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(54) DUAL PURPOSE SURGICAL INSTRUMENT FOR CUTTING AND COAGULATING TISSUE

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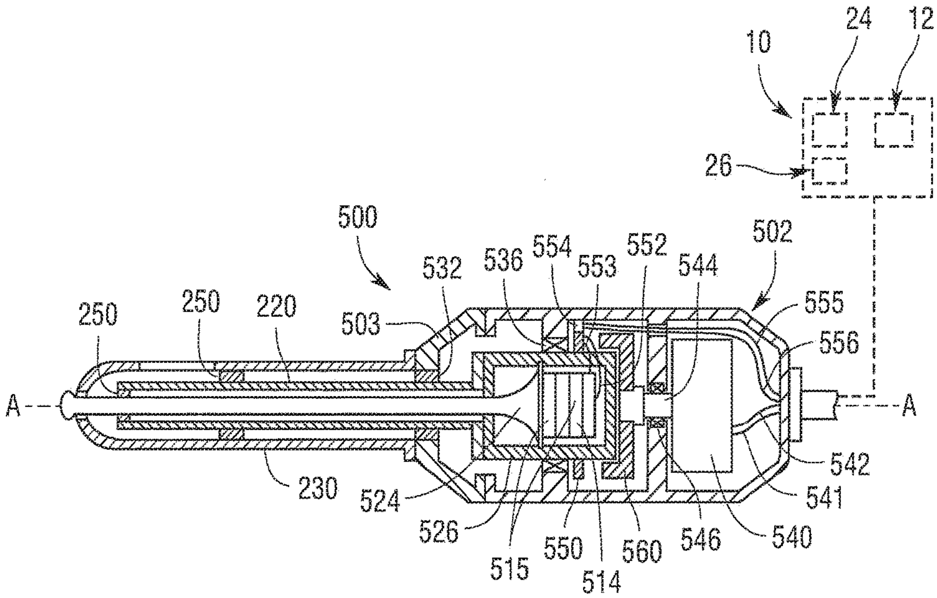
(57) **ABSTRACT**

An ultrasonic surgical instrument is disclosed. The ultrasonic surgical instrument may include: a housing, a motor assembly supported by the housing, a cutting blade, wherein a proximal end of the cutting blade is configured to be removably coupled to the motor assembly, an ultrasonic transducer assembly supported by the housing, an ultrasonic blade, wherein a proximal end of the ultrasonic blade is configured to be removably coupled to the ultrasonic transducer assembly, and an outer sheath configured to support the cutting blade and the ultrasonic blade, wherein a proximal end of the outer sheath is configured to be removably coupled to the housing.



