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(58) **Field of Classification Search**

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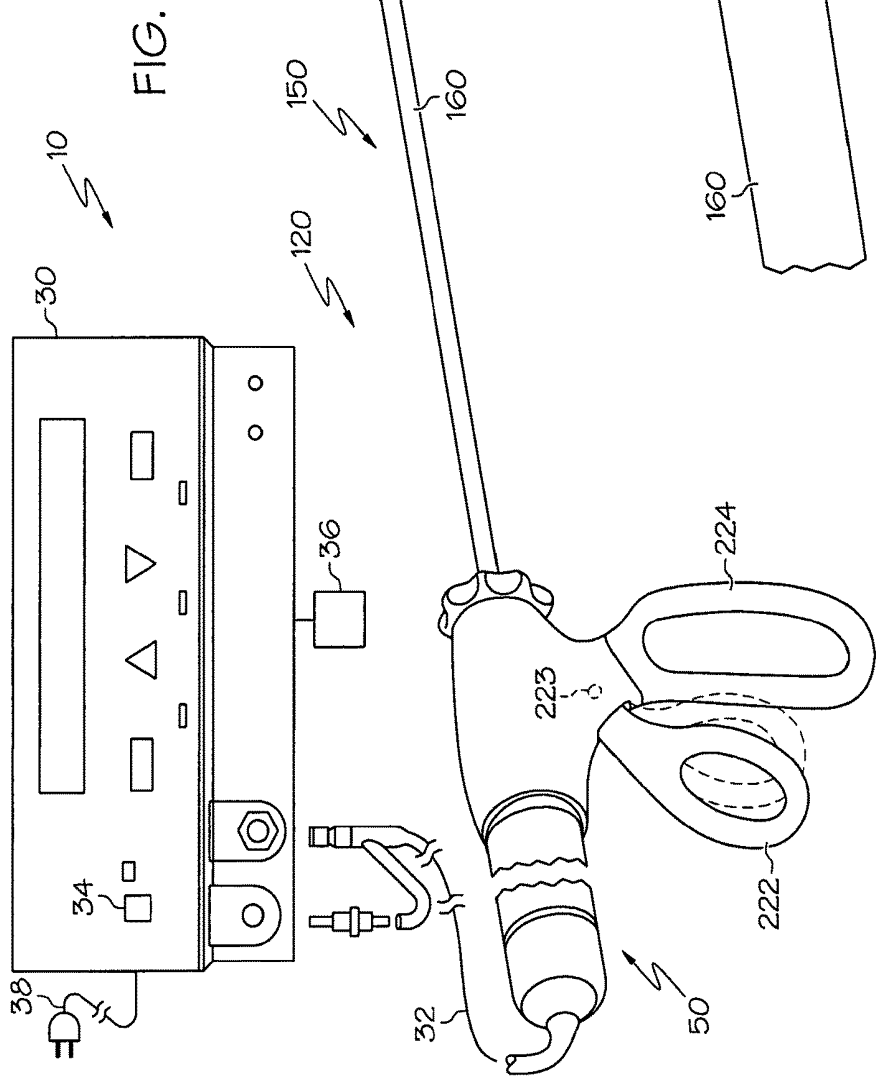
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FIG. 1

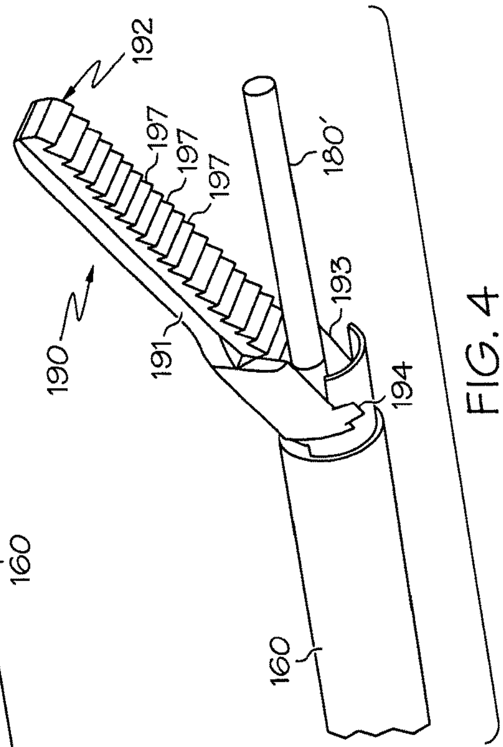
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FIG. 4

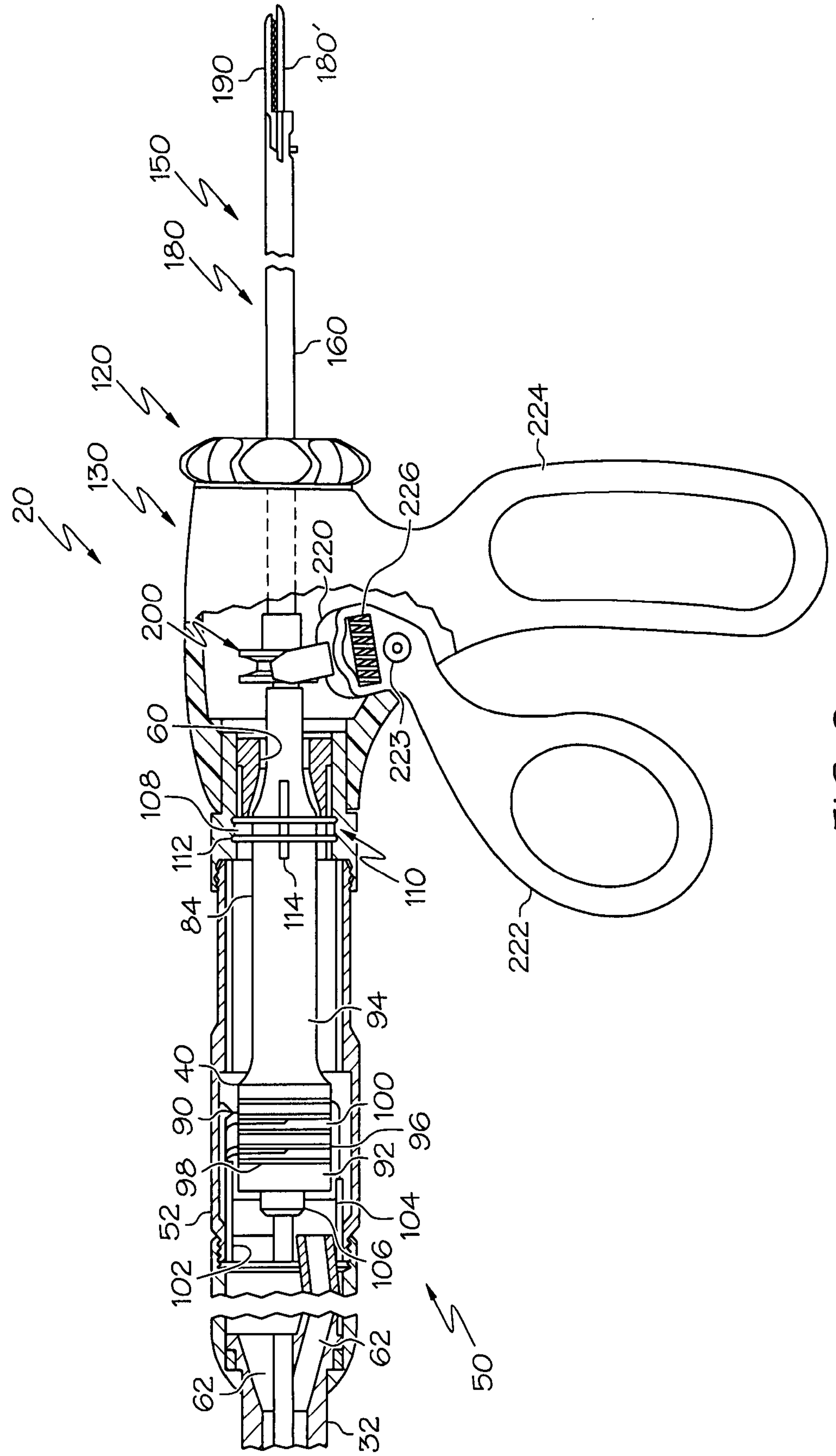
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FIG. 2

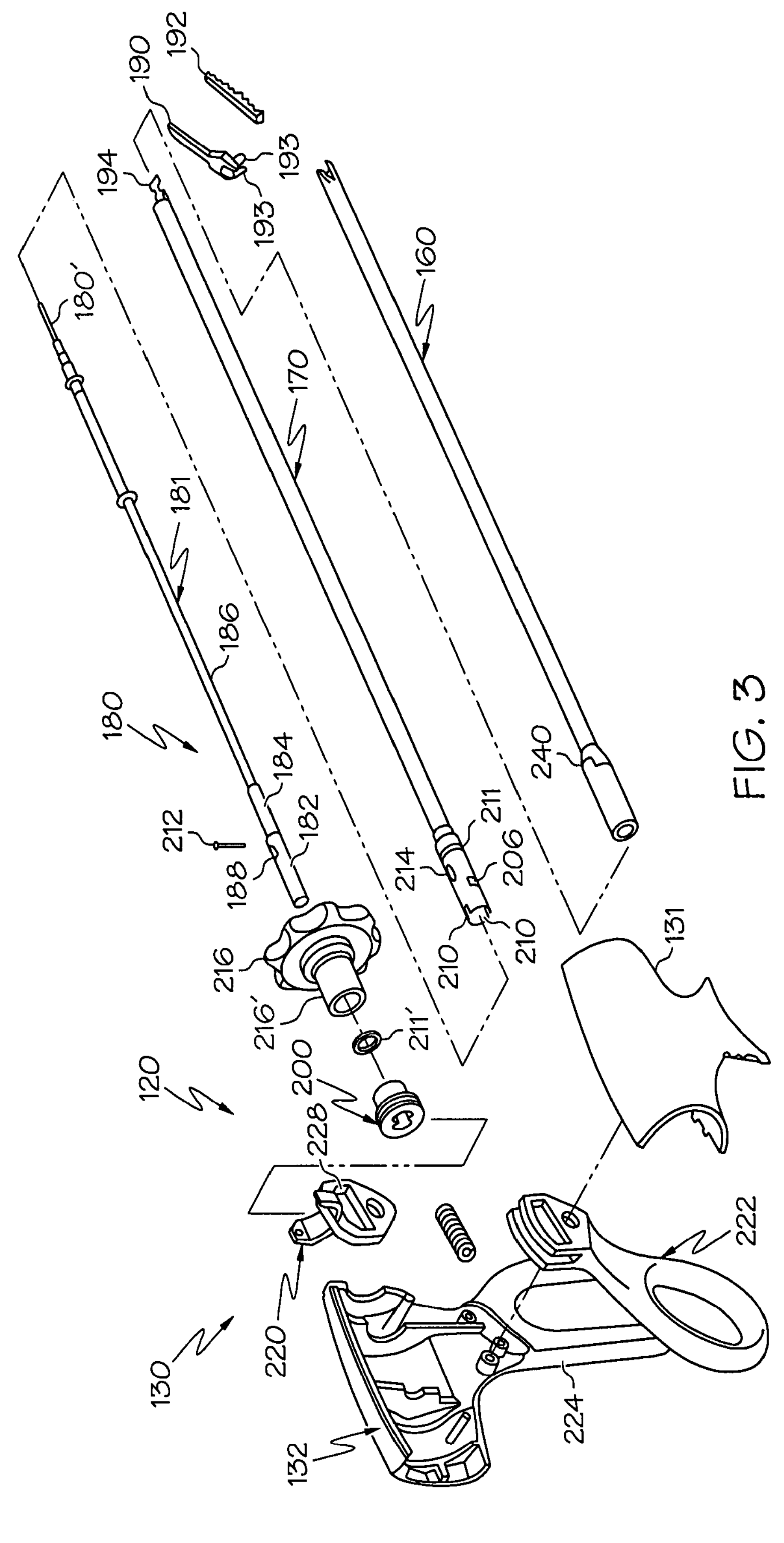

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FIG. 3

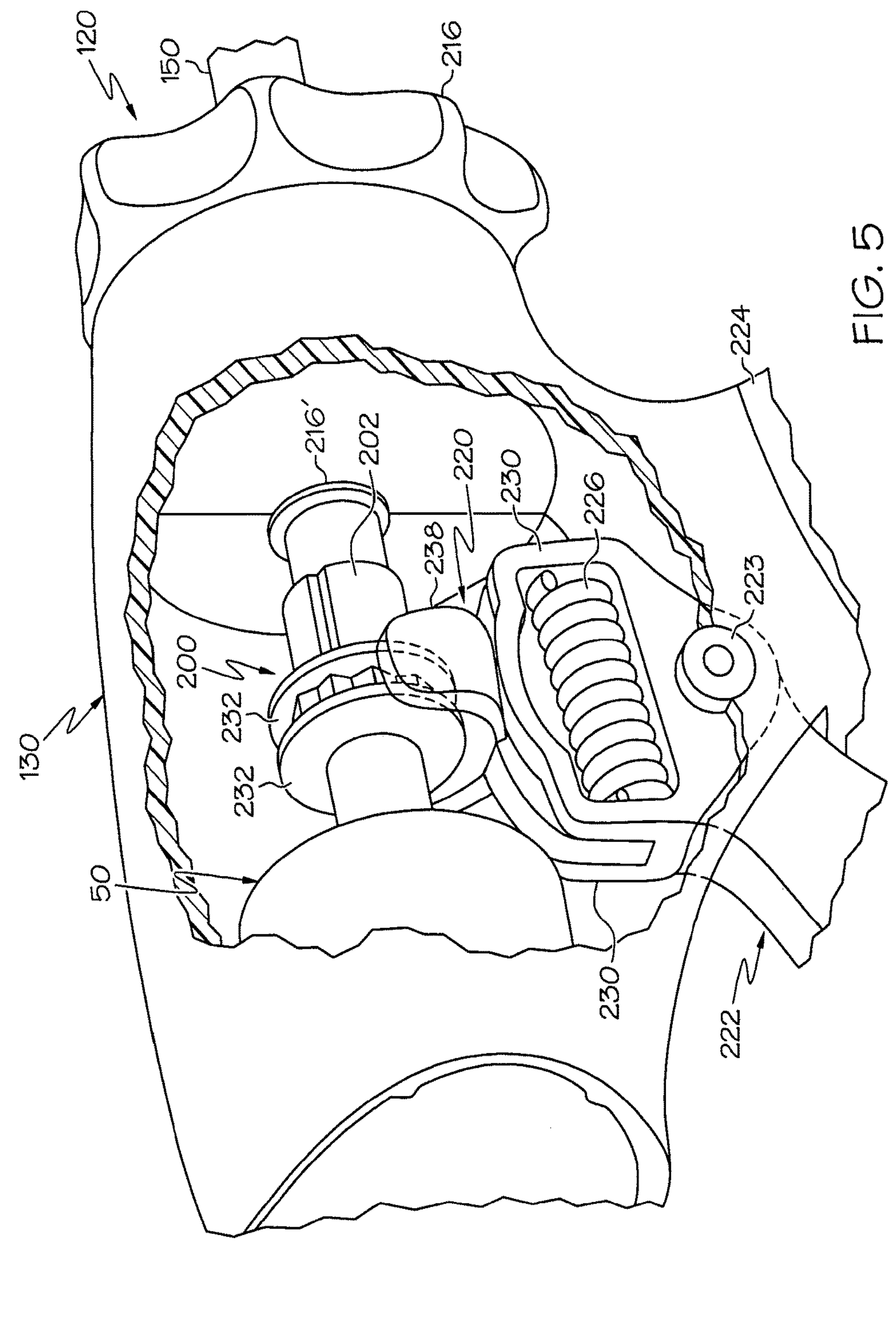
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FIG. 5

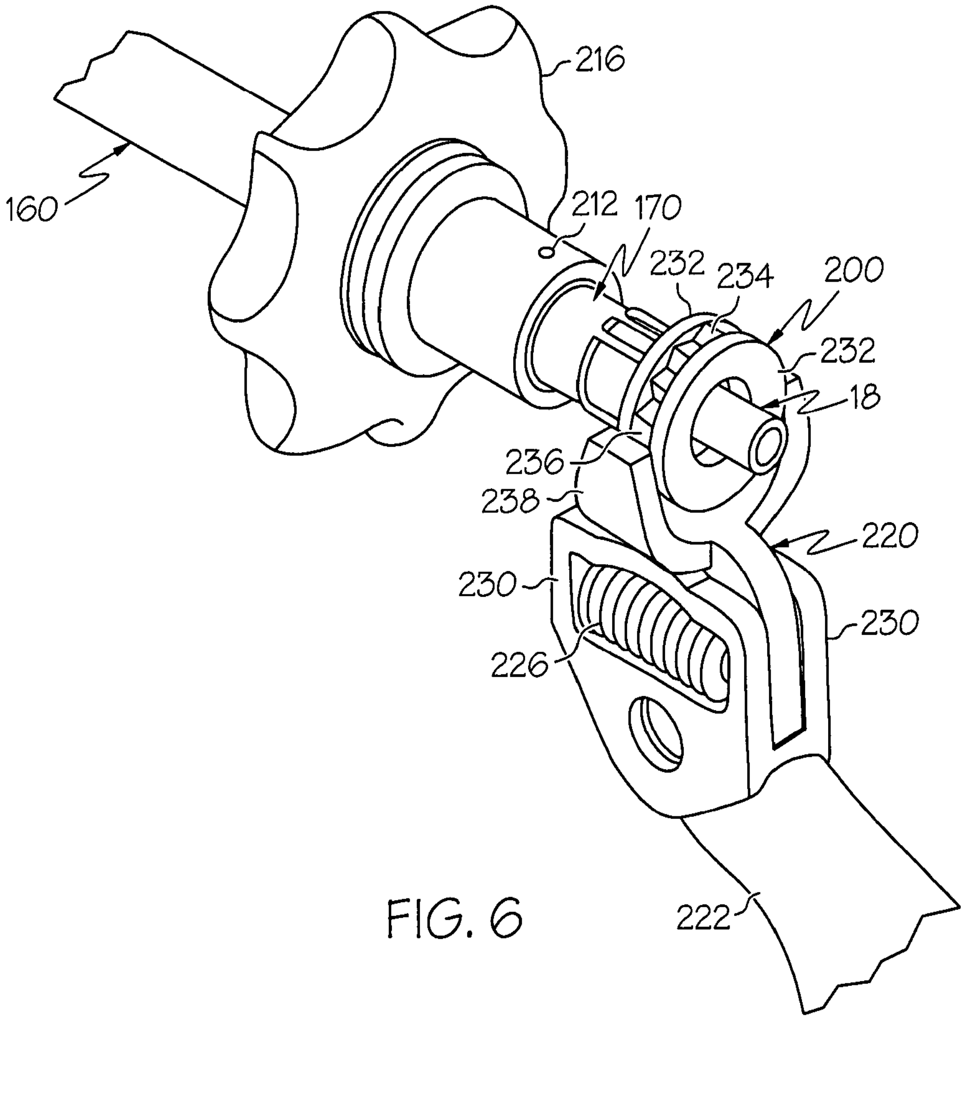

FIG. 6

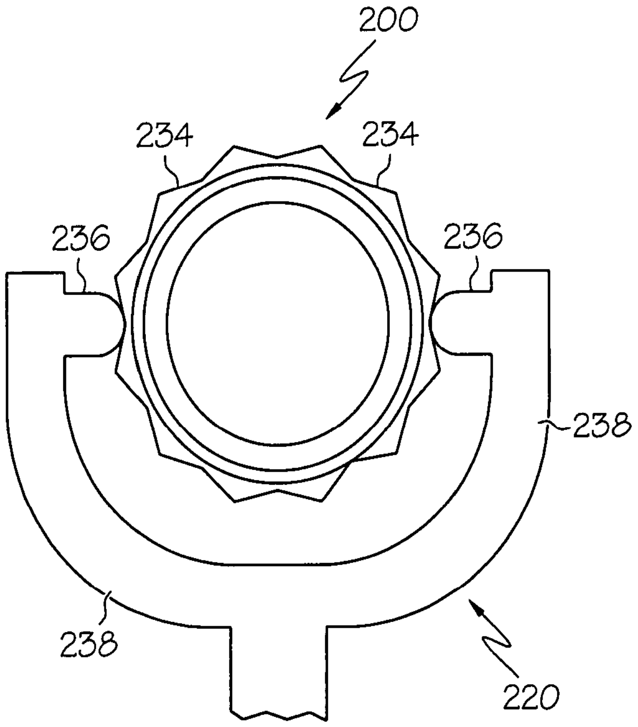
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FIG. 7

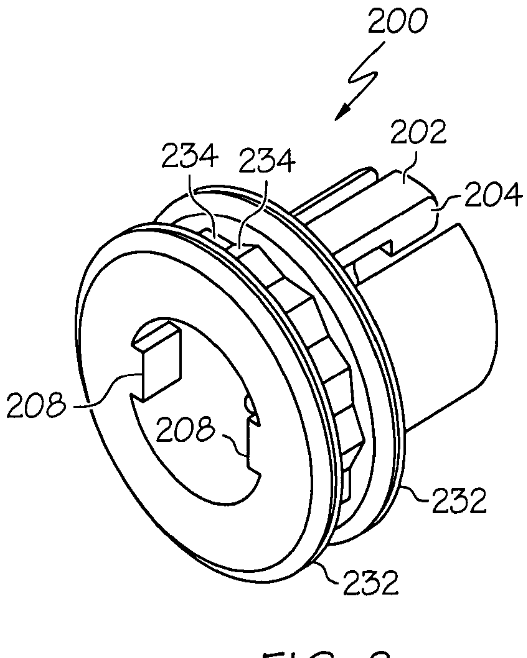
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FIG. 8

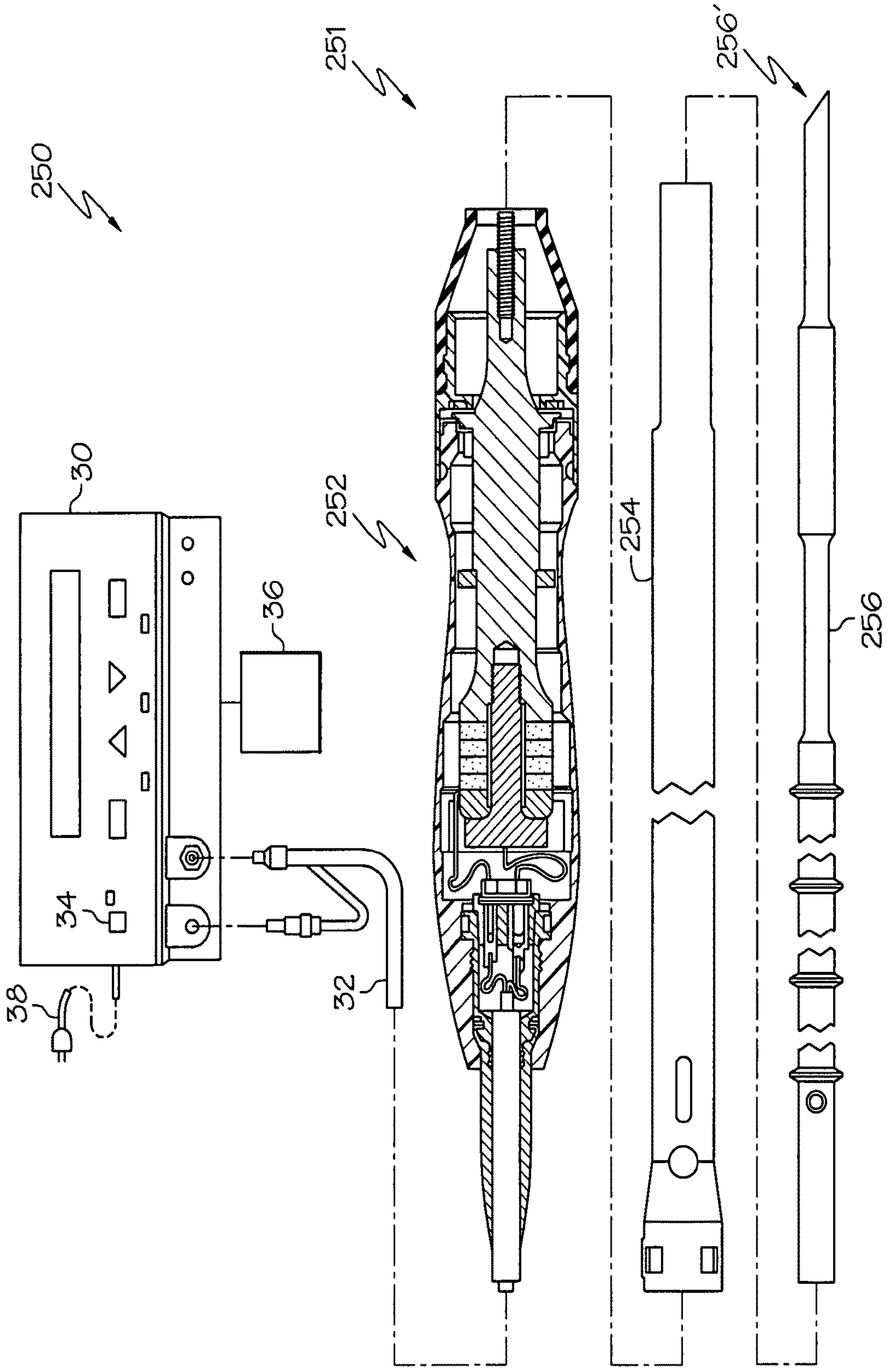

FIG. 9

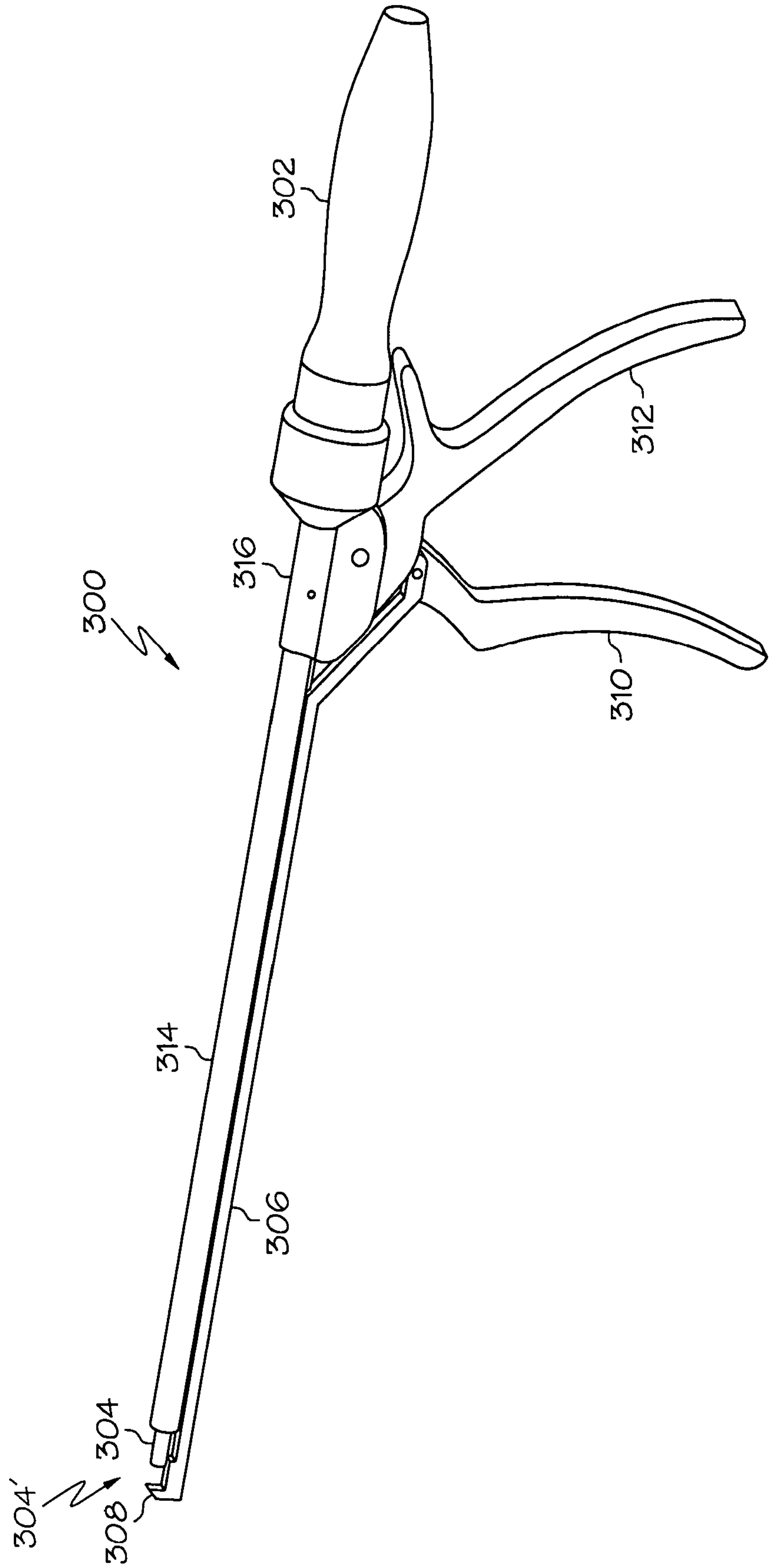

FIG. 10

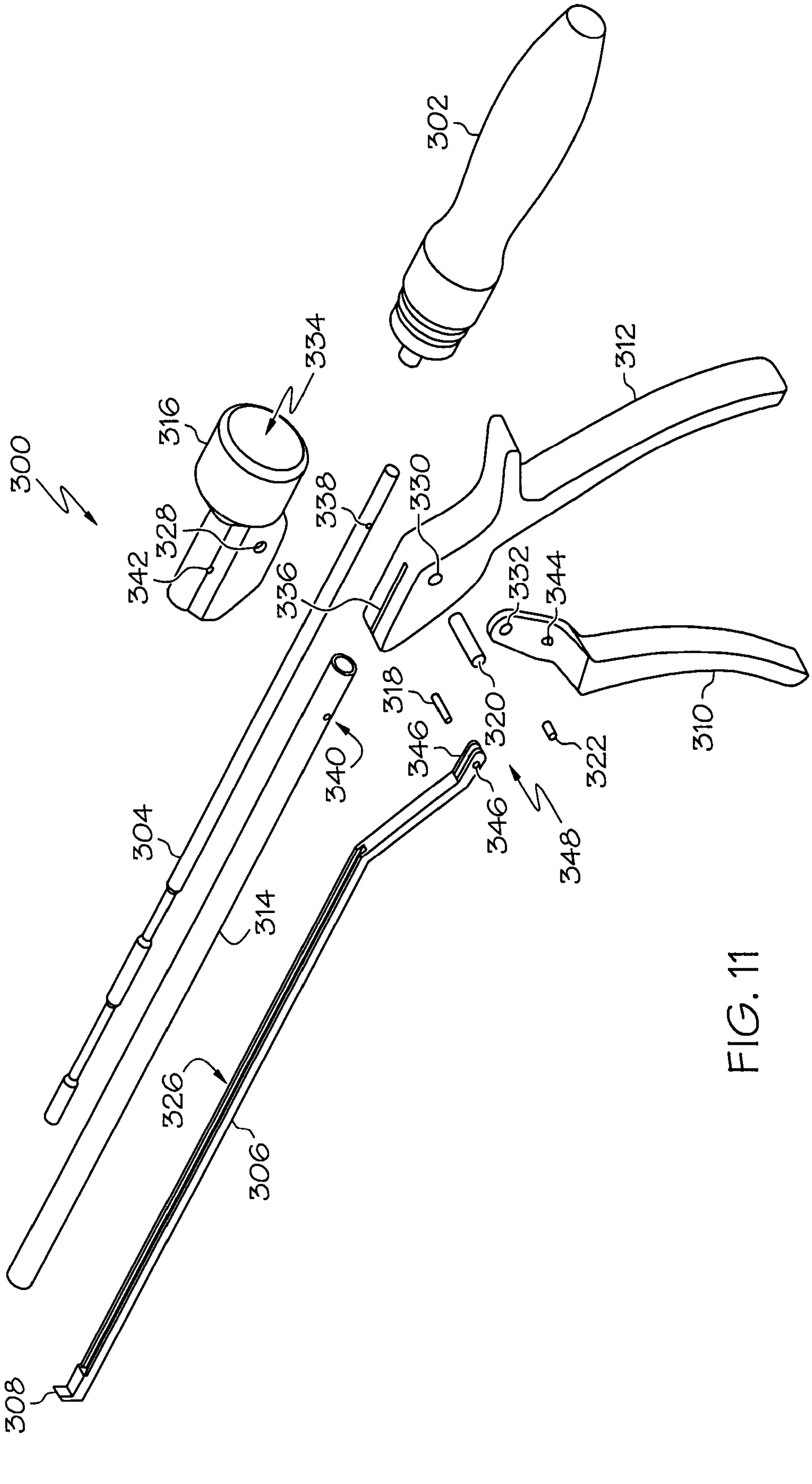
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FIG. 11

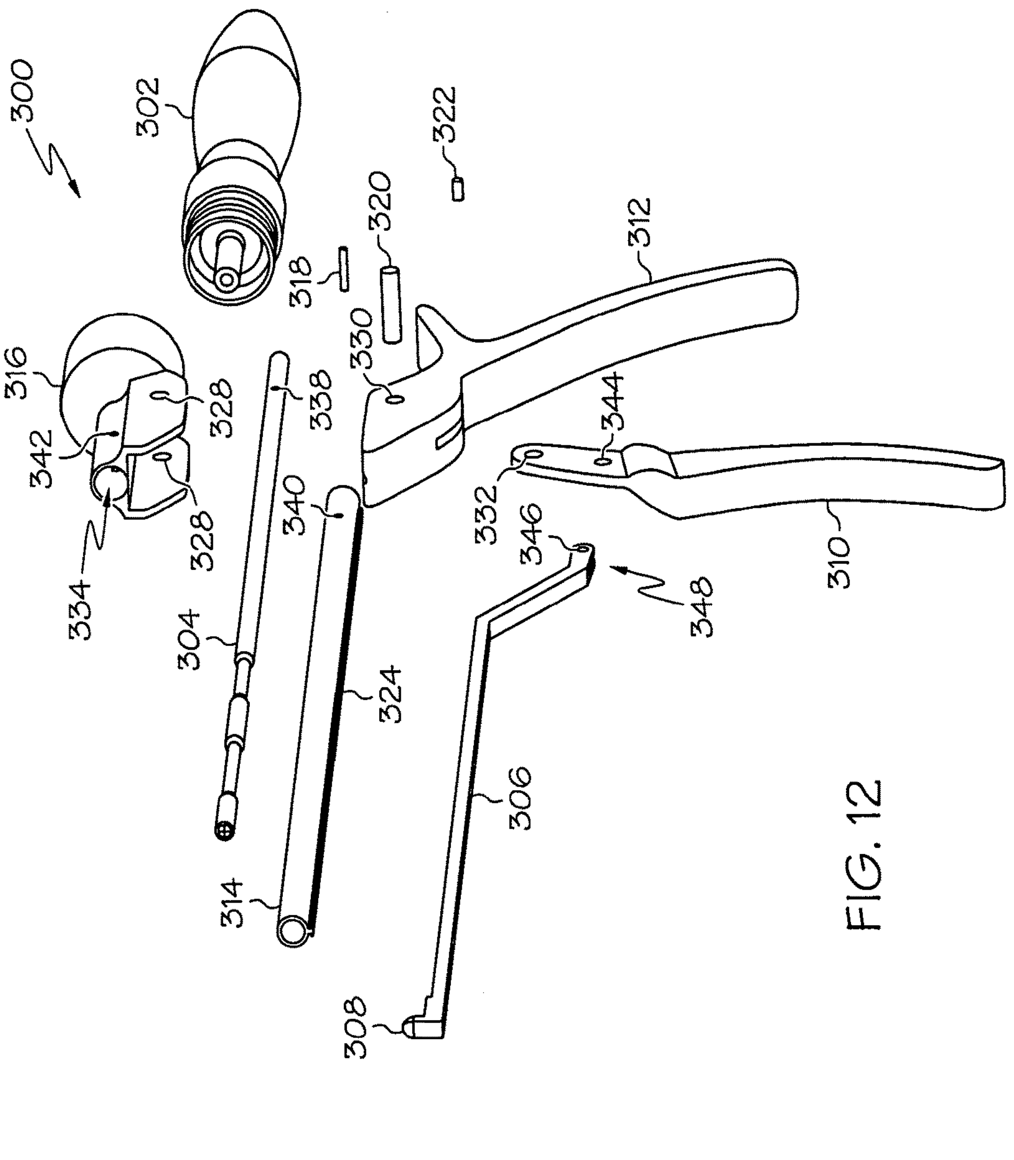
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FIG. 12