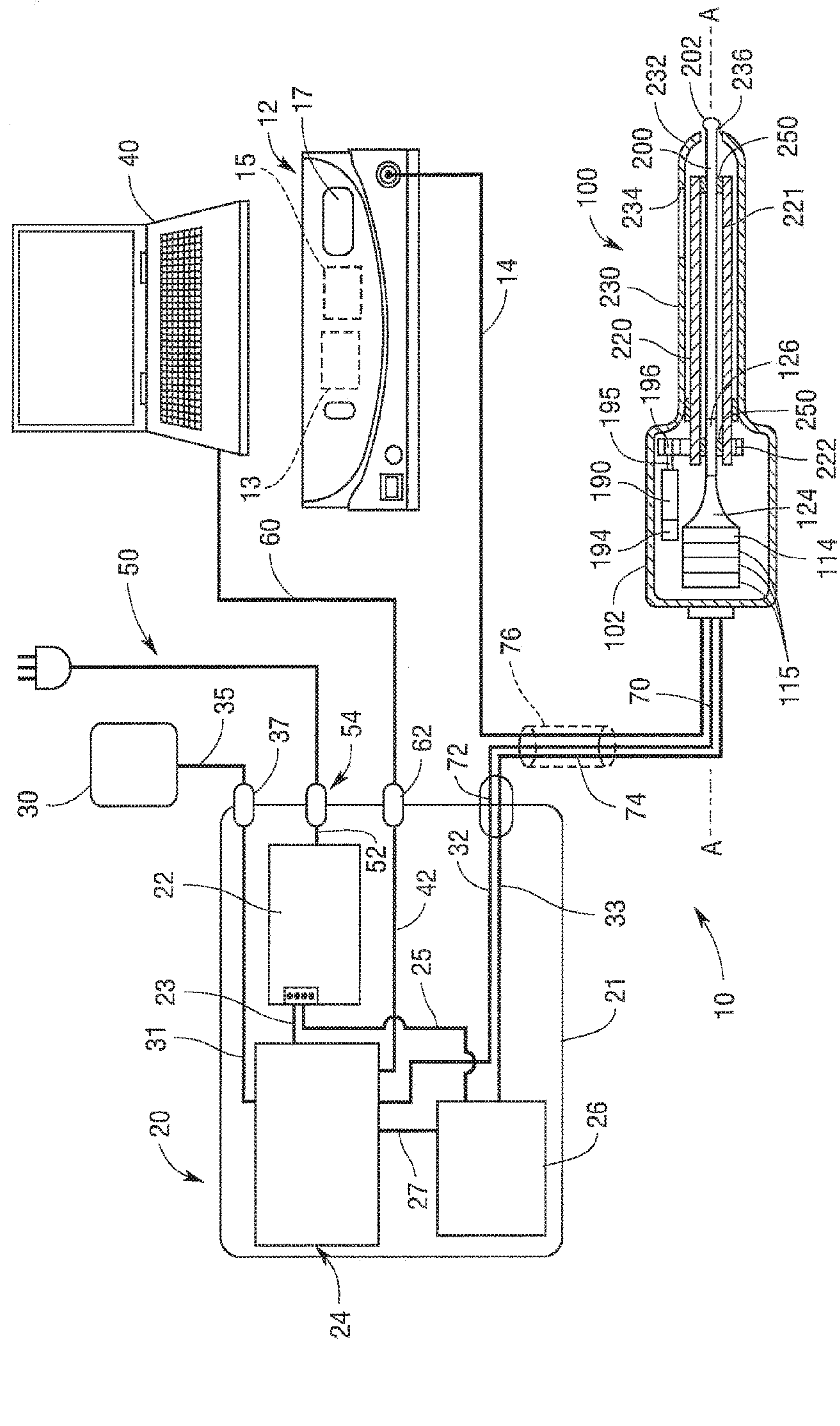


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Fig. 1

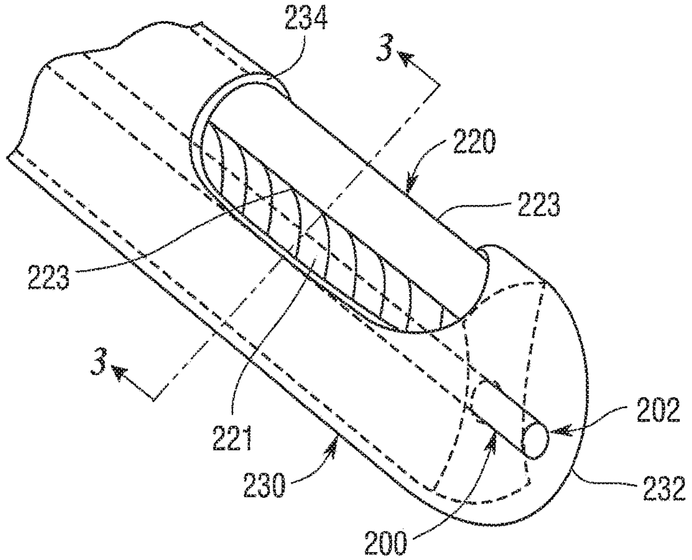


Fig.2

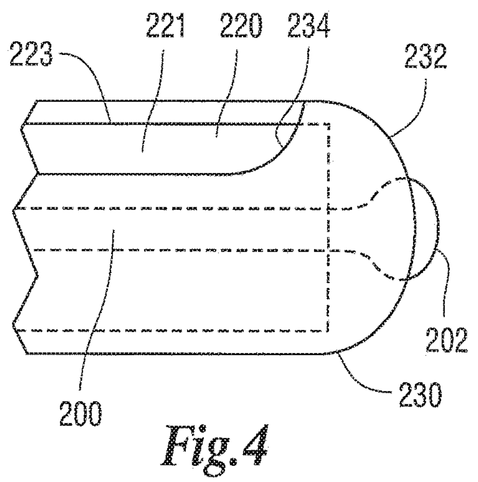


Fig.4

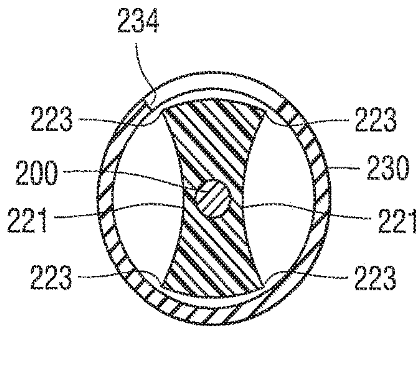
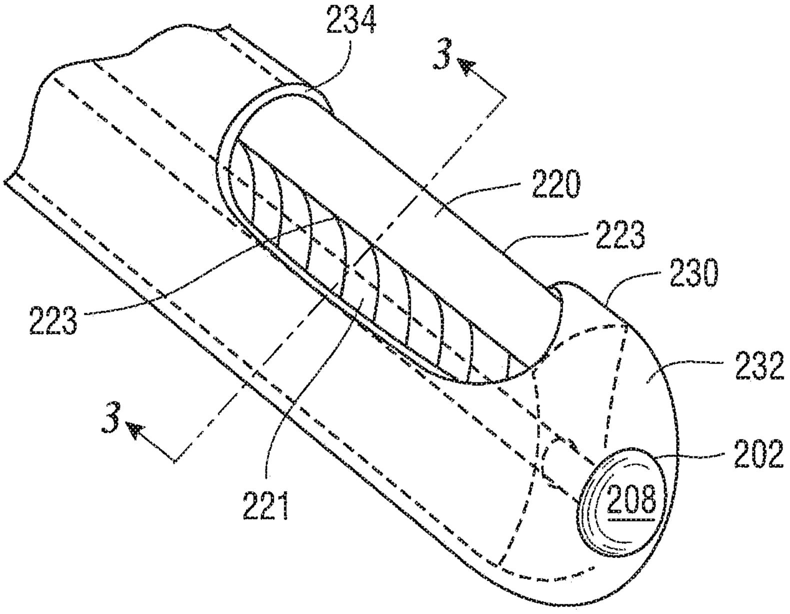