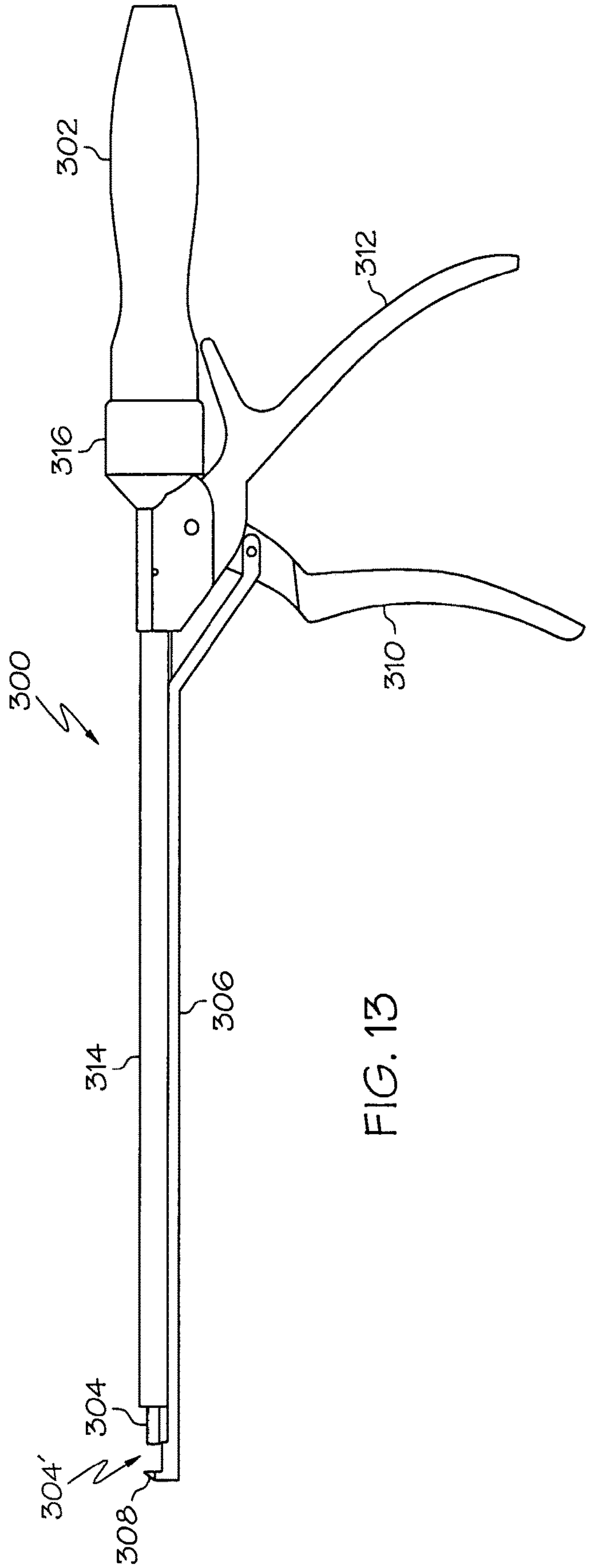


FIG. 13

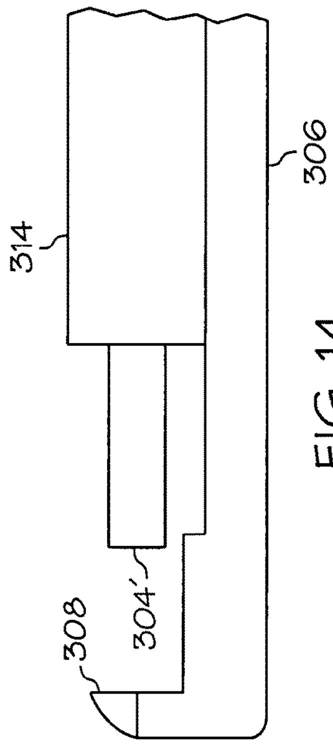


FIG. 14

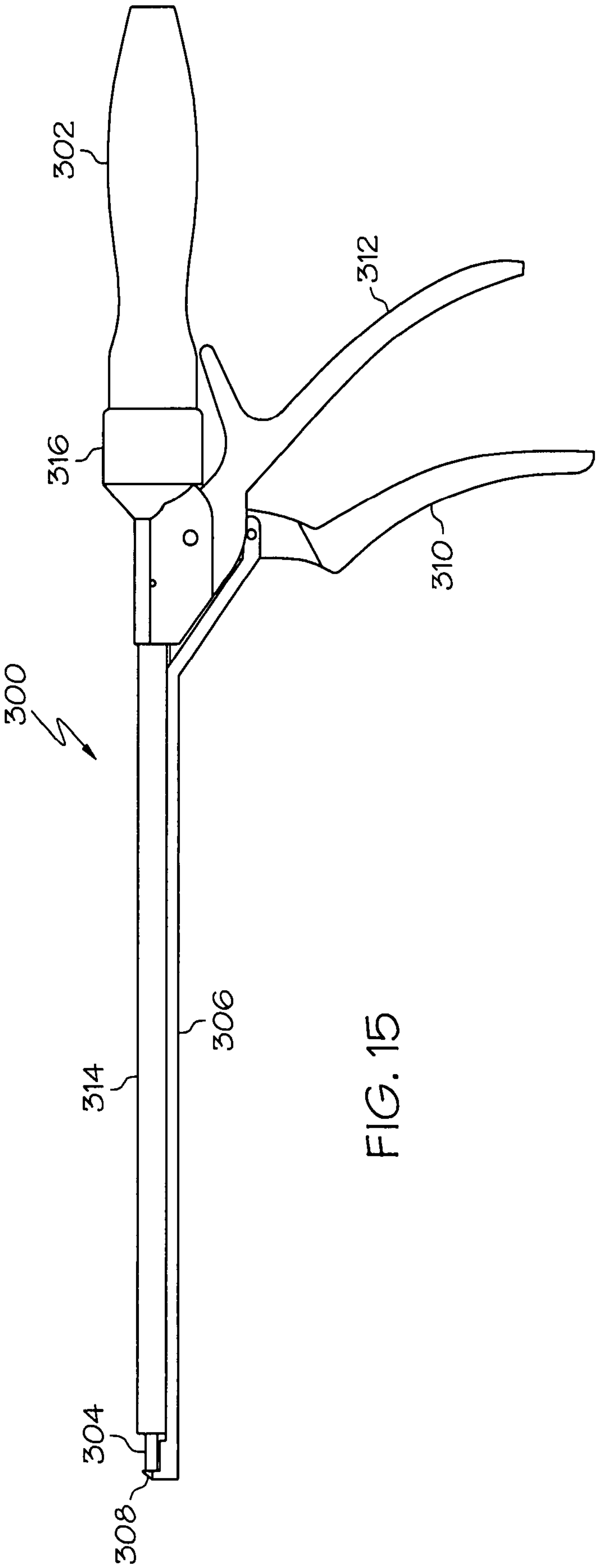


FIG. 15

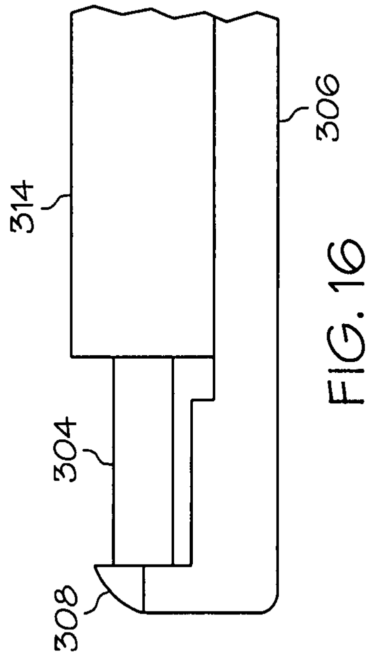


FIG. 16

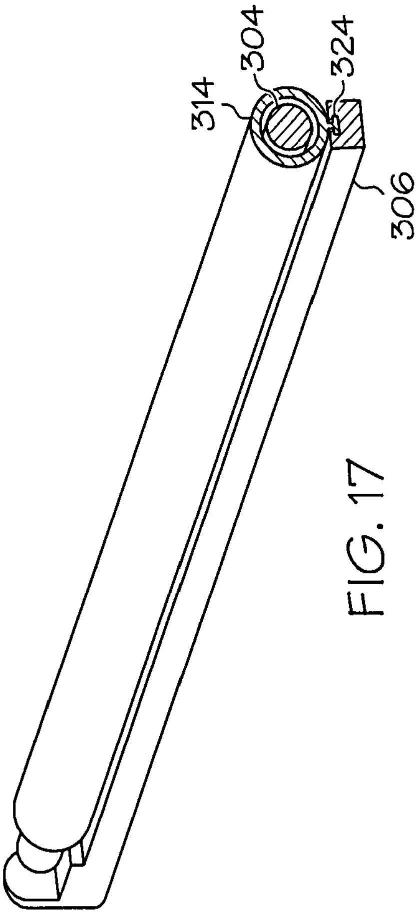


FIG. 17

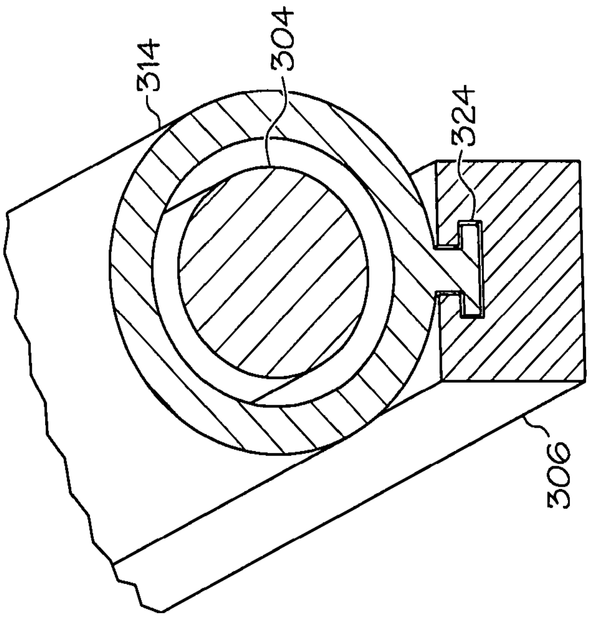


FIG. 18

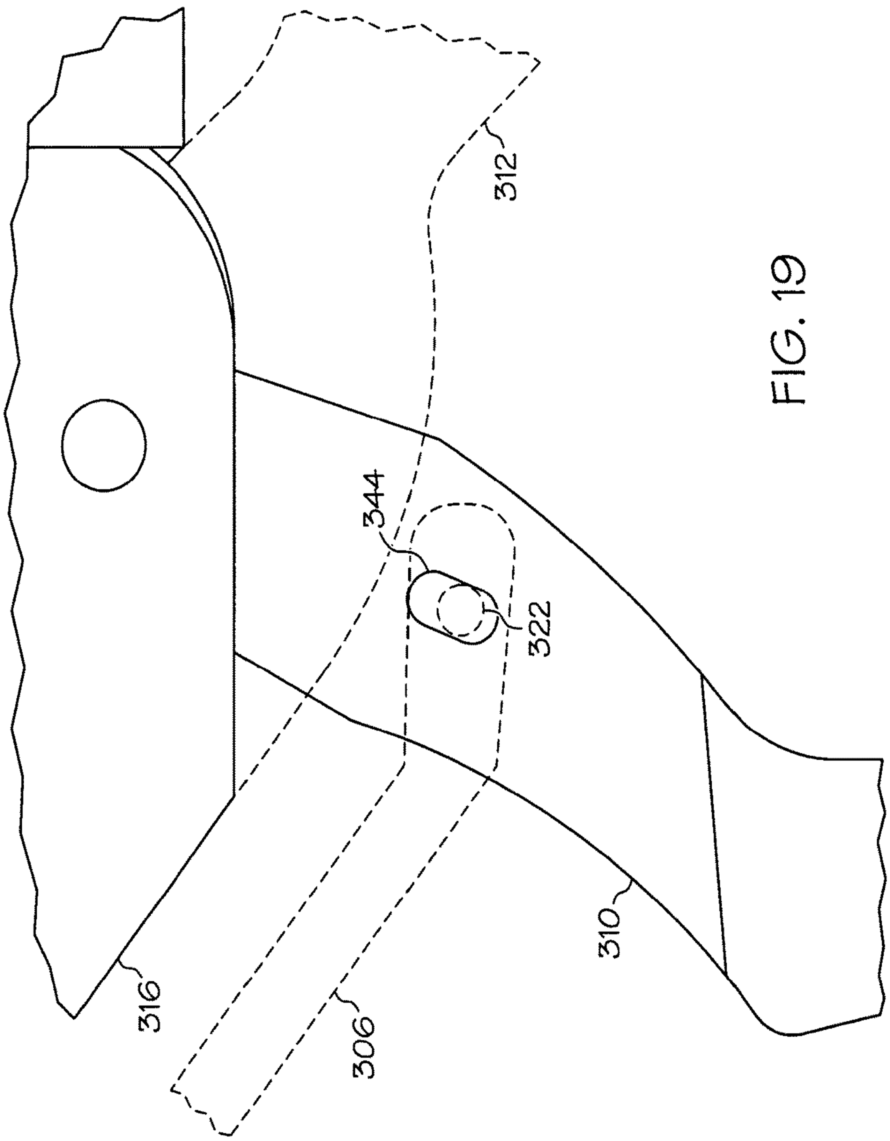


FIG. 19

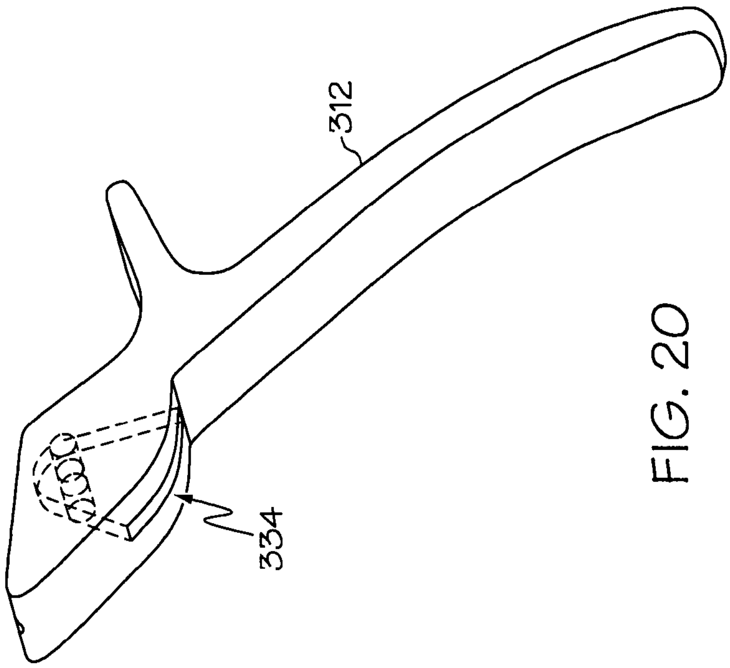


FIG. 20

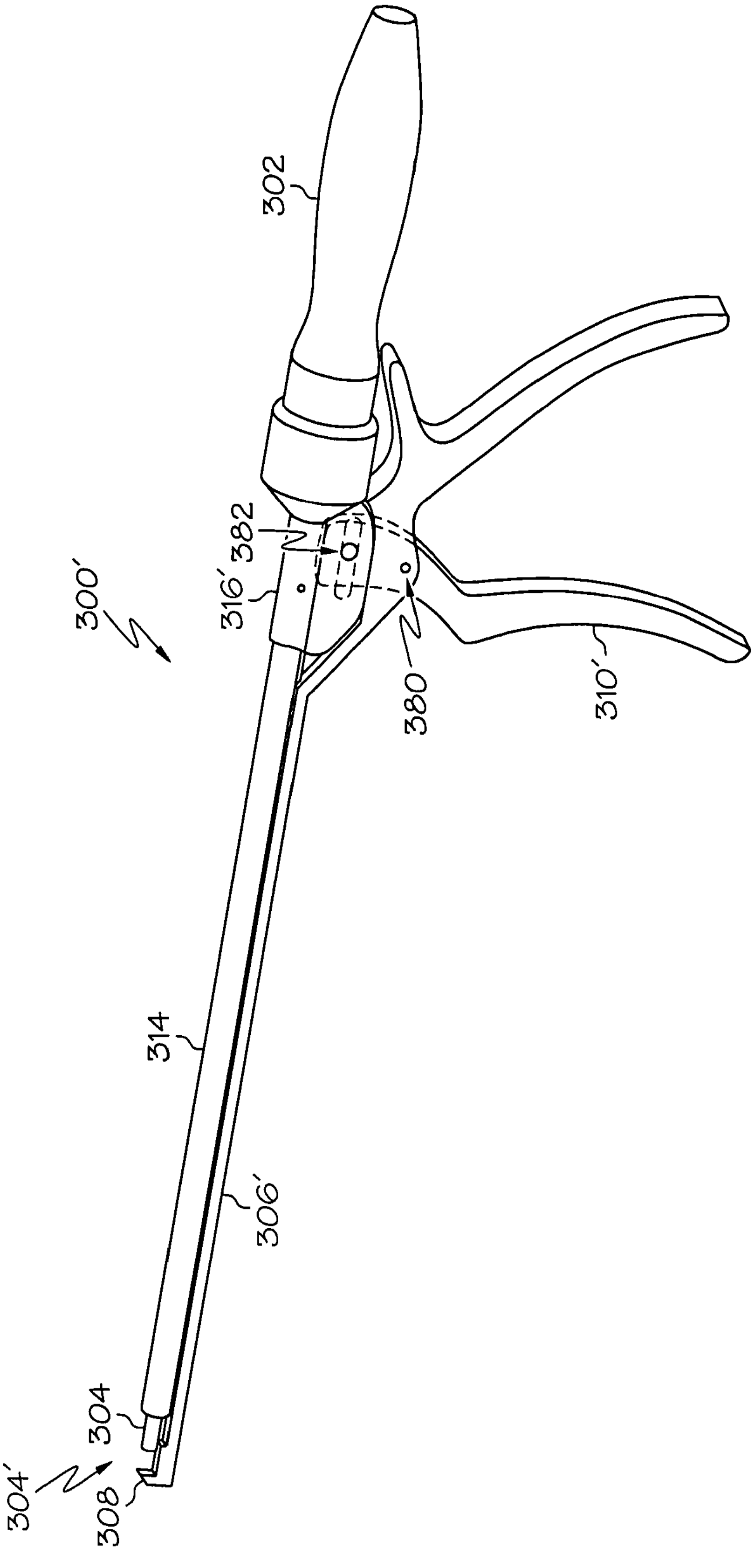


FIG. 20A

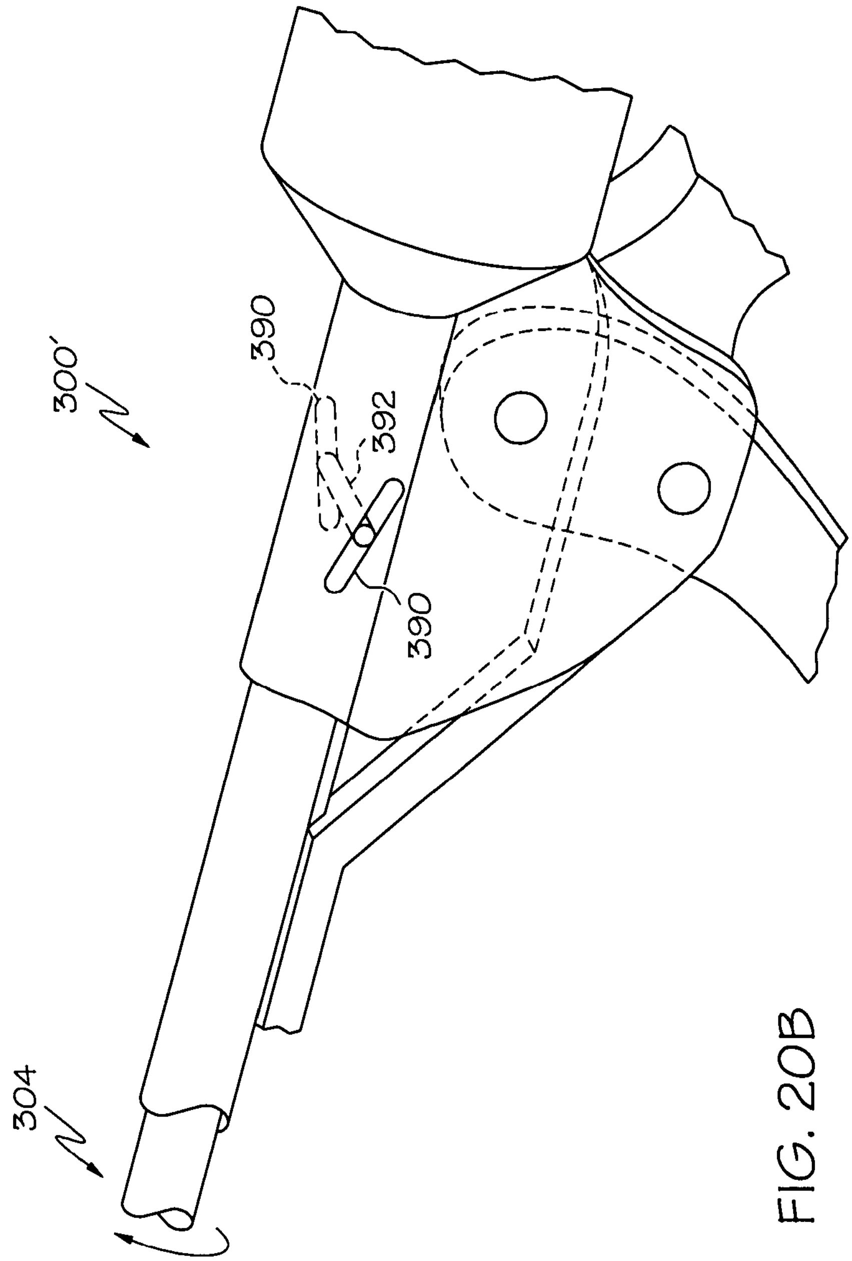


FIG. 20B

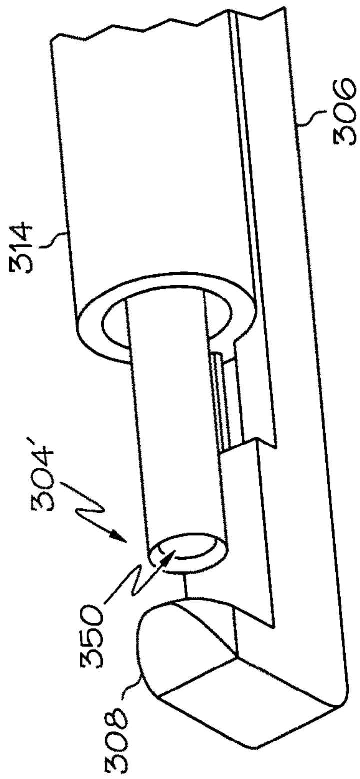


FIG. 21

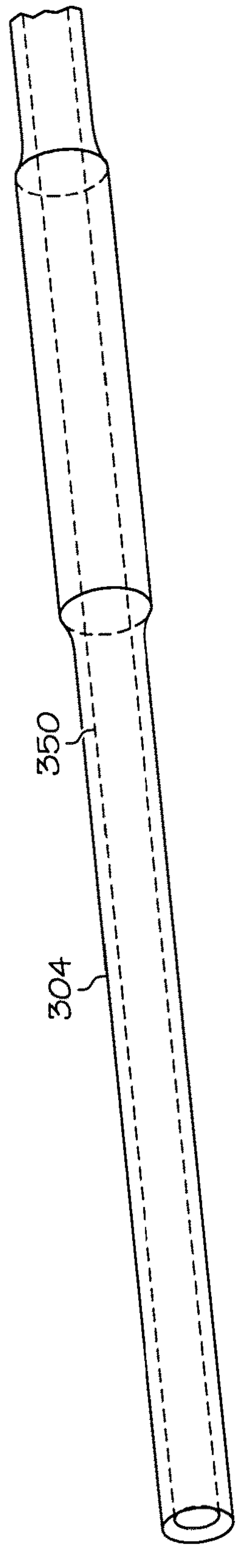


FIG. 22

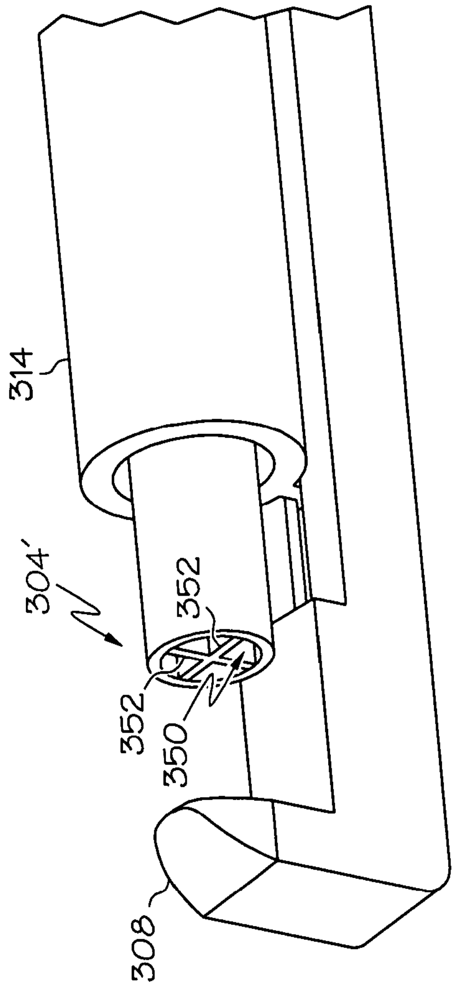


FIG. 23

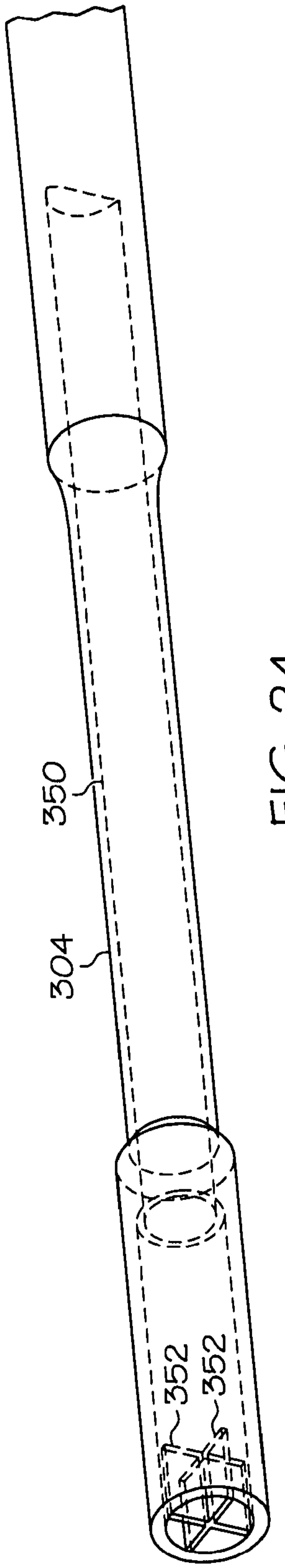


FIG. 24

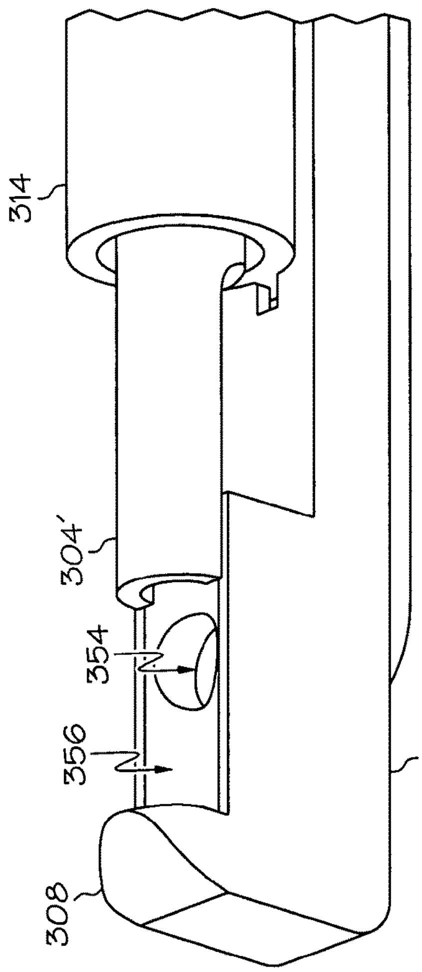


FIG. 25

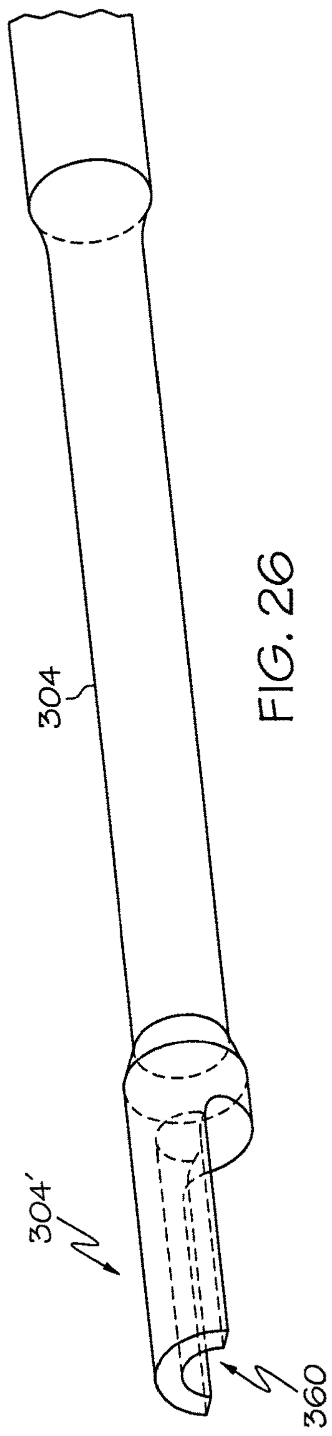


FIG. 26

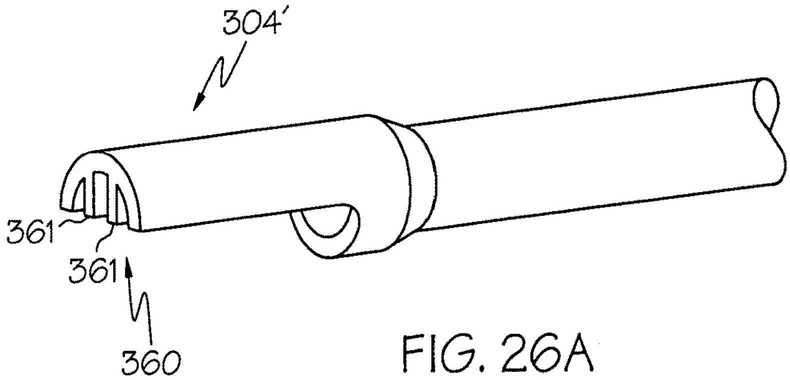


FIG. 26A

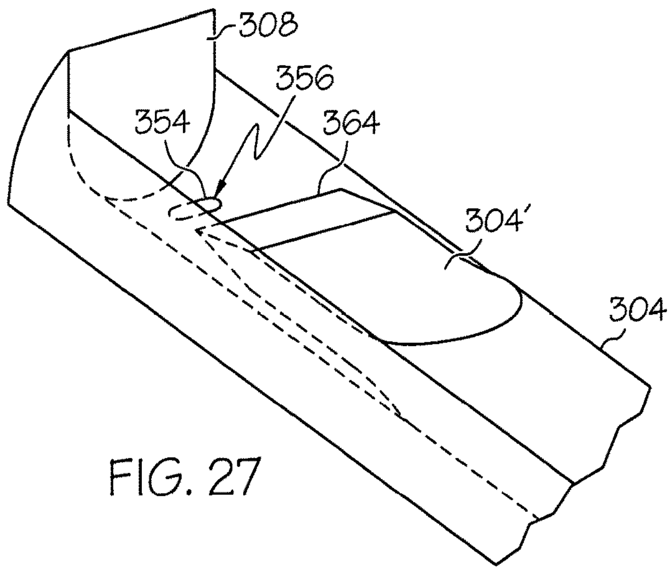


FIG. 27

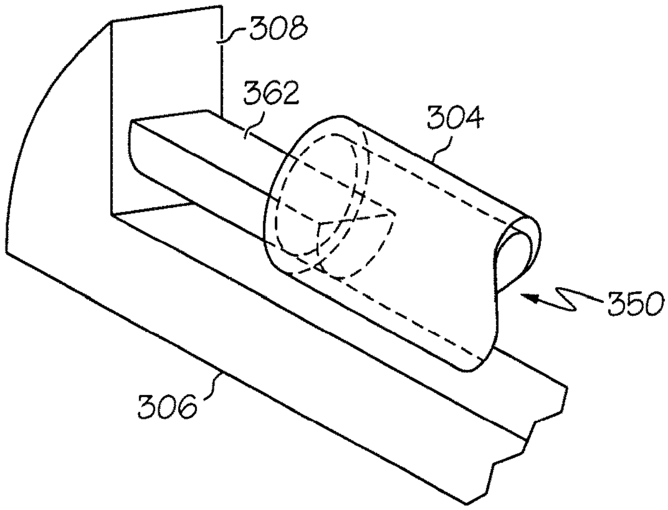


FIG. 28

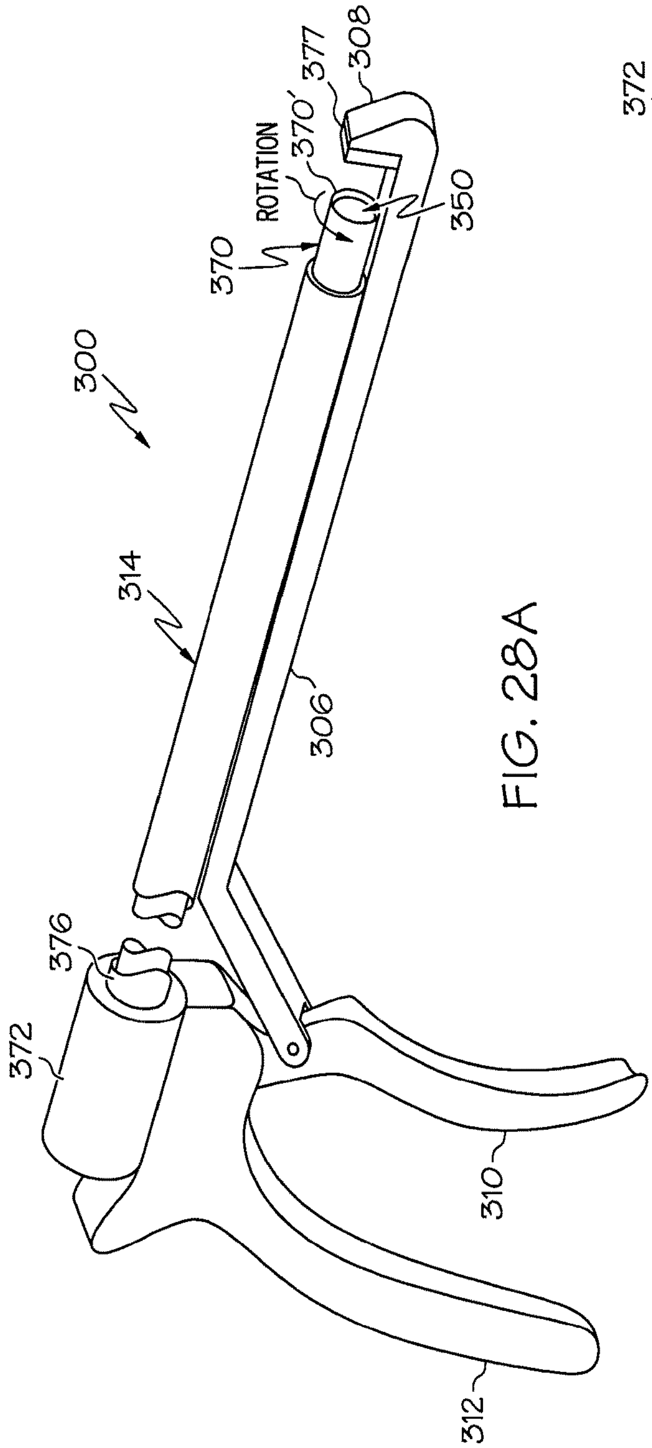


FIG. 28A

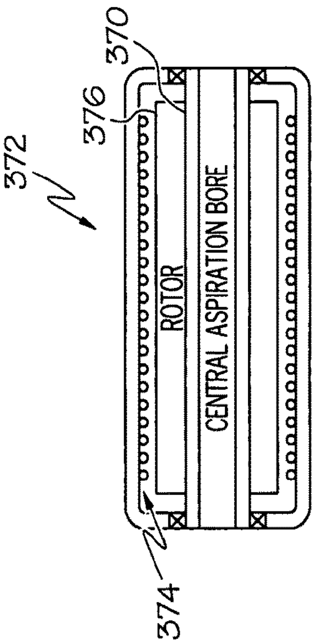


FIG. 28B

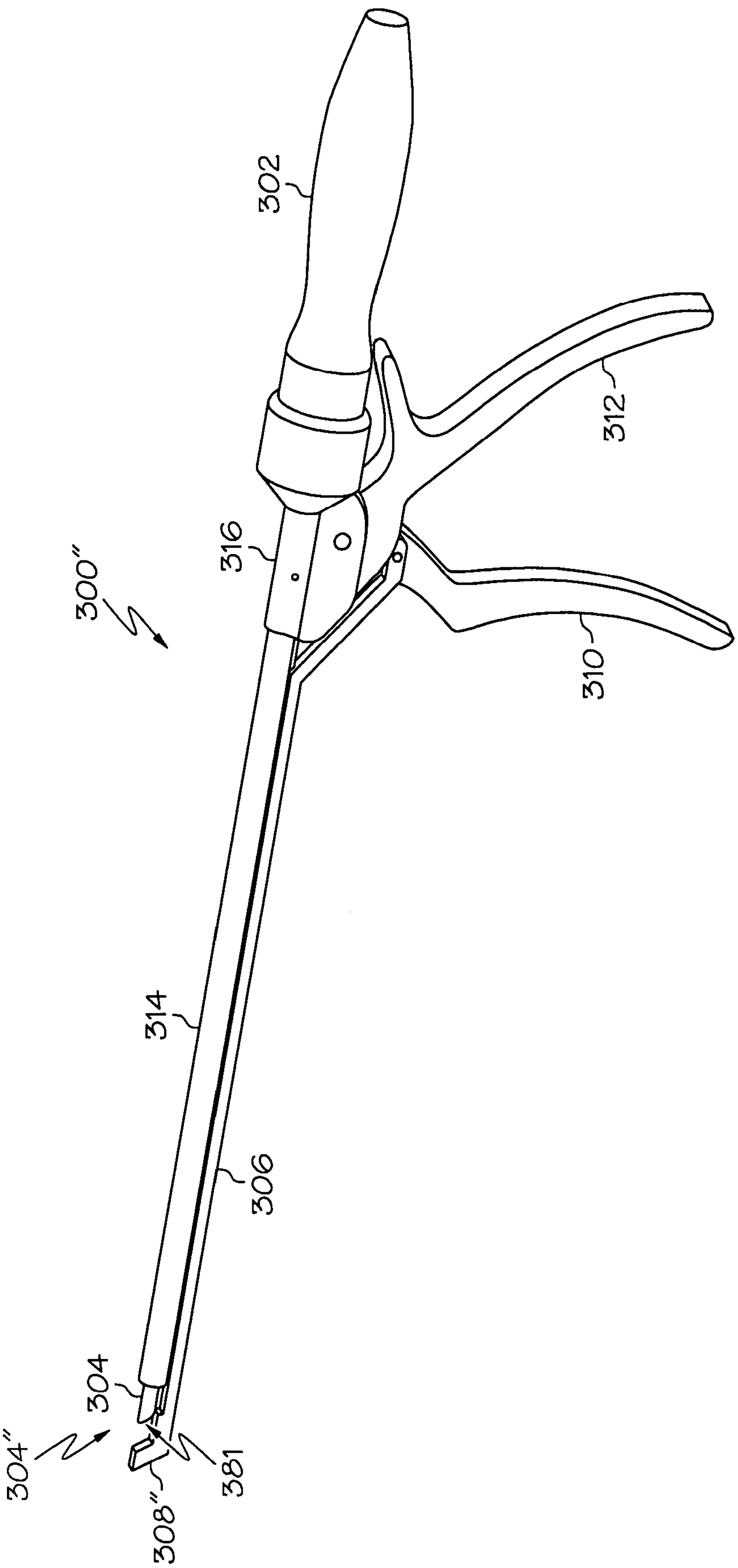


FIG. 28C

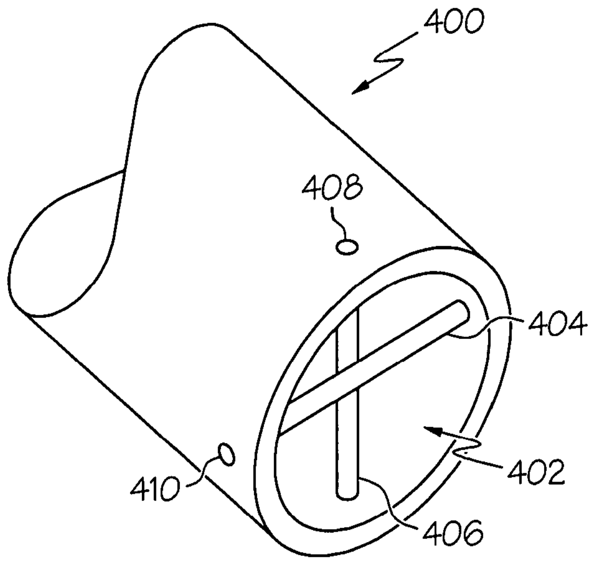


FIG. 29

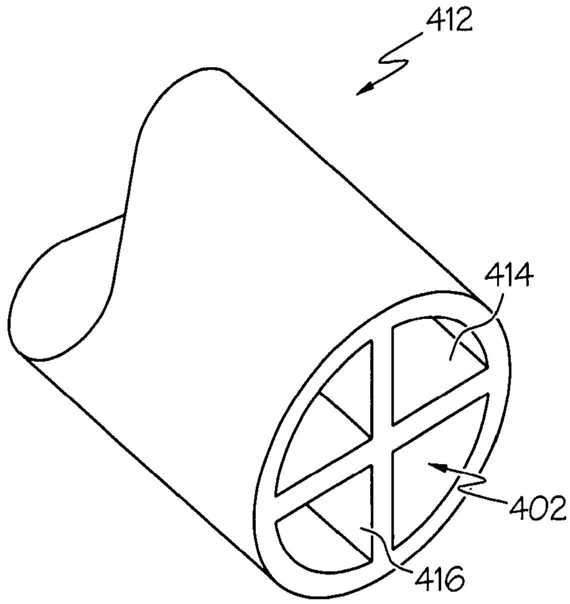
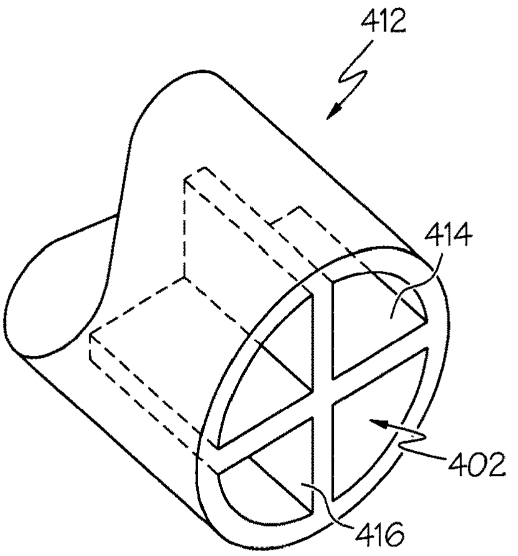


FIG. 30



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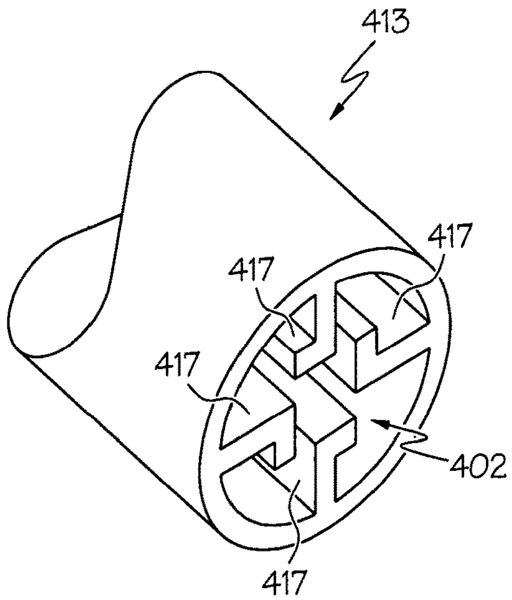


FIG. 31A

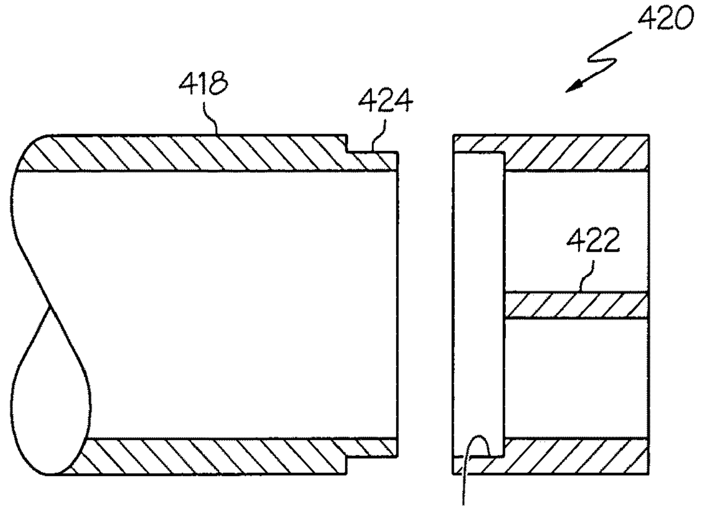


FIG. 32

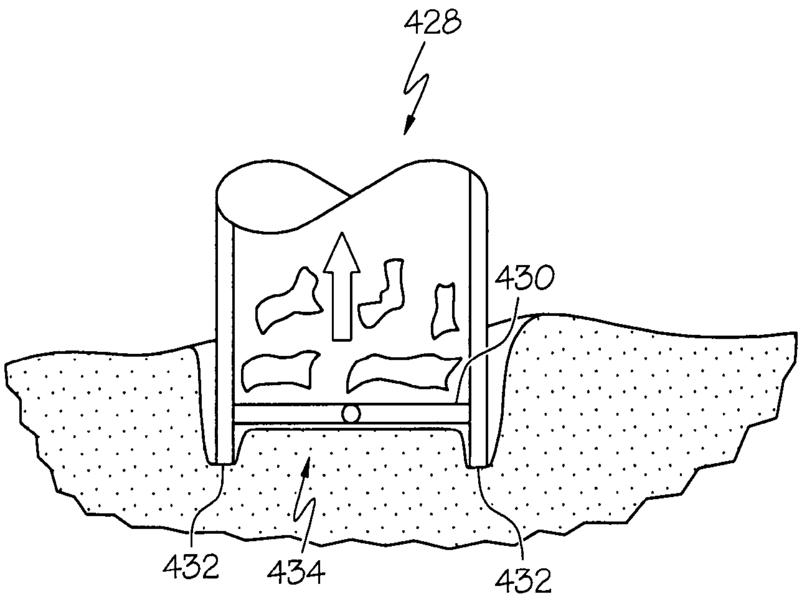


FIG. 33

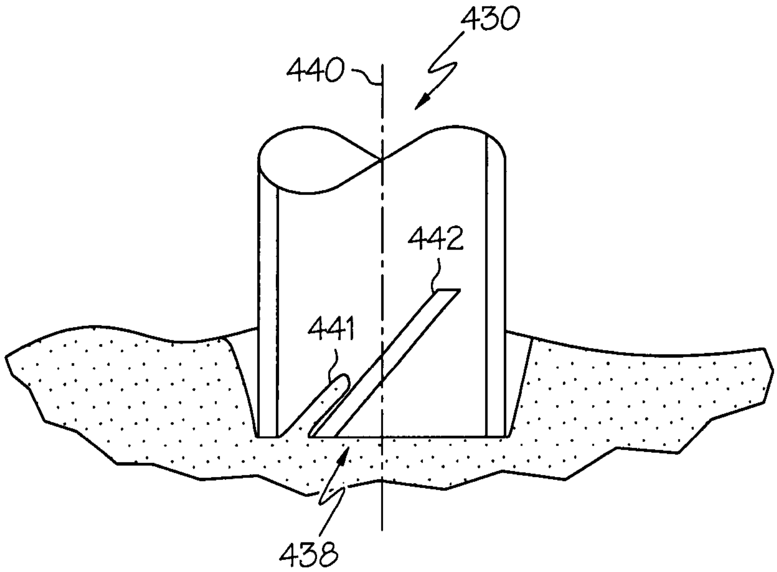


FIG. 34

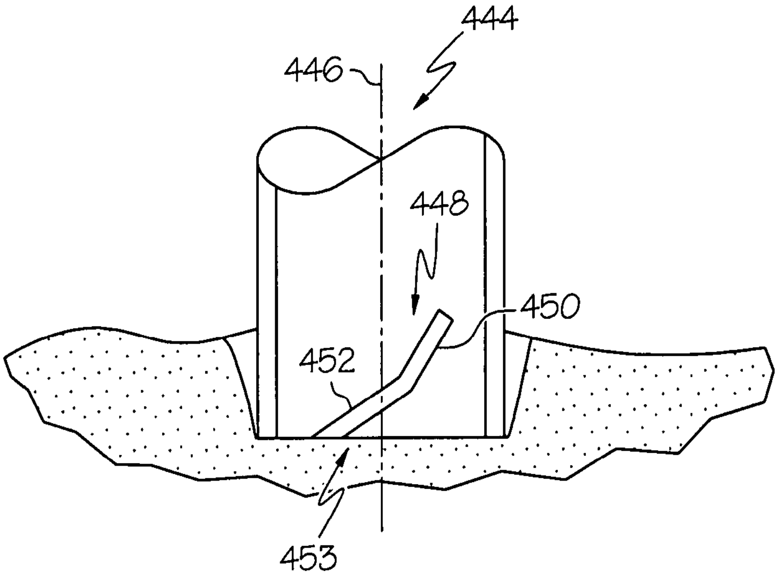


FIG. 35

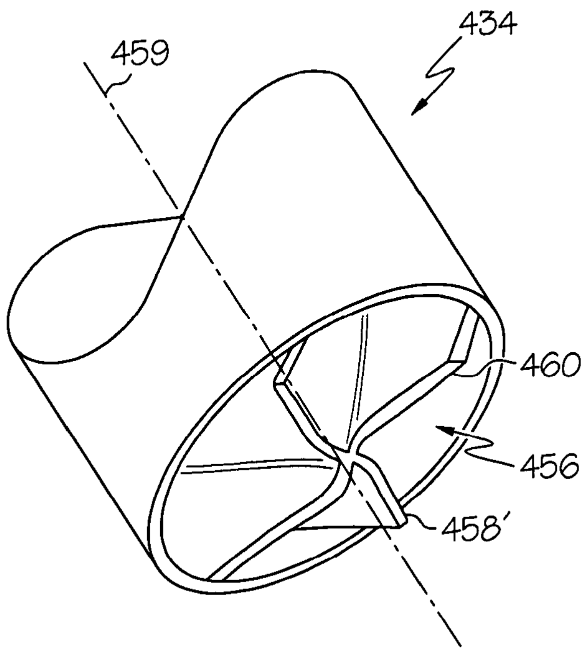


FIG. 36

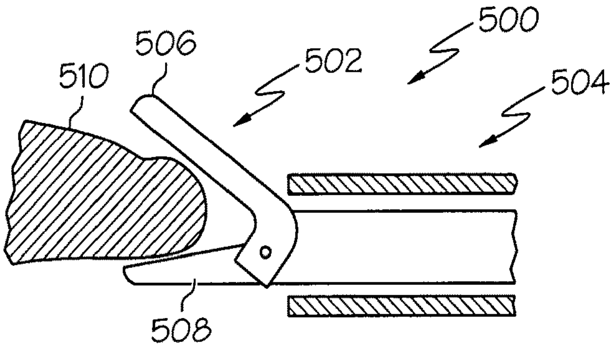


FIG. 37

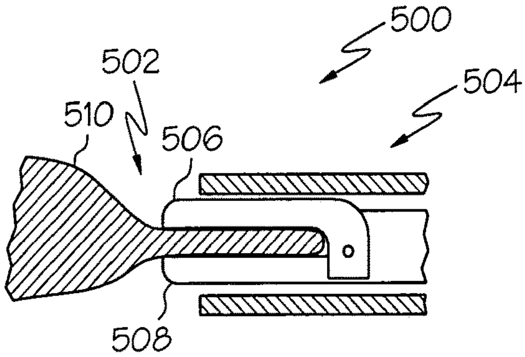


FIG. 38

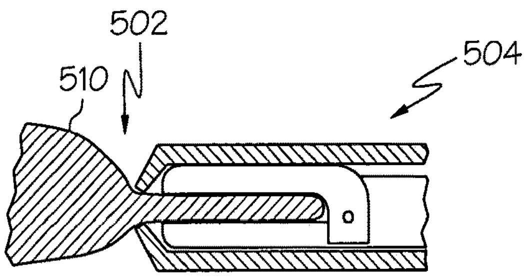


FIG. 39

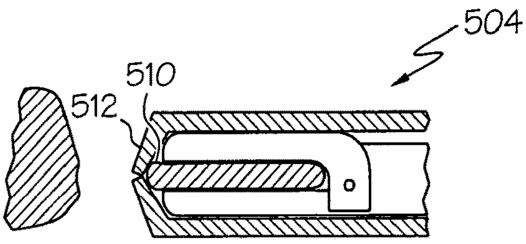


FIG. 40

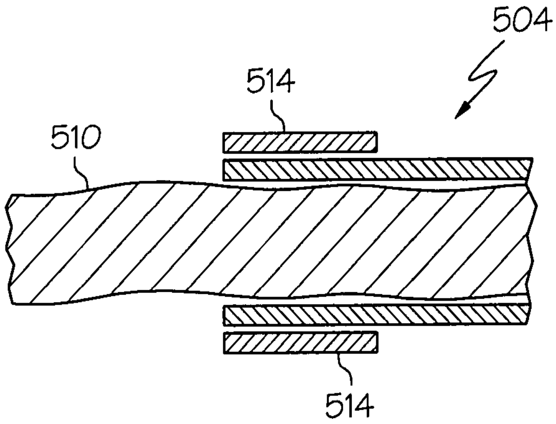


FIG. 41

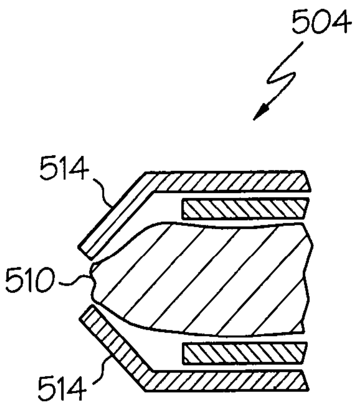


FIG. 42

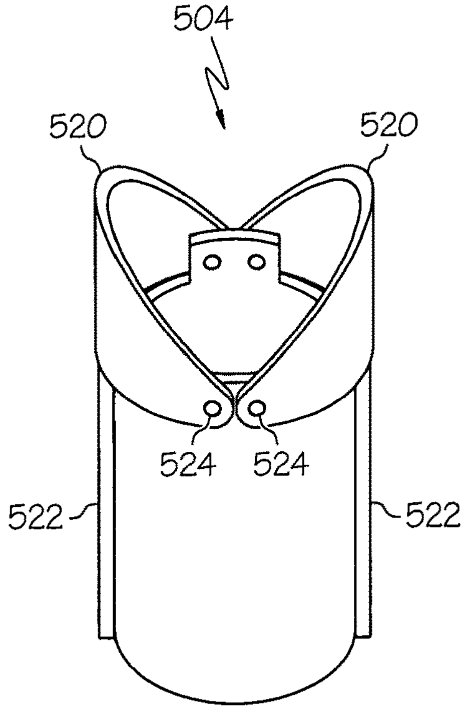


FIG. 43

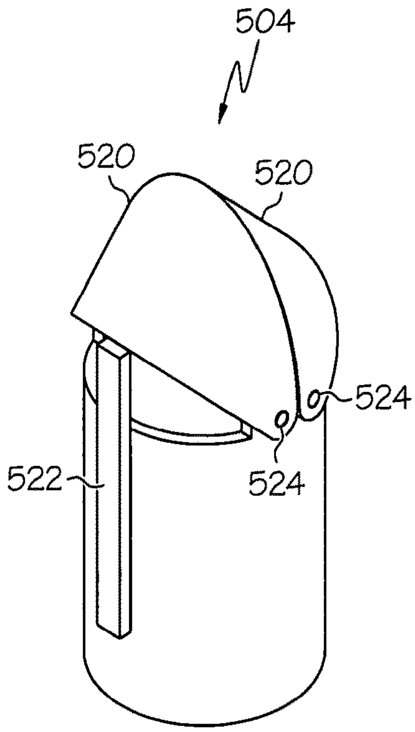


FIG. 44

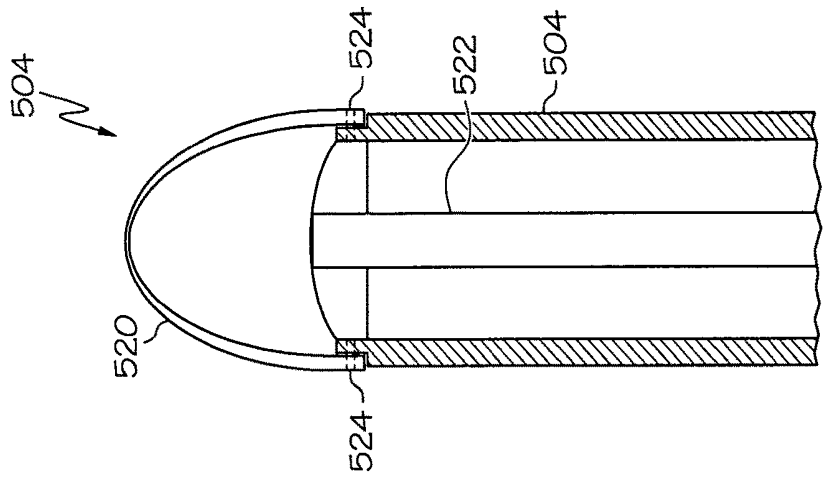


FIG. 46

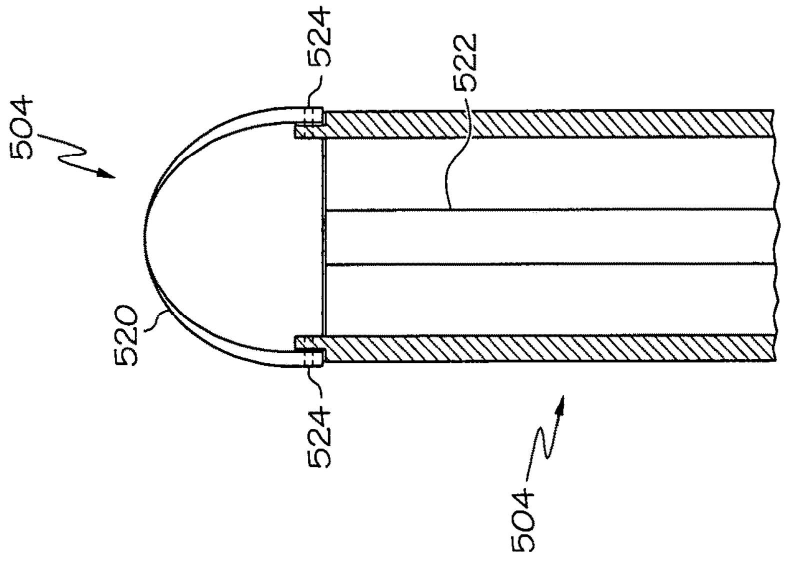


FIG. 45

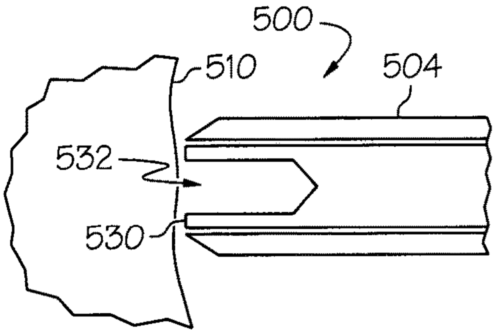


FIG. 47

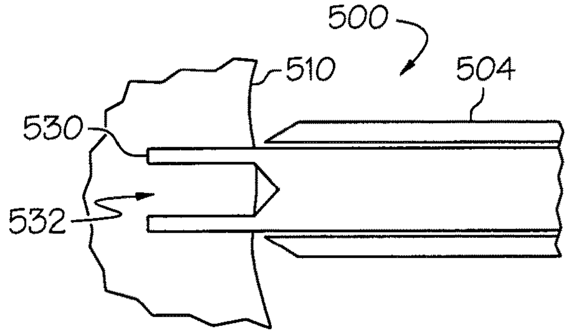


FIG. 48

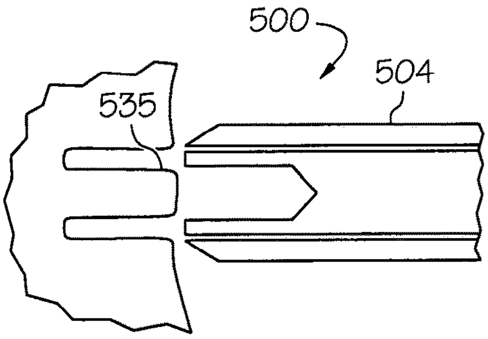


FIG. 49

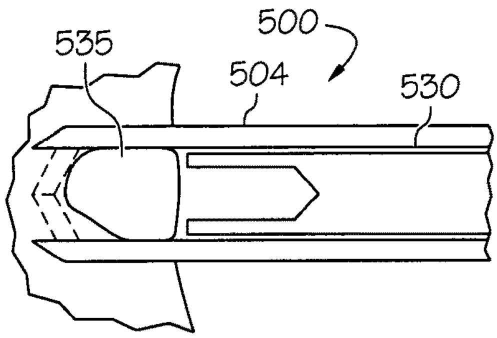


FIG. 50

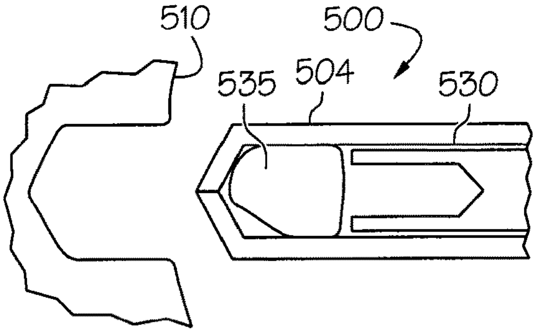
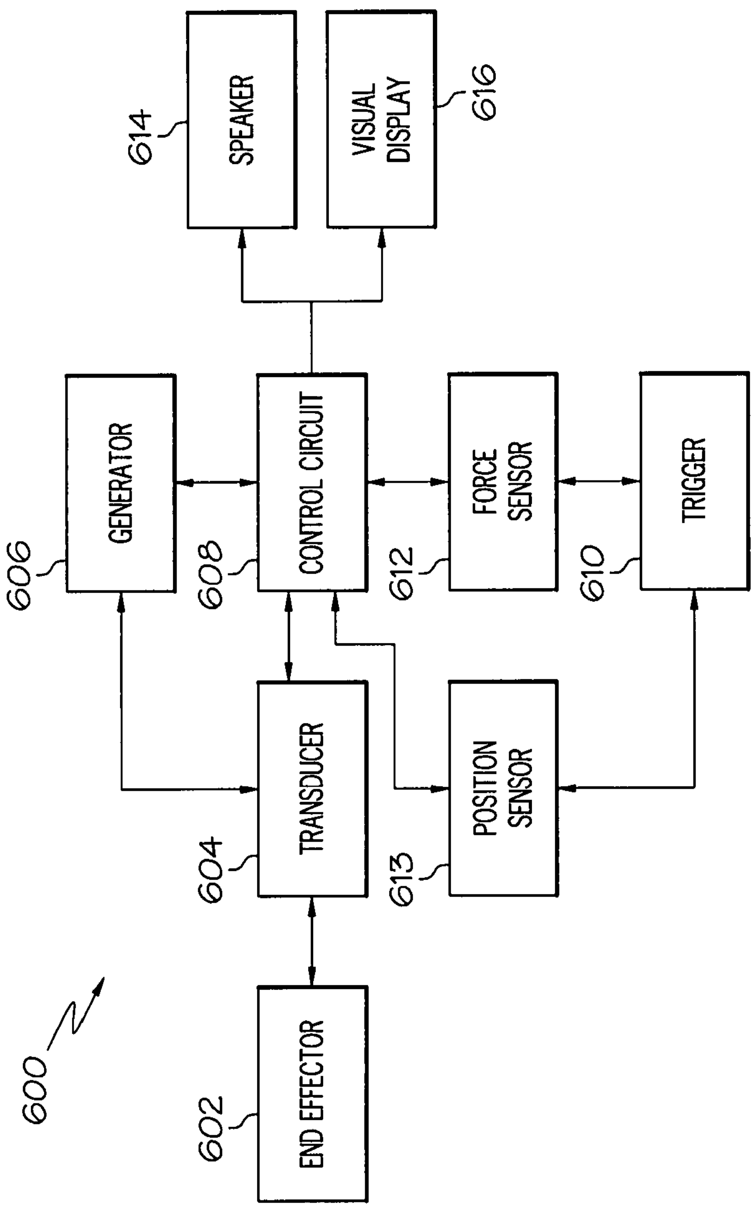


FIG. 51



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END EFFECTOR
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TRANSDUCER
606
GENERATOR
608
CONTROL CIRCUIT
612
FORCE SENSOR
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TRIGGER
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POSITION SENSOR
614
SPEAKER
616
VISUAL DISPLAY

FIG. 52

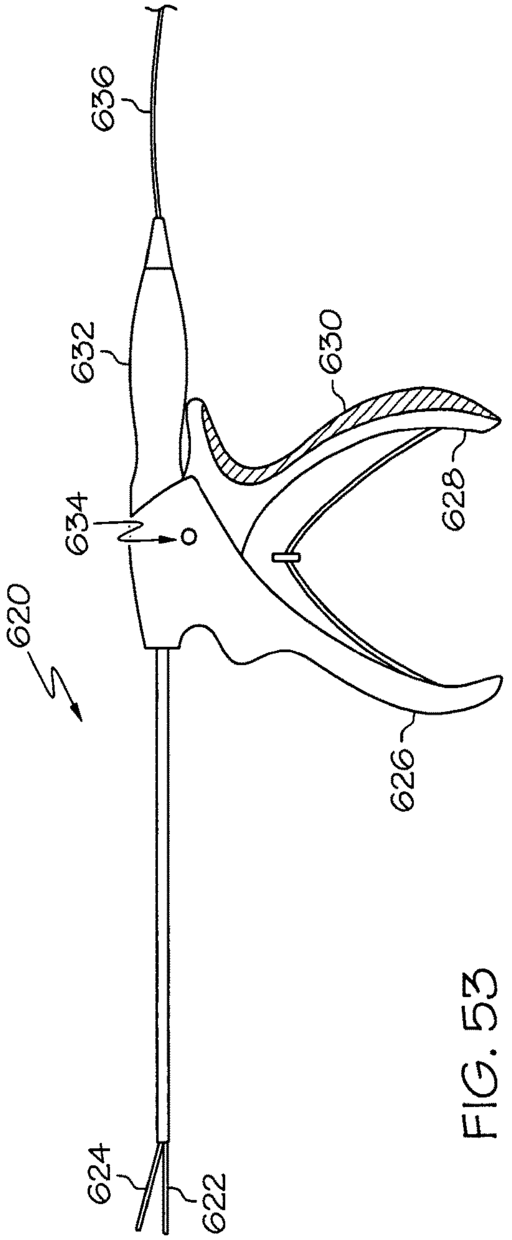

FIG. 53

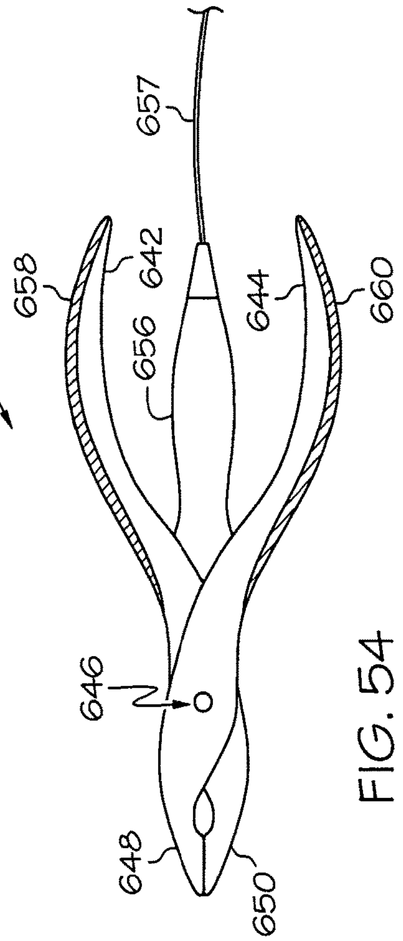

FIG. 54

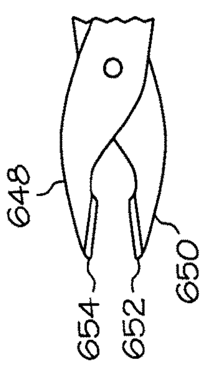

FIG. 55

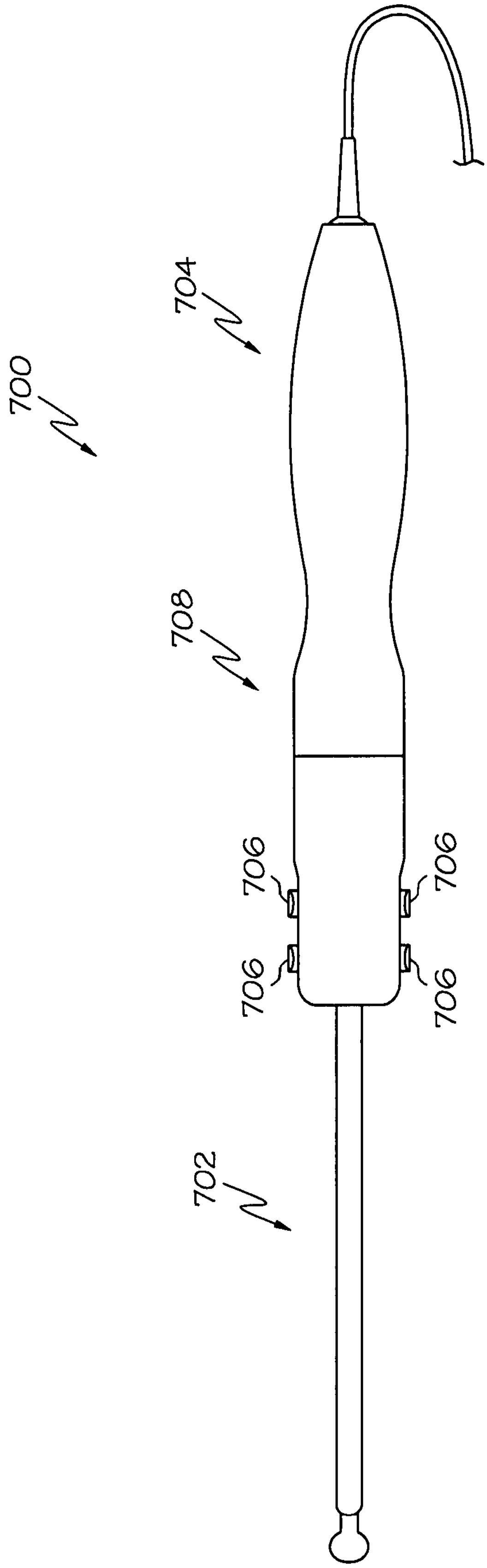

FIG. 56

SURGICAL INSTRUMENTS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation application claiming priority under 35 U.S.C. § 120 to U.S. patent application Ser. No. 14/645,796, entitled SURGICAL INSTRUMENTS, filed Mar. 12, 2015, which issued on Jul. 18, 2017 as U.S. Pat. No. 9,707,004, which is a divisional application claiming priority under 35 U.S.C. § 121 to U.S. patent application Ser. No. 14/444,335, entitled SURGICAL INSTRUMENTS, filed Jul. 28, 2014, which issued on Dec. 29, 2015 as U.S. Pat. No. 9,220,527, which is a divisional application claiming priority under 35 U.S.C. § 121 to U.S. patent application Ser. No. 11/881,602, entitled SURGICAL INSTRUMENTS, filed Jul. 27, 2007, which issued on Aug. 19, 2014 as U.S. Pat. No. 8,808,319, the entire disclosures of which are hereby incorporated by reference herein.

BACKGROUND

Ultrasonic instruments, including both hollow core and solid core instruments, are used for the safe and effective treatment of many medical conditions. Ultrasonic instruments, are advantageous because they may be used to cut and/or coagulate organic tissue using energy in the form of mechanical vibrations transmitted to a surgical end effector at ultrasonic frequencies. Ultrasonic vibrations, when transmitted to organic tissue at suitable energy levels and using a suitable end effector, may be used to cut, dissect, elevate or cauterize tissue or to separate muscle tissue off bone. Such instruments may be used for open procedures or minimally invasive procedures, such as endoscopic or laparoscopic procedures, wherein the end effector is passed through a trocar to reach the surgical site.

Activating or exciting the end effector (e.g., cutting blade) of such instruments at ultrasonic frequencies induces longitudinal vibratory movement that generates localized heat within adjacent tissue, facilitating both cutting and coagulation. Because of the nature of ultrasonic instruments, a particular ultrasonically actuated end effector may be designed to perform numerous functions, including, for example, cutting and coagulation.

Ultrasonic vibration is induced in the surgical end effector by electrically exciting a transducer, for example. The transducer may be constructed of one or more piezoelectric or magnetostrictive elements in the instrument hand piece. Vibrations generated by the transducer section are transmitted to the surgical end effector via an ultrasonic waveguide extending from the transducer section to the surgical end effector. The waveguides and end effectors are designed to resonate at the same frequency as the transducer. Therefore, when an end effector is attached to a transducer the overall system frequency is the same frequency as the transducer itself.

The zero to peak amplitude of the longitudinal ultrasonic vibration at the tip, d, of the end effector behaves as a simple sinusoid at the resonant frequency as given by:

$$d=A\sin(\omega t)$$

where:

ω=the radian frequency which equals 2π times the cyclic frequency, f; and

A=the zero-to-peak amplitude.

The longitudinal excursion is defined as the peak-to-peak (p-t-p) amplitude, which is just twice the amplitude of the sine wave or 2 A.

Ultrasonic surgical instruments may be divided into two types, single element end effector devices and multiple-element end effector devices. Single element end effector devices include instruments such as scalpels and ball coagulators. Single-element end effector instruments have limited ability to apply blade-to-tissue pressure when the tissue is soft and loosely supported. Sometimes, substantial pressure may be necessary to effectively couple ultrasonic energy to the tissue. This inability to grasp the tissue results in a further inability to fully coapt tissue surfaces while applying ultrasonic energy, leading to less-than-desired hemostasis and tissue joining. In these cases, multiple-element end effectors may be used. Multiple-element end effector devices, such as clamping coagulators, include a mechanism to press tissue against an ultrasonic blade that can overcome these deficiencies.

Many surgical procedures utilizing harmonic and non-harmonic instruments create extraneous tissue fragments and other materials at the surgical site. If this material is not removed, it may obstruct the clinician's view and also may interfere with the blade or other end effector of the surgical device. To remove the material, the clinician must remove the instrument from the surgical area and introduce an aspiration tool. This can break the clinician's concentration and also contribute to physical and mental fatigue.

Also, in some surgical procedures, it is desirable to remove a core or other integral portion of tissue. In these procedures, the clinician uses a first instrument to grasp and sometimes cut an outline of the tissue to be removed. Then a second instrument is utilized to remove the tissue from surrounding material, often while the tissue is still grasped by the first instrument. This process may be particularly challenging for clinicians because it can require the use of multiple instruments, often simultaneously. Also, many coring procedures are performed at very delicate portions of the anatomy that require precise cuts.

In addition, existing harmonic instruments allow the clinician to turn them on or off, but provide limited control over the powerdelivered to tissue once the instrument is turned on. This limits the usefulness of harmonic instruments in delicate surgical procedures, where fine cutting control is required.

SUMMARY

In one general aspect, the various embodiments are directed to a surgical device. The surgical device may comprise a transducer configured to provide vibrations along a longitudinal axis and an end effector coupled to the transducer and extending from the transducer along the longitudinal axis. The surgical device also may comprise a lower jaw extending parallel to the end effector. The lower jaw may comprise a clamp face extending toward the longitudinal axis. Also, the lower jaw may be slidable relative to the end effector to bring the clamp face toward a distal end of the end effector.

In another general aspect, the various embodiments are directed to another surgical device comprising an end effector. The end effector may comprise a hollow portion defining a central lumen and at least one member extended across at least a portion of the central lumen at about a distal end of the end effector.

In yet another general aspect, the various embodiments are directed to a surgical device comprising a central instru-

ment and an outer sheath surrounding the central instrument. The central instrument may be configured to engage tissue, and may be slidable relative to the outer sheath. The outer sheath may comprise a distal edge configured to clamp the tissue when the central instrument is slid to a position proximal from the distal edge of the outer sheath.

According to still another general aspect, the various embodiments are directed to a surgical device comprising a transducer configured to energize an end effector and a trigger actuable to cause the end effector to be energized. The end effector may be coupled to the transducer. The surgical device may further comprise a sensor positioned to sense a force exerted on the trigger, and control circuit in communication with the sensor. The control circuit may be configured to increase power delivered to the end effector by the transducer in response to an increase of the force exerted on the trigger.

FIGURES

The novel features of the various embodiments are set forth with particularity in the appended claims. The various embodiments, however, both as to organization and methods of operation, together with further objects and advantages thereof, may best be understood by reference to the following description, taken in conjunction with the accompanying drawings as follows.

FIG. **1** illustrates one embodiment of a surgical system including a surgical instrument and an ultrasonic generator;

FIG. **2** illustrates one embodiment of the surgical instrument shown in FIG. **1**;

FIG. **3** illustrates an exploded view of one embodiment the surgical instrument shown in FIG. **1**;

FIG. **4** illustrates one embodiment of a clamping mechanism that may be used with the surgical instrument shown in FIG. **1**;

FIG. **5** illustrates a cut-away view of one embodiment of the surgical instrument shown in FIG. **1**;

FIG. **6** illustrates various internal components of one embodiment of the surgical instrument shown in FIG. **1**;

FIG. **7** illustrates one embodiment of a drive yoke of the surgical instrument shown in FIG. **1**;

FIG. **8** illustrates one embodiment of a drive collar of the surgical instrument shown in FIG. **1**;

FIG. **9** illustrates one embodiment of a surgical system including a surgical instrument having single element end effector;

FIG. **10** illustrates one embodiment of a surgical device;

FIGS. **11-12** illustrate exploded views of one embodiment of the surgical device shown in FIG. **10**;

FIG. **13** illustrates a side view of one embodiment of the surgical device shown in FIG. **10** with the blade and clamp face separated from one another;

FIG. **14** illustrates a distal portion of one embodiment of the surgical device shown in FIG. **10** with the blade and clamp face separated from one another;

FIG. **15** illustrates a side view of one embodiment of the surgical device shown in FIG. **10** with the blade and clamp face translated toward one another;

FIG. **16** illustrates a distal portion of one embodiment of the surgical device shown in FIG. **10** with the blade and clamp face translated toward one another;

FIGS. **17-18** illustrate one embodiment of a lower jaw and outer sheath of the surgical device shown in FIG. **10**;

FIGS. **19-20** illustrate a handle region of one embodiment of the surgical device shown in FIG. **10**;

FIG. **20**A illustrates one embodiment of the surgical device shown in FIG. **10**;

FIG. **20**B illustrates one embodiment of the surgical device shown in FIG. **20**A where the end effector is configured to rotate as it moves forward toward the clamp face;

FIG. **21** illustrates a distal portion of one embodiment of the surgical device shown in FIG. **10** including a blade defining a hollow lumen;

FIG. **22** illustrates one embodiment of the blade shown in FIG. **21**;

FIG. **23** illustrates a distal portion of one embodiment of the surgical device shown in FIG. **10** including a blade defining a hollow lumen and having members extending across the hollow lumen;

FIG. **24** illustrates one embodiment of the blade shown in FIG. **23**;

FIG. **25** illustrates a distal portion of one embodiment of the surgical device shown in FIG. **10** including a jaw member defining a lumen;

FIG. **26** illustrates one embodiment of a blade for use with the surgical device as shown in FIG. **25**;

FIG. **26**A illustrates an additional embodiment of the blade of FIG. **26** having cutting members positioned within a cavity of the blade.

FIG. **27** illustrates a distal portion of one embodiment of the surgical device shown in FIG. **10**;

FIG. **28** illustrates a distal portion of one embodiment of the surgical device shown in FIG. **10** including a plug feature received into a hollow lumen of the end effector;

FIG. **28**A illustrates one embodiment of the surgical device of FIG. **10** including a rotating end effector;

FIG. **28**B illustrates one embodiment of an electric motor for use with the surgical device of FIG. **28**A.

FIG. **28**C illustrates one embodiment of the surgical device of FIG. **28**A having an angled blade;

FIG. **29** illustrates one embodiment of a hollow core end effector comprising members extending across a lumen;

FIG. **30** illustrates one embodiment of a hollow core end effector comprising members extending across a lumen;

FIG. **31** illustrates a cut away view of one embodiment of the hollow core end effector shown in FIG. **30**;

FIG. **31**A illustrates one embodiment of a hollow core end effector having angled members;

FIG. **32** illustrates one embodiment of an end effector having a non-integral blade;

FIG. **33** illustrates one embodiment of an end effector having a member extended across a lumen and edges extending beyond the member;

FIG. **34** illustrates one embodiment of an end effector having an inter-lumen member positioned non-parallel to a longitudinal axis of the end effector;

FIG. **35** illustrates one embodiment of an end effector having a multi-section inter-lumen member;

FIG. **36** illustrates one embodiment of an end effector having inter-lumen members extending distally;

FIG. **37** illustrates one embodiment of a surgical device comprising a central instrument and an outer sheath;

FIG. **38** illustrates one embodiment of the surgical device shown in FIG. **37** where the central instrument is grasping tissue;

FIG. **39** illustrates one embodiment of the surgical device shown in FIG. **37** where the outer sheath has clamped the tissue;

FIG. **40** illustrates one embodiment of the surgical device shown in FIG. **37** where the tissue has been severed;

FIGS. **41-42** illustrate one embodiment of the surgical device shown in FIG. **37** where the outer sheath comprises edge members;

FIGS. **43** and **45** illustrate one embodiment of the outer sheath of the device shown in FIG. **37** comprising a pair of jaw members in an open position;

FIGS. **44** and **46** illustrate one embodiment of the outer sheath of the device shown in FIG. **37** where the jaw members are in a closed position;

FIG. **47** illustrates one embodiment of another surgical device having a central instrument and an outer sheath;

FIG. **48** illustrates one embodiment of the surgical instrument of FIG. **47** where the central instrument is extended into tissue;

FIG. **49** illustrates one embodiment of the surgical instrument of FIG. **47** where the central instrument has been retracted from the tissue;

FIG. **50** illustrates one embodiment of the surgical instrument of FIG. **47** where the outer sheath has been extended into the tissue;

FIG. **51** illustrates one embodiment of the surgical instrument of FIG. **47** where the outer sheath has been retracted from the tissue;

FIG. **52** illustrates a block diagram of one embodiment of a surgical device;

FIG. **53** illustrates one embodiment of a surgical device;

FIG. **54** illustrates one embodiment of a surgical device;

FIG. **55** illustrates a distal portion of one embodiment of the surgical device shown in FIG. **54**; and

FIG. **56** illustrates one embodiment of a surgical device **700** comprising a hand-piece adapter.

DESCRIPTION

Before explaining the various embodiments in detail, it should be noted that the embodiments are not limited in application or use to the details of construction and arrangement of parts illustrated in the accompanying drawings and description. The illustrative embodiments may be implemented or incorporated in other embodiments, variations and modifications, and may be practiced or carried out in various ways. For example, the surgical instruments and blade configurations disclosed below are illustrative only and not meant to limit the scope or application thereof. Also, the blade and end effector designs described hereinbelow may be used in conjunction with any suitable device. Furthermore, unless otherwise indicated, the terms and expressions employed herein have been chosen for the purpose of describing the illustrative embodiments for the convenience of the reader and are not to limit the scope thereof.

Examples of ultrasonic surgical instruments and blades are disclosed in U.S. Pat. Nos. 5,322,055 and 5,954,736, 6,309,400 B2, 6,278,218 B1, 6,283,981 B1, and 6,325,811 B1, which are incorporated herein by reference in their entirety. These references disclose ultrasonic surgical instrument designs and blade designs where a longitudinal mode of the blade is excited. The result is a longitudinal standing wave within the instrument. Accordingly, the instrument has nodes, where the transverse motion is equal to zero, and anti-nodes, where the transverse motion is at its maximum. The instrument's tissue end effector is often positioned at an anti-node to maximize its longitudinal motion.

Various embodiments will now be described to provide an overall understanding of the principles of the structure, function, manufacture, and use of the devices and methods disclosed herein. One or more examples of these embodiments are illustrated in the accompanying drawings. Those of ordinary skill in the art will understand that the devices and methods specifically described herein and illustrated in the accompanying drawings are non-limiting embodiments and that the scope of the various embodiments is defined solely by the claims. The features illustrated or described in connection with one embodiment may be combined with the features of other embodiments. Such modifications and variations are intended to be included within the scope of the claims.

It will be appreciated that the terms "proximal" and "distal" are used herein with reference to a clinician gripping a surgical device at its hand piece assembly, or other comparable piece. Thus, the end effector is distal with respect to the more proximal hand piece assembly. It will be further appreciated that, for convenience and clarity, spatial terms such as "top" and "bottom" also are used herein with respect to the clinician gripping the hand piece assembly, or comparable piece. However, surgical instruments are used in many orientations and positions, and these terms are not intended to be limiting and absolute.

FIG. **1** illustrates one embodiment of a surgical system including a surgical instrument and an ultrasonic generator. FIG. **2** illustrates one embodiment of the apparatus shown in FIG. **1**. In the embodiment illustrated in FIGS. **1-2**, the surgical system **10** includes an ultrasonic clamp coagulator instrument **120** and an ultrasonic generator **30**. The surgical instrument **120** includes an ultrasonic drive unit **50**. As will be further described, an ultrasonic transducer of the drive unit **50**, and an ultrasonic end effector **180** of the clamp instrument **120**, together provide an acoustic assembly of the surgical system **10**, with the acoustic assembly providing ultrasonic energy for surgical procedures when powered by generator **30**. It will be noted that, in some applications, the ultrasonic drive unit **50** is referred to as a "hand piece assembly" because the surgical instrument **120** of the surgical system **10** is configured such that a clinician grasps and manipulates the ultrasonic drive unit **50** during various procedures and operations. The instrument **120** may include a scissors-like grip arrangement which facilitates positioning and manipulation of the instrument **120** apart from manipulation of the ultrasonic drive unit **50**.

The generator **30** of the surgical system **10** sends an electrical signal through a cable **32** at a selected excursion, frequency, and phase determined by a control system of the generator **30**. As will be further described, the signal causes one or more piezoelectric elements of the acoustic assembly of the surgical instrument **120** to expand and contract along a longitudinal axis, thereby converting the electrical energy into mechanical motion. The mechanical motion results in longitudinal waves of ultrasonic energy that propagate through the acoustic assembly in an acoustic standing wave to vibrate the acoustic assembly at a selected frequency and excursion. The end effector **180** is placed in contact with tissue of the patient to transfer the ultrasonic energy to the tissue. For example, a distal portion of blade **180'** of the end effector may be placed in contact with the tissue. As further described below, a surgical tool, such as, a jaw or clamping mechanism, may be utilized to press the tissue against the blade **180'**.

As the end effector **180** couples with the tissue, thermal energy or heat is generated as a result of friction, acoustic absorption, and viscous losses within the tissue. The heat is sufficient to break protein hydrogen bonds, causing the highly structured protein (e.g., collagen and muscle protein) to denature (e.g., become less organized). As the proteins are denatured, a sticky coagulum forms to seal or coagulate small blood vessels. Deep coagulation of larger blood vessels results when the effect is prolonged.

The transfer of the ultrasonic energy to the tissue causes other effects including mechanical tearing, cutting, cavitation, cell disruption, and emulsification. The amount of cutting as well as the degree of coagulation obtained varies with the excursion of the end effector **180**, the frequency of vibration, the amount of pressure applied by the user, the sharpness of the end effector **180**, and the coupling between the end effector **180** and the tissue.

In the embodiment illustrated in FIG. **1**, the generator **30** includes a control system integral with the generator **30**, a power switch **34**, and a triggering mechanism **36**. The power switch **34** controls the electrical power to the generator **30**, and when activated by the triggering mechanism **36**, the generator **30** provides energy to drive the acoustic assembly of the surgical system **10** frequency and to drive the end effector **180** at a predetermined excursion level. The generator **30** drives or excites the acoustic assembly at any suitable resonant frequency of the acoustic assembly.

When the generator **30** is activated via the triggering mechanism **36**, electrical energy is continuously applied by the generator **30** to a transducer stack or assembly **40** of the acoustic assembly. A phase-locked loop in the control system of the generator **30** monitors feedback from the acoustic assembly. The phase lock loop adjusts the frequency of the electrical energy sent by the generator **30** to match the resonant frequency of the selected longitudinal mode of vibration of the acoustic assembly. In addition, a second feedback loop in the control system maintains the electrical current supplied to the acoustic assembly at a pre-selected constant level in order to achieve substantially constant excursion at the end effector **180** of the acoustic assembly.

The electrical signal supplied to the acoustic assembly will cause the distal end of the end effector **180**, e.g., the blade **180'**, to vibrate longitudinally in the range of, for example, approximately 20 kHz to 250 kHz. According to various embodiments, the blade **180'** may vibrate in the range of about 54 kHz to 56 kHz, for example, at about 55.5 kHz. In other embodiments, the blade **180'** may vibrate at other frequencies including, for example, about 31 kHz or about 80 kHz. The excursion of the vibrations at the blade can be controlled by, for example, controlling the amplitude of the electrical signal applied to the transducer assembly **40** of the acoustic assembly by the generator **30**.

As noted above, the triggering mechanism **36** of the generator **30** allows a user to activate the generator **30** so that electrical energy may be continuously supplied to the acoustic assembly. The triggering mechanism **36** may comprise a foot activating switch that is detachably coupled or attached to the generator **30** by a cable or cord. Alternatively, the triggering mechanism can be configured as a hand switch incorporated in the ultrasonic drive unit **50** to allow the generator **30** to be activated by a user.

The generator **30** also has a power line **38** for insertion in an electro-surgical unit or conventional electrical outlet. It is contemplated that the generator **30** can also be powered by a direct current (DC) source, such as a battery. The generator **30** can comprise any suitable generator, such as Model No. GEN04, available from Ethicon Endo-Surgery, Inc.

In the embodiment illustrated in FIGS. **1** and **3**, the ultrasonic drive unit **50** of the surgical instrument includes a multi-piece housing **52** adapted to isolate the operator from the vibrations of the acoustic assembly. The drive unit housing **52** can be shaped to be held by a user in a conventional manner, but it is contemplated that the present clamp coagulator instrument **120** principally be grasped and manipulated by a scissors-like arrangement provided by a housing of the apparatus, as will be described. While the multi-piece housing **52** is illustrated, the housing **52** may comprise a single or unitary component.

The housing **52** of the ultrasonic drive unit **50** generally includes a proximal end, a distal end, and a cavity extending longitudinally therein. The distal end of the housing **52** includes an opening **60** configured to allow the acoustic assembly of the surgical system **10** to extend therethrough, and the proximal end of the housing **52** is coupled to the generator **30** by the cable **32**. The cable **32** may include ducts or vents **62** to allow air or other fluids to be introduced into the housing **52** of the ultrasonic drive unit **50** to cool the transducer assembly **40** of the acoustic assembly.

The housing **52** of the ultrasonic drive unit **50** may be constructed from a durable plastic, such as ULTEM®. It is also contemplated that the housing **52** may alternatively be made from a variety of materials including other plastics (e.g. liquid crystal polymer (LCP), nylon, or polycarbonate) and/or metals (e.g., aluminum, steel, etc.). A suitable ultrasonic drive unit **50** is Model No. HP054, available from Ethicon Endo-Surgery, Inc.

The acoustic assembly of the surgical instrument generally includes a first acoustic portion and a second acoustic portion. The first acoustic portion may be carried by the ultrasonic drive unit **50**, and the second acoustic portion (in the form of an end effector **180**, as will be described) is carried by the ultrasonic clamp coagulator **120**. The distal end of the first acoustic portion is operatively coupled to the proximal end of the second acoustic portion, preferably by a threaded connection.

In the embodiment illustrated in FIG. **2**, the first acoustic portion includes the transducer stack or assembly **40** and a mounting device **84**, and the second acoustic portion includes the end effector **180**. The end effector **180** may in turn comprise a transmission component, or waveguide **181** (FIG. **3**), as well as a distal portion, or blade **180'**, for interfacing with tissue.

The components of the acoustic assembly may be acoustically tuned such that the length of each component is an integral number of one-half wavelengths ($n\lambda/2$), where the wavelength λ is the wavelength of a pre-selected or operating longitudinal vibration frequency f_0 of the acoustic assembly, and n is any non-negative integer. It is also contemplated that the acoustic assembly may incorporate any suitable arrangement of acoustic elements.

The transducer assembly **40** of the acoustic assembly converts the electrical signal from the generator **30** into mechanical energy that results in longitudinal vibratory motion of the end effector **180** at ultrasonic frequencies. When the acoustic assembly is energized, a vibratory motion standing wave is generated through the acoustic assembly. The excursion of the vibratory motion at any point along the acoustic assembly depends on the location along the acoustic assembly at which the vibratory motion is measured. A minimum or zero crossing in the vibratory motion standing wave is generally referred to as a node (e.g., where motion is usually minimal), and a local absolute value maximum or peak in the standing wave is generally referred to as an anti-node. The distance between an anti-node and its nearest node is one-quarter wavelength ($\lambda/4$).

In the embodiment illustrated in FIG. **2**, the transducer assembly **40** of the acoustic assembly, which is also known as a "Langevin stack", generally includes a transduction portion **90**, a first resonator **92**, and a second resonator **94**. The transducer assembly **40** may be an integral number of one-half system wavelengths ($n\lambda/2$) in length. It is to be understood that other embodiments of the transducer assembly **40** may comprise a magnetostrictive, electromagnetic or electrostatic transducer.

The distal end of the first resonator **92** is connected to the proximal end of transduction section **90**, and the proximal end of the second resonator **94** is connected to the distal end of transduction portion **90**. The first and second resonators **92** and **94** may be fabricated from titanium, aluminum, steel, or any other suitable material, and most preferably, the first resonator **92** is fabricated from 303 stainless steel and the second resonator **94** is fabricated from 7075-T651 Aluminum. The first and second resonators **92** and **94** have a length determined by a number of variables, including the length of the transduction section **90**, the speed of sound of material used in the resonators **92** and **94**, and the desired fundamental frequency f_0 of the transducer assembly **40**. The second resonator **94** can be tapered inwardly from its proximal end to its distal end to function as a velocity transformer and amplify the ultrasonic vibration excursion.

The transduction portion **90** of the transducer assembly **40** may comprise a piezoelectric section of alternating positive electrodes **96** and negative electrodes **98**, with the piezoelectric elements **100** alternating between the electrodes **96** and **98**. The piezoelectric elements **100** can be fabricated from any suitable material, such as, for example, lead zirconate-titanate, lead metaniobate, lead titanate, or other piezoelectric material. Each of the positive electrodes **96**, negative electrodes **98**, and piezoelectric elements **100** have a bore extending through the center. The positive and negative electrodes **96** and **98** are electrically coupled to wires **102** and **104**, respectfully. The wires **102** and **104** transmit the electrical signal from the generator **30** to the electrodes **96** and **98**.

The piezoelectric elements **100** may be held in compression between the first and second resonators **92** and **94** by a bolt **106**. The bolt **106** may have a head, a shank, and a threaded distal end. The bolt **106** may be inserted from the proximal end of the first resonator **92** through the bores of the first resonator **92**, the electrodes **96** and **98**, and piezoelectric elements **100**. The threaded distal end of the bolt **106** is screwed into a threaded bore in the proximal end of second resonator **94**. The bolt **106** may be fabricated from steel, titanium, aluminum, or other suitable material. For example, the bolt **106** may be fabricated from Ti-6Al-4V Titanium or from 4037 low alloy steel.

The piezoelectric elements **100** may be energized in response to the electrical signal supplied from the generator **30** to produce an acoustic standing wave in the acoustic assembly. The electrical signal causes an electromagnetic field across the piezoelectric elements **100**, causing the piezoelectric elements **100** to expand and contract in a continuous manner along the longitudinal axis of the voltage gradient, producing high frequency longitudinal waves of ultrasonic energy. The ultrasonic energy is transmitted through the acoustic assembly to the end effector **180**.

The mounting device **84** of the acoustic assembly has a proximal end, a distal end, and may have a length substantially equal to an integral number of one-half system wavelengths (nλ/2). The proximal end of the mounting device **84** may be axially aligned and coupled to the distal end of the second resonator **94** by an internal threaded connection near an anti-node. It is also contemplated that the mounting device **84** may be attached to the second resonator **94** by any suitable means, and the second resonator **94** and mounting device **84** may be formed as a single or unitary component.

The mounting device **84** is coupled to the housing **52** of the ultrasonic drive unit **50** near a node. The mounting device **84** may include an integral mounting flange **108** disposed around its periphery. The mounting flange **108** may be disposed in an annular groove **110** formed in the housing **52** of the ultrasonic drive unit **50** to couple the mounting device **84** to the housing **52**. A compliant member or material **112**, such as a pair of silicone rubber O-rings attached by stand-offs, may be placed between the annular groove **110** of the housing **52** and the integral flange **108** of the mounting device **86** to reduce or prevent ultrasonic vibration from being transmitted from the mounting device **84** to the housing **52**.

The mounting device **84** may be secured in a predetermined axial position by a plurality of pins **114**, for example, four. The pins **114** are disposed in a longitudinal direction ninety (90) degrees apart from each other around the outer periphery of the mounting device **84**. The pins **114** are coupled to the housing **52** of the ultrasonic drive unit **50** and are disposed through notches in the acoustic mounting flange **108** of the mounting device **84**. The pins **114** may be fabricated from stainless steel. According to various embodiments, the pins **114** may be formed as integral components of the housing **52**.

The mounting device **84** may be configured to amplify the ultrasonic vibration excursion that is transmitted through the acoustic assembly to the distal end of the end effector **180**. In one embodiment, the mounting device **84** comprises a solid, tapered horn. As ultrasonic energy is transmitted through the mounting device **84**, the velocity of the acoustic wave transmitted through the mounting device **84** is amplified. It is contemplated that the mounting device **84** be configured as any suitable shape, such as, for example, a stepped horn, a conical horn, an exponential horn, a unitary gain horn, or the like.

The mounting device **84** may be acoustically coupled to the second acoustic portion of the ultrasonic clamp coagulator instrument **120**. The distal end of the mounting device **84** may be coupled to the proximal end of the second acoustic portion by an internal threaded connection near an anti-node, but alternative coupling arrangements can be employed.

FIG. **3** illustrates an exploded view of one embodiment the surgical instrument shown in FIG. **1**. The proximal end of the ultrasonic clamp coagulator instrument **120** preferably receives and is fitted to the distal end of the ultrasonic drive unit **50** by insertion of the drive unit **50** into the housing **52**, as shown in FIG. **2**. The ultrasonic clamp coagulator instrument **120** may be attached to and removed from the ultrasonic drive unit **50** as a unit. The ultrasonic clamp coagulator **120** may be disposed of after a single use.

The ultrasonic clamp coagulator instrument **120** may include a handle assembly or a housing **130**, which may comprise mating housing portions **131**, **132**, and an elongated or endoscopic portion **150**. When the present apparatus is configured for endoscopic use, the construction can be dimensioned such that portion **150** has an outside diameter of about 5.5 mm. The elongated portion **150** of the ultrasonic clamp coagulator instrument **120** may extend substantially orthogonally from the apparatus housing **130**. The elongated portion **150** can be selectively rotated with respect to the housing **130** as described below. The elongated portion **150** may include an outer tubular member or sheath **160**, an inner tubular actuating member **170**, and the second acoustic portion of the acoustic system in the form of an end effector **180** including a blade **180'**. As will be described, the outer sheath **160**, the actuating member **170**, and the end effector

180 may be joined together for indexed rotation as a unit (together with ultrasonic drive unit **50**) relative to housing **130**.

The proximal end of the end effector **180** of the second acoustic portion may be detachably coupled to the mounting device **84** of the ultrasonic drive unit **50** near an anti-node as described above. The end effector **180** may have a length substantially equal to an integer number of one-half system wavelengths ($n\lambda/2$). The end effector **180** may be fabricated from a solid core shaft constructed out of material which propagates ultrasonic energy efficiently, such as a titanium alloy (e.g., Ti-6Al-4V) or an aluminum alloy. It is contemplated that the end effector **180** can alternatively be fabricated from any other suitable material.

As described, the end effector **180** may include a waveguide **181**. The waveguide **181** may be substantially semi-flexible. It will be recognized that the waveguide **181** can alternatively be substantially rigid or may comprise a flexible wire. The waveguide **181** may be configured to amplify the mechanical vibrations transmitted through the waveguide to the blade as is well known in the art. The waveguide **181** may further have features to control the gain of the longitudinal vibration along the waveguide **181** and features to tune the waveguide to the resonant frequency of the system.

It will be recognized that the end effector **180** may have any suitable cross-sectional dimension. For example, the end effector **180** may have a substantially uniform cross-section or the end effector **180** may be tapered at various sections or may be tapered along its entire length.

Referring now to FIG. **3**, the waveguide **181** portion of the end effector **180** is shown to comprise a first section **182**, a second section **184**, and a third section **186**. The first section **182** of may extend distally from the proximal end of the end effector **180**, and has a substantially continuous cross-section dimension. The first section **182** may include at least one radial hole or aperture **188** extending diametrically therethrough, substantially perpendicular to the axis of the end effector **180**. The aperture **188** may be positioned at a node, but may be otherwise positioned. It will be recognized that the aperture **188** may have any suitable depth and may be any suitable shape. The aperture **188** is configured to receive a connector pin member which connects the wave guide **181**, the tubular actuating member **170**, and the tubular outer sheath **160** together for conjoint, indexed rotation relative to apparatus housing **130**.

The second section **184** of the wave guide **181** extends distally from the first section **182**. The second section **184** preferably also has a substantially continuous cross-section. The diameter of the second section **184** may be smaller than the diameter of the first section **182** and larger than the diameter of the third section **186**. As ultrasonic energy passes from the first section **182** of the end effector **180** into the second section **184**, narrowing of the second section **184** will result in an increased amplitude of the ultrasonic energy passing therethrough.

The third section **186** extends distally from the distal end of the second section **184**. The third section **186** also has a substantially continuous cross-section. The third section **186** also may include small diameter changes along its length. According to various embodiments, the transition from the second section **184** to the third section **186** may be positioned at an anti-node so that the diameter change in the third section does not bring about an increase in the amplitude of vibration.

The third section **186** may have a plurality of grooves or notches (not shown) formed in its outer circumference. The grooves may be located at nodes of the end effector **180** to act as alignment indicators for the installation of a damping sheath (not shown) and stabilizing silicone rings or compliant supports during manufacturing. A seal may be provided at the distal-most node, nearest the blade **180'**, to abate passage of tissue, blood, and other material in the region between the waveguide and actuating member **170**.

The blade **180'** of the end effector **180** may be integral therewith and formed as a single unit. The blade **180'** may alternately be connected by a threaded connection, or by a welded joint. According to various embodiments, the blade **180'** may be mechanically sharp or mechanically blunt. The distal end of the blade **180'** is disposed near an anti-node in order to tune the acoustic assembly to a preferred resonant frequency f_0 when the acoustic assembly is not loaded by tissue. When the transducer assembly is energized, the distal end of the blade **180'** is configured to move longitudinally in the range of, for example, approximately 10-500 microns peak-to-peak, and preferably in the range of about 10 to about 100 microns at a predetermined vibrational frequency f_0.

In accordance with the illustrated embodiment, the blade **180'** may be cylindrical for cooperation with the associated clamping mechanism of the clamp coagulator **120**. The end effector **180** may receive suitable surface treatment, as is known in the art.

FIG. **4** illustrates one embodiment of a clamping mechanism that may be used with the surgical instrument shown in FIG. **1**. The clamping mechanism may be configured for cooperative action with the blade **180'** of the end effector **180**. The clamping mechanism includes a pivotally movable clamp arm **190**, which is pivotally connected at the distal end thereof to the distal end of outer tubular sheath **160**. The clamp arm **190** includes a clamp arm tissue pad **192**, preferably formed from TEFLON® or other suitable low-friction material, which is mounted for cooperation with the blade **180'**, with pivotal movement of the clamp arm **190** positioning the clamp pad **192** in substantially parallel relationship to, and in contact with, the blade **180'**. By this construction, tissue to be clamped is grasped between the tissue pad **192** and the blade **180'**. The tissue pad **192** may be provided with a sawtooth-like configuration including a plurality of axially spaced, proximally extending gripping teeth **197** to enhance the gripping of tissue in cooperation with the blade **180'**.

Pivotal movement of the clamp arm **190** with respect to the blade **180'** is effected by the provision of at least one, and preferably a pair of lever portions **193** of the clamp arm **190** at the proximal end thereof. The lever portions **193** are positioned on respective opposite sides of the end effector **180** and blade **180'**, and are in operative engagement with a drive portion **194** of the reciprocal actuating member **170**. Reciprocal movement of the actuating member **170**, relative to the outer tubular sheath **160** and the end effector **180**, thereby effects pivotal movement of the clamp arm **190** relative to the blade **180'**. The lever portions **193** can be respectively positioned in a pair of openings defined by the drive portion **194**, or otherwise suitably mechanically coupled therewith, whereby reciprocal movement of the actuating member **170** acts through the drive portion **194** and lever portions **193** to pivot the clamp arm **190**.

FIG. **5** illustrates a cut-away view of one embodiment of the surgical instrument shown in FIG. **1**, while FIG. **6** illustrates various internal components of one embodiment of the surgical instrument shown in FIG. **1**. FIG. **7** illustrates one embodiment of a drive yoke, and FIG. **8** illustrates one embodiment of a drive collar of the surgical instrument shown in FIG. **1**. In the embodiment illustrated in FIGS. **3** and **5-8**, reciprocal movement of the actuating member **170** is effected by the provision of a drive collar **200** mounted on the proximal end of the actuating member **170** for conjoint rotation. The drive collar **200** may include a pair of diametrically opposed axially extending arms **202** each having a drive lug **204**, with the drive lugs **204** being biased by the arms **202** into engagement with suitable openings **206** defined by the proximal portion of tubular actuating member **170**. Rotation of the drive collar **200** together with the actuating member **170** is further effected by the provision of a pair of keys **208** diametrically engageable with suitable openings **210** defined by the proximal end of the actuating member **170**. A circumferential groove **211** on the actuating member **170** receives an O-ring **211'** (FIG. **3**) for engagement with the inside surface of outer sheath **160**.

Rotation of the actuating member **170** together with the tubular outer sheath **160** and inner end effector **180** is provided by a connector pin **212** extending through these components of the instrument **120**. The tubular actuating member **170** defines an elongated slot **214** through which the connector pin **212** extends to accommodate reciprocal movement of the actuating member relative to the outer tubular sheath and inner waveguide.

A rotation knob **216** mounted on the outer tubular sheath facilitates rotational positioning of the elongated portion **150** with respect to the housing **130** of the clamp coagulator instrument **120**. Connector pin **212** preferably joins the knob **216** together with the sheath **160**, member **170**, and the end effector **180** for rotation as a unit relative to the housing **130**. In the embodiment, hub portion **216'** of the rotation knob **216** acts to rotatably mount the outer sheath **160**, the actuating member **170**, and the end effector **180** (as a unit with the knob **216**), on the housing **130**.

The drive collar **200** provides a portion of the clamp drive mechanism of the instrument **120**, which effects pivotal movement of the clamp arm **190** by reciprocation of the actuating member **170**. The clamp drive mechanism further includes a drive yoke **220** which is operatively connected with an operating lever **222**, with the operating lever thus interconnected with the reciprocal actuating member **170** via drive yoke **220** and drive collar **200**. The operating lever **222** is pivotally connected to the housing **130** of the apparatus (by a pivot mount **223**) for cooperation in a scissors-like fashion with a handgrip portion **224** of the housing. Movement of the lever **222** toward the handgrip portion **224** translates the actuating member **170** proximally, thereby pivoting the clamp arm **190** toward the blade **180'**.

Operative connection of the drive yoke **220** with the operating lever **222** is provided by a spring **226**, preferably comprising a compression coil spring **226**. The spring **226** fits within a spring slot **228** defined by the drive yoke **220**, which in turn is positioned between a pair of spring retainer flanges **230** of the operating lever **222**. The drive yoke **220** is pivotally movable with respect to the spring flanges **230** (about pivot mount **223** of housing **130**) in opposition to the compression coil spring, which bears against the surfaces of the spring slots defined by each of the spring flanges **230**. In this manner, the force which can be applied to the actuating member **170**, by pivotal movement of the operating lever **222** acting through the drive yoke **220** and the drive collar **200**, is limited by the force with which the spring **226** bears against the spring flanges **230**. Application of excessive force results in pivotal displacement of the drive yoke **220** relative to the spring flanges **230** of the operating lever **222** in opposition to spring **226**. Stop portions of the housing **130** limit the travel of the operating lever **222** to prevent excessive compression of spring **226**. In various embodiments, the force applied to the actuating member **170** may be limited by one or more springs (not shown) operatively positioned between the drive collar **200** and the member **170**. For example, one or more cylindrical springs, such as a wave springs, may be used. An example embodiment utilizing a wave spring in this manner is described in U.S. Pat. No. 6,458,142, which is incorporated herein by reference.

Indexed rotational positioning of the elongated portion **150** of the present clamp coagulator instrument **120** may be provided by the provision of a detent mechanism incorporated into the clamp drive mechanism of the instrument **120**. Specifically, the drive collar **200** may include a pair of axially spaced apart drive flanges **232**. A detent-receiving surface may be provided between the drive flanges **232**, and may define a plurality of circumferentially spaced teeth **234**. The teeth **234** may define detent-receiving depressions generally about the periphery of the drive collar **200**. In the embodiment illustrated in FIG. **7**, twelve (12) of the teeth **234** are provided, thereby providing indexed positioning of the elongated portion **150** of the apparatus at 30° intervals relative to the housing **130** of the apparatus.

Indexed rotational movement may be further achieved by the provision of at least one, and preferably a pair, of diametrically opposed detents **236** respectively provided on cantilevered yoke arms **238** of the drive yoke **220**. By this arrangement, the yoke arms **238** are positioned between the drive flanges **232** for engagement with the confronting surfaces thereof, and bias the detents **236** into engagement with the drive collar **200**. Indexed relative rotation is thus achieved, with the detents **236** of the yoke arms **238** cooperating with the drive flanges **238** for effecting reciprocation of the actuating member **170**. According to various embodiments, the drive yoke **220** may be formed from suitable polymeric material, with the biasing force created by the yoke arms **238** acting on the detents **236** thereof cooperating with the radial depressions defined by the drive collar to resist relative rotational torque less than about 5 to 20 inch-ounces. Accordingly, the elongated portion **150** of the clamp coagulator instrument **120** is maintained in any of its selected indexed rotational positions, relative to the housing **130**, unless a torque is applied (such as by the rotation knob **216**) exceeding this predetermined torque level. A snap-like indexing action is thus provided.

Rotation of the elongated proportion **150** of the present clamp coagulator instrument **120** may be effected together with relative rotational movement of ultrasonic drive unit **50** with respect to housing **130**. In order to join the elongated portion **150** to the ultrasonic drive unit **50** in ultrasonic-transmitting relationship, the proximal portion of the outer tubular sheath **160** may be provided with a pair of wrench flats **240** (FIG. **3**). The wrench flats allow torque to be applied by a suitable torque wrench or the like to thereby permit the end effector **180** to be joined to the ultrasonic drive unit **50**. The ultrasonic drive unit **50**, as well as the elongated portion **150**, are thus rotatable, as a unit, by suitable manipulation of the rotation knob **216**, relative to the housing **130** of the apparatus. The interior of housing **130** is dimensioned to accommodate such relative rotation of the drive unit **50**.

FIG. **9** illustrates one embodiment of a surgical system **250** including a surgical instrument **251** having single element end effector **256**. The system **250** may include a transducer assembly **252** coupled to the end effector **256** and a sheath **254** positioned around the proximal portions of the end effector **256** as shown. The transducer assembly **252** and end effector **256** may operate in a manner similar to that of the transducer assembly **50** and end effector **180** described above to produce ultrasonic energy that may be transmitted to tissue via blade **256'**

FIG. **10** illustrates one embodiment of a surgical device **300**. FIGS. **11-12** illustrate exploded views of one embodiment of the surgical device **300** shown in FIG. **10**. Generally, the surgical instrument **300** may comprise a transducer assembly **302**, an end effector **304** and a lower jaw **306**. The end effector **304** may be at least partially enclosed by a sheath **314**. The lower jaw **306** may include a clamp face **308**, and may be slidable relative to the end effector to bring the clamp face **308** toward a distal end of the end effector **304**. According to various embodiments, the end effector **304** and/or the lower jaw **306** may define a lumen for aspirating a surgical site. Also, various blades **304'** may be included with the end effector **304**, for example, to bring about different surgical results.

FIGS. **13-14** illustrate one embodiment of the surgical device **300** shown in FIG. **10** configured in an open position with the blade **304'** and clamp **308** separated from one another. In use, a clinician may introduce the device **300** to a surgical site the open position illustrated in FIGS. **13-14**. When the device **300** is properly positioned, the clinician may transition the device **300** to a closed position, for example, by actuating a trigger **310**. FIGS. **15-16** illustrate one embodiment of the surgical device **300** shown in FIG. **10** configured in a closed position with the blade **304'** and clamp **308** translated towards one another. In the embodiment shown in FIGS. **15-16**, the trigger has been rotated towards a handle **312**, causing the lower jaw **306** to translate relative to the end effector **304**, and bringing the clamp face **308** towards the blade **304'**. In this way tissue may be clamped between the blade **304'** and the clamp face **308**. Energizing the end effector **304** may cause coagulation and/or cutting of the clamped tissue.

The various components of the surgical device **300** may be arranged in any suitable way. FIGS. **19-20** illustrate a handle region of one embodiment of the device **300** shown in FIG. **10**. According to various embodiments, a frame member **316** may couple to the handle **312** and the trigger **310**. The handle **312** may include a slot **334** for receiving the trigger **310**. When the trigger **310** is positioned within the slot **334**, and the frame member **316** is fitted over the handle **312** and trigger **310**, the bore holes **328**, **330** and **332** may align (FIGS. **11-12**). Pin **320** may pass through bore holes **328**, **330** and **332** to secure the frame member **316**, the handle **312** and the trigger **310**. The transducer assembly **302** and the end effector **304** may be received into a cavity **334** of the frame member **316**. The sheath **314** may be received into a distal end of the cavity **334**. A pin **318** may be placed through bore holes **340**, **338** and **342** to secure the sheath **314**, the end effector **304** and the frame member **316**. In addition, the sheath **314** may include a tongue feature **324** that may be received into a corresponding groove feature **336** of the handle **312**. (FIG. **11**) FIGS. **17-18** illustrate one embodiment of a lower jaw **306** and outer sheath **314** of the surgical device **300** shown in FIG. **10**, including a view of the tongue feature **324** of the sheath **314**.

The lower jaw **306** may be coupled to the trigger **310** as well as the sheath **314**, allowing the lower jaw **306** to translate relative to the sheath **314** and the end effector **304** when the trigger **310** is drawn toward the handle **312**. For example, the lower jaw **306** may define a groove feature **326** configured to receive the tongue feature **324** of the sheath (FIGS. **17-18**). A proximal end **348** of the lower jaw **306** may define one or more bore holes **346**. The bore hole(s) **346** may be aligned with a slot **344** of the trigger **312**, allowing pin **322** to be inserted. As illustrated in FIG. **19**, the trigger **310** may pivot toward the handle **312** about pin **320**. This may cause the pin **322** to slide within the slot **344**, exerting a proximally directed force on the lower jaw **306** and causing the clamp face **308** to translate toward the blade **304'** of the end effector **304**.

In the embodiments described above, the lower jaw **306** is slidable while the end effector **304** remains stationary. FIG. **20**A illustrates one embodiment of a surgical device **300'** where the lower jaw is stationary and the end effector is slidable. A frame member **316'** may couple the transducer **302**, sheath **314** and end effector **304**. A trigger **310'** may couple to a consolidated handle/lower jaw member **306'** at pivot point **380**, and to the frame member **316'** at pivot point **382**. According to various embodiments, the pivot points **380** and **382** may comprise a pin and slot, as described above. In use, the clinician may pull the trigger **310'** toward the proximal portion of the handle/lower jaw member **306'**. This may cause the trigger **310'** to rotate about the pivot point **380** and exert a distal force on the frame member **316'**, transducer **302** and end effector **304**, pushing the blade **304'** of the end effector distally toward the clamp face **308**.

FIG. **20**B illustrates one embodiment of the surgical device **300'** where the end effector **304** is configured to rotate as it moves forward toward the clamp face **308**. The frame member **316'** may include slots **390**. The end effector **304** may include a pin **392**, which may be received by the slots **390**. As the end effector **304** is moved distally, as described above, the orientation of the slots **392** may exert a torque on the pint **392**, and consequently the end effector **304**, causing it to rotate as shown. In various embodiments, the pin **392** may be replaced with multiple pins (not shown). For example, one pin may be placed on a first side of the end effector **304** and may be received by a first slot **390**, while another pin may be placed on a second side of the end effector **304** and may be received by a second slot **390** opposite the first.

The end effector **304** and the blade **304'** may be constructed according to any suitable solid or hollow-core configuration. FIG. **21** illustrates a distal portion of one embodiment of the surgical device shown in FIG. **10** including a blade **304'** defining a hollow lumen **350**. FIG. **22** illustrates one embodiment of the blade **304'** shown in FIG. **21**. According to various embodiments, suction may be provided through the lumen **350** to aspirate tissue that is cut and coagulated by the end effector **304**. FIG. **23** illustrates a distal portion of one embodiment of the surgical device **300** shown in FIG. **10** including a blade **304'** defining a hollow lumen **350** and having two members **352** extending across the hollow lumen **350**. FIG. **24** illustrates one embodiment of the blade **304'** shown in FIG. **21**. The members **352** may serve to cut tissue into portions smaller than the diameter of the lumen **350**, thus lessening the risk of clogging the lumen **350**. Various embodiments may include more or fewer members **352** than are shown. Also, the members **352** are shown to intersect one another at a right angle, although any other suitable configuration may be used.

FIG. **25** illustrates a distal portion of one embodiment of the surgical device **300** shown in FIG. **10** including a jaw member **306** defining a lumen, while FIG. **26** illustrates one embodiment of a blade **304'** for use with the surgical device as shown in FIG. **25**. The blade **304'** of the end effector **304** may define a cavity **360**. When the clamp face **308** is brought toward the blade **304'**, the cavity **360** may cover a corresponding well **356** defined by the lower jaw **306**. They well **356** may define an opening **354** to a lumen located within the lower jaw **306**. Tissue cut and or coagulated by the end effector **304** may be aspirated via the lumen and its opening **354**. FIG. **26**A illustrates an additional embodiment of the blade **304'** having cutting members **361** positioned within the cavity **360**. In use, the cutting members may morcellate tissue, reducing the size of tissue pieces received into the opening **354** and lessening the risk that the lumen will clog. FIG. **27** illustrates a distal portion of one embodiment of the surgical device shown in FIG. **10**. In the embodiment shown in FIG. **27**, the end effector **304** may include a blade **304'** defining a sharp edge **364**. The blade **304'** may cover the well **356** and lumen opening **354** as described above.

FIG. **28** illustrates a distal portion of one embodiment of the surgical device **300** shown in FIG. **10** including a plug feature **362** received into a hollow lumen **350** of the end effector **304**. When the clamp face **308** is brought toward the end effector **304**, the plug feature **362** may be received into a lumen **350** defined by the end effector **304**. In this way, the plug feature may help to remove any clogs or blockages present within the lumen **350**. According to various embodiments, the plug feature **362** may have a cross sectional area smaller than that of the lumen **350**. This may generally limit tissue portions removed by the device **300** to sizes smaller than the diameter of the lumen **350**, reducing the likelihood of clogs.

FIG. **28**A illustrates one embodiment of the surgical device **300** including a rotating end effector **370**. The rotating end effector **370** may mount to an electric motor **372**. FIG. **28**B illustrates one embodiment of the electric motor **372** mounted to the end effector **370**. A rotor **376** of the motor **372** may be mounted around the end effector **370**. A coil **374** of the motor **372** may, when energized, cause the rotor **376** and end effector **370** to rotate clockwise or counter-clockwise. In use, the lower jaw **306** may be translated with respect to the end effector **370**, causing the clamp face **308** to translate toward a blade **370'** of the rotating end effector **370**. According to various embodiments, the embodiment shown in FIGS. **28**A and **28**B also may include a transducer (not shown in FIGS. **28**A and **28**B) for ultrasonically exciting the end effector **370**. Accordingly, the end effector **370** may be rotated and ultrasonically excited simultaneously. Also, FIG. **28**A illustrates a clamp pad **377** positioned between the clamp face **308** and the blade **370'**. The clamp pad **377** may be made from any suitable material including, for example, a polymeric material.

FIG. **28**C illustrates one embodiment of the surgical device **300"** having an angled blade **304"**. The lower jaw **306** and clamp face **308"** may slide relative to the end effector **304** and blade **304"** according to any suitable method including, for example, the methods described above with respect to FIGS. **10**, **20**A, and **20**B. The blade **304"** may have a distal surface **381** that is angled relative to the device **300"**. For example, the distal surface **381** of the blade **304"** may be angled at an angle of 45°. According to various embodiments, the clamp face **308"** may also be angled, as shown, to match the angle of the blade **304"**.

FIGS. **29**-**36** show various embodiments of hollow core end effectors that may be utilized to cut and/or coagulate tissue. The end effectors may define a central lumen and may comprise at least one member extended across at least a portion of the central lumen at a distal end of the end effector. The member or members may serve to break-up bone or other tissue before it passes through the lumen, making it less likely that the lumen will be clogged by tissue material. According to various embodiments, the end effectors may be utilized with any suitable manual or ultrasonic instrument. For example, the end effectors may be utilized with the surgical devices **10**, **250** and **300** described above.

FIG. **29** illustrates one embodiment of a hollow core end effector **400** comprising members **404**, **406** extending across a lumen **402** defined by the end effector **400**. The members **404** and **406** may comprise wires that may be bonded to the end effector **400** at various points including points **408** and **410**. The wires may be bonded to the end effector **400** according to any suitable method including, welding, adhesive, etc. Also, although the embodiment shown in FIG. **29** includes two members **404** and **406** intersecting at about the center of the lumen **402**, it will be appreciated that any other suitable configuration or number of members may be utilized. FIG. **30** illustrates one embodiment of a hollow core end effector **412** comprising members **414**, **416** extending across a lumen **402**, while FIG. **31** illustrates a cut away view of one embodiment of the hollow core end effector **412** shown in FIG. **30**. In the embodiment shown in FIGS. **30**-**31**, the members **414** and **416** may be machined into the end effector **412** itself. Accordingly, portions of the members **414**, **416** may extend proximally into the lumen **402**. FIG. **31**A illustrates one embodiment of a hollow core end effector **413** having angled members **417**. The members **417** may not extend across the lumen **402**. Instead, some or all of the angled members **417** may terminate in a central portion of the lumen **402**.

FIG. **32** illustrates one embodiment of an end effector **418** having a non-integral blade **420**. The blade **420** may include one or more members **422**, for example, as described above with respect to end effectors **400** and **412**. The blade **420** may be bonded to the remainder of the end effector **418** according to any suitable method. For example, the surfaces **424** and **426** may be threaded, allowing the blade **420** to be threaded onto the remainder of the end effector **418**. Also, the blade **420** and end effector **418** may be coupled by press fitting, welding, brazing, adhesive bonding, etc. According to various embodiments, the non-integral blade **420** and the remainder of the end effector **418** may be made from different materials. For example, the end effector **418** may be made from a titanium alloy or other material with a low resistance to ultrasonic wave transmission. The blade **420** may be, in turn, made from material that is easily machined, and/or holds an edge such as, for example, a steel.

FIG. **33** illustrates one embodiment of an end effector **428** having a member **430** extended across a lumen **434** and edges **432** extending beyond the member **430**. The member **430**, as shown, is positioned proximally from the distal edge of the end effector **428**. For example, the member **430** may be recessed within the lumen **434** by a distance of up to 15 mm. FIG. **34** illustrates one embodiment of an end effector **436** having an inter-lumen member **442** positioned non-parallel to a longitudinal axis **440** of the end effector **436**. The member **442** may extend proximally into the lumen **438** at an angle that is not parallel to the axis **440**. This may facilitate the cutting and removing of small portions of tissue, such as tissue portion **441**. FIG. **35** illustrates one embodiment of an end effector **444** having a multi-section inter-lumen member **448**. Each of the sections **450**, **452** of the inter-lumen member **448** may be positioned at different angles relative to the longitudinal axis **446**. FIG. **36** illustrates one embodiment of an end effector **454** having inter-lumen members **458**, **460** extending distally from the lumen **434**. The members **458**, **460** may be angled relative to the longitudinal axis **459**, as described above. The members **458** and **460** also may extend beyond the distal edge of the other portions of the end effector **454**.

FIGS. **37**-**54** illustrate various embodiments of surgical devices that may be used as an ultrasonic or unpowered device to remove tissue portions. The embodiments illustrated in FIGS. **37-54** may be useful in surgical applications where it is desirable to remove a core or other integral portion of bone or other tissue. The devices may generally comprise a central instrument configured to engage tissue and an outer sheath surrounding the central instrument. The central instrument and sheath may be slidable relative to one another. Also, the outer sheath may comprise a distal edge configured to clamp the tissue when the central instrument is slid to a position proximal from the distal edge of the outer sheath.

FIGS. **37-40** illustrate a sequence of one embodiment of a surgical device **500** in use. The surgical device **500** may comprise a central instrument **502** and an outer sheath **504**. The central instrument **502** comprises two jaw members **506** and **508**. In use, the jaw member **506** may be pivotable toward the jaw member **508**. According to various embodiments, the jaw member **508** may be ultrasonically energized, for example, as described above. FIG. **37** illustrates one embodiment of the surgical device **500** with a portion of tissue **510** positioned between the jaw members **506**, **508**. FIG. **38** illustrates one embodiment of the surgical device **500** shown in FIG. **37** where the central instrument **502** is grasping tissue. This may occur when the jaw members **506**, **508** are pivoted toward one another to engage the tissue **510**. In the embodiment shown in FIG. **38**, the outer sheath **504** has been moved distally relative to the central instrument **502**. FIG. **39** illustrates one embodiment of the surgical device **500** shown in FIG. **37** where the outer sheath **504** has clamped the tissue **510**. This may occur when a distal portion of the outer sheath **504** clears the distal edge of the central instrument **502**, allowing the outer sheath **504**, and/or a component thereof, to clamp the tissue **510**. According to various embodiments, a distal edge **512** of the outer sheath **504** may define a sharp edge to sever the tissue. Also, according to various embodiments, outer sheath **504** may be ultrasonically activated to promote cutting and/or coagulation. Once the outer sheath **504** has clamped the tissue **510**, a clinician may manipulate the device **500**, causing the clamped tissue **510** to tear or break. FIG. **40** illustrates one embodiment of the surgical device **500** shown in FIG. **37** where the tissue **510** has been severed.

The outer sheath **504** may exert a clamping force on the tissue **510** according to various different methods. For example, the outer sheath **504** may be constructed such that the distal edge portion **512** is biased in upon itself. Accordingly, the rest state of the edge portion **512** may be a closed or clamped position, as illustrated in FIG. **40**. When the central instrument **502** is extended distally through the outer sheath **504**, it may separate the edge portion **512**, for example, as illustrated in FIGS. **37-38**. According to various embodiments, the distal edge **512** may include multiple distal edge portions separated by one or more longitudinal slots (not shown). This may allow the distal edge **512** to separate. When the central instrument **502** is retracted through the outer sheath **504** the edge portion **512** may contract to its closed or clamped position, cutting or otherwise clamping the tissue **510**. According to various embodiments, the edge portion **512** of the outer sheath **504** may be ultrasonically activated to promote cutting and/or coagulation of the tissue **510**.

FIGS. **41-42** illustrate one embodiment of the surgical device **500** shown in FIG. **37** where the outer sheath comprises edge members **514**. The edge members **514** may extend distally, as shown in FIG. **41**, in response to the actuation of a trigger or other component of the device (not shown). When the edge members **514** reach the distal end of the outer sheath, they contract toward one another, as shown in FIG. **42**, to sever or otherwise clamp the tissue **510**. According to various embodiments, the members **514** may be ultrasonically activated.

FIGS. **43-46** illustrate one embodiment of the outer sheath **504** including jaw members **520**. The jaw members **520** may pivot toward one another about pivot points **524** in response to distal movement of extenders **522**. For example, when the central instrument **502** is initially engaging tissue **510**, as shown in FIGS. **37-38**, the extenders **522** may be retracted, leaving the jaw members **520** in an open position as shown in FIGS. **43** and **45**. When the outer sheath **504** is extended distally relative to the central instrument, the extenders **522** may be translated distally. Distal translation of the extenders **522** may be caused by various mechanical or automated forces, for example, in response to a clinician activating a trigger or other component of the device (not shown). This distal translation may cause the jaw members **520** to pivot about pivot points **524** to a closed position, as shown in FIGS. **44** and **46**.

FIGS. **47-51** illustrate another sequence of one embodiment of a surgical device **500** in use. The embodiment shown in FIGS. **47-51** may comprise a central instrument **530** that includes an ultrasonic end effector defining a coring cavity **532**. When the central instrument **530** is extended into tissue **510**, it may cut and/or coagulate around a portion of the tissue **535** corresponding to the cavity **532**. FIG. **47** illustrates one embodiment of the surgical instrument **500** brought into the proximity of a mass of tissue **510**. FIG. **48** illustrates one embodiment of the surgical instrument **500** of FIG. **47** where the central instrument **530** is extended into the tissue **510**. Ultrasonic energy may be provided to the central instrument **530**, allowing it to cut into the tissue **510**. FIG. **49** illustrates one embodiment of the surgical instrument **500** of FIG. **47** where the central instrument **530** has been retracted from the tissue **510**, leaving a core section **535** that has been partially severed from the tissue **510**. FIG. **50** illustrates one embodiment of the surgical instrument **500** of FIG. **47** where the outer sheath **504** has been extended into the tissue **510**. The outer sheath **504** may either sever the core section **535**, or clamp it, allowing the clinician to tear or otherwise loosen the core section **535**. FIG. **51** illustrates one embodiment of the surgical instrument **500** of FIG. **47** where the outer sheath **504** has been retracted from the tissue **510**, removing the core section **535**. According to various embodiments, the device **500** may omit the central instrument **502**. For example, the outer sheath **504** may be ultrasonically energized to cut a portion of the tissue **510** in a manner similar to that of the central instrument **530**. The outer sheath **504** may then clamp the tissue **510** for severing or tearing, for example, as described above.

The surgical device **500** may be operated by a clinician from a handle portion (not shown) that may include one or more triggers for actuating the central instrument **502** and the outer sheath **504**. For example, the central instrument **502** may be actuated by any suitable manual or automatic means including, for example, a mechanical design similar to that described above with respect to the blade **180'** and clamp arm **190**. The outer sheath **504** may similarly be extended and actuated by any suitable manual or automatic means. For example, the outer sheath **504** may be extended distally in response to the actuation of a trigger in a manner similar to the way that the reciprocal actuating member **170** is extended distally in response to actuation of the operating lever **222** described above. According to various embodiments, the central instrument **502** and the outer sheath **504** may be actuated by a single pull of a trigger. For example, a single trigger pull may both actuate the central instrument **502** and also subsequently extend and actuate the outer sheath **504**.

FIGS. **52-55** illustrate force-feedback surgical devices, according to various embodiments, configured to apply ultrasonic energy to tissue at a variable power level and/or end effector amplitude. The level of power or end effector amplitude provided to the devices may be determined, for example, based on the force applied to a trigger, and/or the position or travel of the trigger. It will be appreciated that force feedback surgical devices, such as the embodiments shown in FIGS. **52-55**, may give clinicians an increased level of control over the ultrasonic power delivered by the devices, facilitating precise operations.

FIG. **52** illustrates a block diagram of one embodiment of a force feedback surgical device **600**. The device **600** may include an ultrasonic end effector **602**, which may be activated when a clinician operates a trigger **610**. When the trigger **610** is actuated, a force sensor **612** may generate a signal indicating the amount of force being applied to the trigger **610**. In addition to, or instead of force sensor **612**, the device **600** may include a position sensor **613**, which may generate a signal indicating the position of the trigger **610** (e.g., how far the trigger has been depressed or otherwise actuated). A control circuit **608** may receive the signals from the sensors **612** and/or **613**. The control circuit **608** may include any suitable analog or digital circuit components. The control circuit **608** also may communicate with the generator **606** and/or the transducer **604** to modulate the power delivered to the end effector **602** and/or the generator level or blade amplitude of the end effector **602** based on the force applied to the trigger **610** and/or the position of the trigger **610**. For example, as more force is applied to the trigger **610**, more power and/or a higher blade amplitude may be delivered to the end effector **602**. According to various embodiments, the force sensor **612** may be replaced by a multi-position switch (not shown). Each position of the switch may correspond to a different level of power to be delivered to the end effector **602**.

According to various embodiments, the end effector **602** may include a clamping mechanism, for example, such as that described above with respect to FIG. **4**. When the trigger **610** is initially actuated, clamping mechanism may close, clamping tissue between a clamp arm and the end effector **602**. As the force applied to the trigger increases (e.g., as sensed by force sensor **612**) the control circuit **608** may increase the power delivered to the end effector **602** by the transducer **604** and/or the generator level or blade amplitude brought about in the end effector **602**. In one embodiment; trigger position, as sensed by position sensor **613**, may be used by the control circuit **608** to set the power and/or amplitude of the end effector **602**. For example, as the trigger is moved further towards a fully actuated position, the power and/or amplitude of the end effector **602** may be increased.

According to various embodiments, the surgical device **600** also may include one or more feedback devices for indicating the amount of power delivered to the end effector **602**. For example, a speaker **614** may emit a signal indicative of the end effector power. According to various embodiments, the speaker **614** may emit a series of pulse sounds, where the frequency of the sounds indicates power. In addition to, or instead of the speaker **614**, the device may include a visual display **616**. The visual display **616** may indicate end effector power according to any suitable method. For example, the visual display **616** may include a series of light emitting diodes (LEDs), where end effector power is indicated by the number of illuminated LEDs. The speaker **614** and/or visual display **616** may be driven by the control circuit **608**. According to various embodiments, the device **600** may include a ratcheting device (not shown) connected to the trigger **610**. The ratcheting device may generate an audible sound as more force is applied to the trigger **610**, providing an indirect indication of end effector power.

The device **600** may include other features that may enhance safety. For example, the control circuit **608** may be configured to prevent power from being delivered to the end effector **602** in excess of a predetermined threshold. Also, the control circuit **608** may implement a delay between the time when a change in end effector power is indicated (e.g., by speaker **614** or display **616**), and the time when the change in end effector power is delivered. In this way, a clinician may have ample warning that the level of ultrasonic power that is to be delivered to the end effector **602** is about to change.

Force-feedback ultrasonic devices, such as the device **600**, may be physically implemented in any suitable form. For example, FIG. **53** illustrates one embodiment of a force-feedback surgical device **620**. The device **620** may comprise an ultrasonic end effector **622** excitable by a transducer **632**. The transducer **632** may be in communication with a generator (not shown) via a wire **636**. A clamp arm **624** may be pivotable towards the end effector **622** when a clinician pulls a trigger **628** towards a handle **626**, similar to the clamp arm **190** and blade **180'** described above. A sensor **630** positioned on the trigger **628** may measure the force applied to the trigger **628** by the clinician and/or the position of the trigger **628**. It will be appreciated that the sensor **630** may be alternatively placed at other locations within the device **620** including, for example, at trigger pivot point **634** or between the end effector **622** and clamp arm **624**. A control circuit (not shown) may be positioned at any suitable location on or in the device **620** including, for example, within the handle **626** or trigger **628**, the ultrasonic drive unit **50** or the generator **30**.

FIG. **54-55** illustrate one embodiment of another force-feedback surgical device **640**, which may be configured as an ultrasonic rongeur-type device. The device **640** may include a pair of handles **642**, **644** that when squeezed towards one another about pivot point **646** may cause a pair of distally positioned jaw members **648**, **650** to pivot towards one another to engage tissue by clamping or severing. One or both of the jaw members **648**, **650** may include an ultrasonically active end effector. For example, FIG. **54** illustrates an ultrasonic end effector **652** positioned on jaw member **650** and driven by transducer **656**. The transducer **656** may be in communication with a generator (not shown) via a wire **657**. A clamp pad **654** may be positioned opposite the end effector **652**. The transducer **656** may be positioned between the handles **642**, **644**, as shown, or at any other suitable position. For example, the transducer **656** may be positioned within one of the handles **642**, **644**. Force sensors **658**, **660** may be positioned on the handles **642**, **644** as shown, or may be positioned at various other locations within the device **640** including, for example, at the pivot point **646**. Likewise, the control circuit (not shown) may be positioned at any suitable location on or in the device **640**.

FIG. **56** illustrates one embodiment of another force feedback surgical device **700** comprising a hand-piece adapter **708**. The device **700** may also comprise a transducer **704** configured to drive an end effector **702**, for example, as described herein. The hand-piece adapter **708** may comprise one or more switches **706** for operating the transducer **704** and end effector **702**. For example, actuating one or more of the switches **706** may cause the device **700** to activate. The switches **706** may correspond to the trigger **610** described with respect to FIG. **52**. One or more sensors (not shown in FIG. **56**) may be provided to sense the travel of the switches **706** and/or the amount of force applied to the switches **706** by the clinician. A control circuit (not shown in FIG. **56**) may modulate the device power and/or end effector amplitude based on the output of the one or more sensors as described herein.

The devices disclosed herein can be designed to be disposed of after a single use, or they can be designed to be used multiple times. In either case, however, the device may be reconditioned for reuse after at least one use. Reconditioning can include any combination of the steps of disassembly of the device, followed by cleaning or replacement of particular elements, and subsequent reassembly. In particular, the device may be disassembled, and any number of particular elements or components of the device may be selectively replaced or removed in any combination. Upon cleaning and/or replacement of particular components, the device may be reassembled for subsequent use either at a reconditioning facility, or by a surgical team immediately prior to a surgical 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.

Preferably, the various embodiments described herein will be processed before surgery. First, a new or used instrument is obtained and if necessary cleaned. The instrument can then be sterilized. In one sterilization technique, the instrument is placed in a closed and sealed container, such as a plastic or TYVEK® bag. The container and instrument are then placed in a field of radiation that can penetrate the container, such as gamma radiation, x-rays, or high-energy electrons. The radiation kills bacteria on the instrument and in the container. The sterilized instrument can then be stored in the sterile container. The sealed container keeps the instrument sterile until it is opened in the medical facility.

It is preferred that the device is sterilized prior to surgery. This can be done by any number of ways known to those skilled in the art including beta or gamma radiation, ethylene oxide, steam.

Although various embodiments have been described herein, many modifications and variations to those embodiments may be implemented. For example, different types of end effectors may be employed. Also, where materials are disclosed for certain components, other materials may be used. The foregoing description and following claims are intended to cover all such modification and variations.

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 materials 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.

What is claimed is:

1. A surgical device, comprising:
- a surgical instrument, comprising:
  - an end effector, including:
    - a first jaw member; and
    - a second jaw member, wherein at least one of the first jaw member or the second jaw member is pivotable toward the other to grasp tissue; and
- an outer sheath surrounding the surgical instrument, wherein the outer sheath is slidable relative to the surgical instrument along a longitudinal axis between:
  - a first position, wherein the first jaw member and the second jaw member are positioned within the outer sheath proximal to a distal portion of the outer sheath; and
  - a second position, wherein the first jaw member and the second jaw member are positioned outside the outer sheath distal to the distal portion of the outer sheath;
- wherein the distal portion of the outer sheath is configured to clamp tissue.

2. The surgical device of claim **1**, wherein the first jaw member is configured to pivot toward the second jaw member, and wherein the second jaw member comprises an ultrasonic blade coupled to a proximally positioned transducer.

3. The surgical device of claim **1**, wherein the distal portion of the outer sheath comprises a distal edge configured to treat clamped tissue.

4. The surgical device of claim **3**, wherein the distal edge comprises a sharp edge to cut the clamped tissue.

5. The surgical device of claim **3**, further comprising a transducer positioned to ultrasonically excite the distal edge to at least one of cut or coagulate the clamped tissue.

6. The surgical device of claim **3**, wherein, in the first position, the distal portion is structured to bias upon itself.

7. The surgical device of claim **6**, wherein the distal edge comprises a plurality of distal edge portions separated by longitudinal slots.

8. The surgical device of claim **1**, wherein the distal portion comprises:
- a first sheath jaw member; and
- a second sheath jaw member, wherein the first sheath jaw member and the second sheath jaw member are transitionable between an open position in the second position and a closed position in the first position, and wherein the first sheath jaw member and the second sheath jaw member are configured to clamp the tissue in the closed position.

9. The surgical device of claim **8**, wherein the surgical device further comprises a trigger, and wherein the first sheath jaw member and the second sheath jaw member are transitionable to the closed position in response to actuation of the trigger.

10. A surgical device, comprising:
- a surgical instrument comprising an end effector; and
- an outer sheath surrounding the surgical instrument, wherein the outer sheath is slidable relative to the surgical instrument along a longitudinal axis between:
  - a first position, wherein the end effector is positioned within the outer sheath proximal to a distal portion of the outer sheath; and
  - a second positon, wherein the end effector is positioned outside the outer sheath distal to the distal portion of the outer sheath;
- wherein the distal portion of the outer sheath is configured to clamp tissue.

11. The surgical device of claim 10, wherein the end effector includes:

a first jaw member; and

a second jaw member, wherein at least one of the first jaw member or the second jaw member is pivotable toward the other to grasp tissue.

12. The surgical device of claim 10, wherein the end effector comprises an ultrasonic blade to at least one of cut or coagulate tissue.

13. The surgical device of claim 12, wherein the distal portion of the outer sheath comprises a distal edge configured to treat the clamped tissue.

14. The surgical device of claim 13, wherein the distal edge comprises a sharp edge to cut the clamped tissue.

15. The surgical device of claim 13, further comprising a transducer positioned to ultrasonically excite the distal edge to at least one of cut or coagulate the clamped tissue.

16. The surgical device of claim 12, wherein the distal portion comprises:

a first sheath jaw member; and

a second sheath jaw member, wherein the first sheath jaw member and the second sheath jaw member are transitionable between an open position in the second position and a closed position in the first position, and wherein the first sheath jaw member and the second sheath jaw member are configured to clamp the tissue in the closed position.

17. The surgical device of claim 16, wherein the surgical device further comprises a trigger, and wherein the first sheath jaw member and the second sheath jaw member are transitionable to the closed position in response to actuation of the trigger.

18. A surgical device, comprising:

a surgical instrument comprising an end effector; and

an outer sheath surrounding the surgical instrument, wherein the outer sheath is slidable relative to the surgical instrument along a longitudinal axis between:

a first position, wherein the end effector is positioned within the outer sheath proximal to a distal edge of the outer sheath; and

a second positon, wherein the end effector is positioned outside the outer sheath distal to the distal edge of the outer sheath;

wherein the distal edge is configured to clamp tissue.

19. The surgical device of claim 18, further comprising a transducer positioned to ultrasonically excite the distal edge to at least one of cut or coagulate the tissue.

20. The surgical device of claim 18, wherein the surgical instrument further comprises a transducer coupled to the end effector to at least one of cut or coagulate the tissue in the second position.

21. A surgical device, comprising:

a surgical instrument comprising an end effector; and

an outer sheath surrounding the surgical instrument, wherein the outer sheath is slidable relative to the surgical instrument along a longitudinal axis between:

a first position, wherein the end effector is positioned outside the outer sheath; and

a second positon, wherein the end effector is positioned within the outer sheath; wherein a distal portion of the outer sheath is configured to clamp tissue.

* * * * *

专利名称(译)	手术器械		
公开(公告)号	US10531910	公开(公告)日	2020-01-14
申请号	US15/653366	申请日	2017-07-18
[标]申请(专利权)人(译)	ETHICON，LLC		
申请(专利权)人(译)	ETHICON LLC		
当前申请(专利权)人(译)	ETHICON LLC		
[标]发明人	HOUSER KEVIN L MUIR STEPHANIE J DELUCA LOUIS T PRICE DANIEL W BOYD WILLIAM D ROBERTSON GALEN C ONEIL MICHAEL J		
发明人	HOUSER, KEVIN L. MUIR, STEPHANIE J. DELUCA, LOUIS T. PRICE, DANIEL W. BOYD, WILLIAM D. ROBERTSON, GALEN C. O'NEIL, MICHAEL J.		
IPC分类号	A61B17/32 A61B17/00 A61B18/14 A61L2/07 A61L2/08 A61L2/20 A61N7/00 A61B10/06 A61B17/3205 A61B18/00 A61B17/29		
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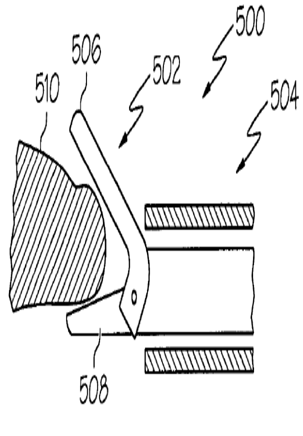
优先权	14/444335 2015-12-29 US		
其他公开文献	US20180092660A1		
外部链接	Espacenet		

摘要(译)

公开了一种手术装置，其包括手术器械和围绕该手术器械的外部护套。 手术器械包括末端执行器，该末端执行器包括第一钳口构件和第二钳口构件。 第一钳夹构件或第二钳夹构件中的至少一个可朝向另一个枢转以抓紧组织。 外部护套可沿着纵向轴线在第一位置之间相对于手术器械滑动，其中第一钳口构件和第二钳口构件位于外部护套内，邻近外部护套的远端部分，第二位置位于第二位置， 其中第一偏航构件和第二偏航构件位于外护套的外部，在外护套的远侧部分的远端。 外护套的远端部分构造成夹持组织。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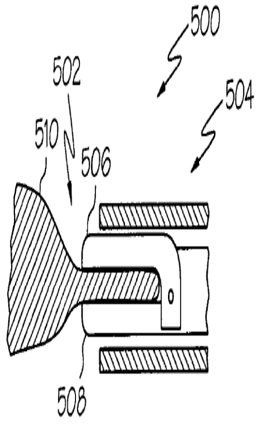
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