Fig.3



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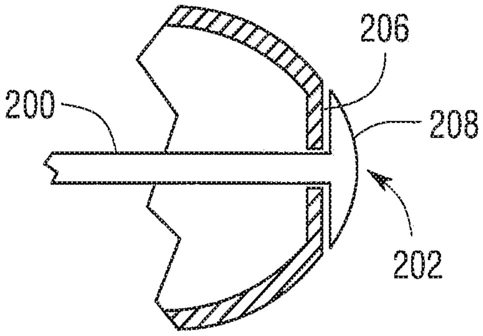

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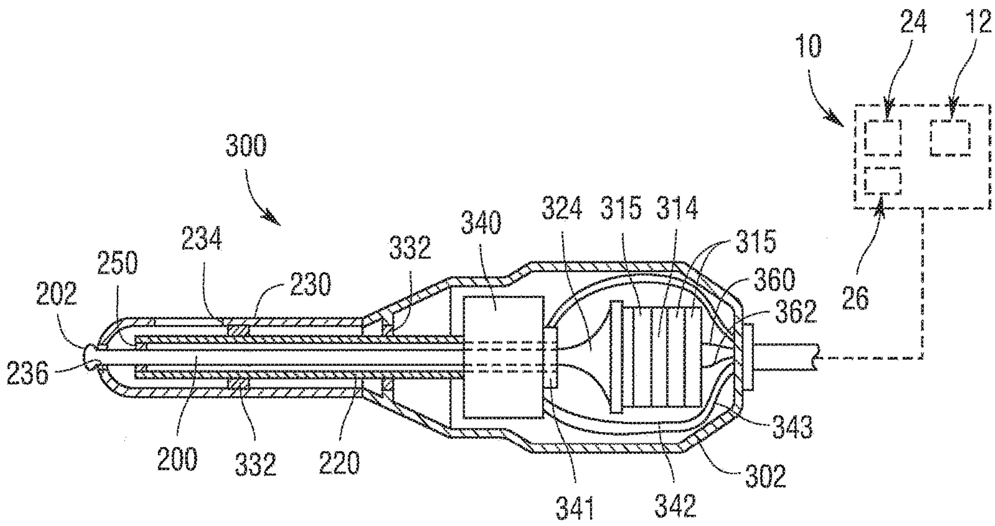
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Fig.7

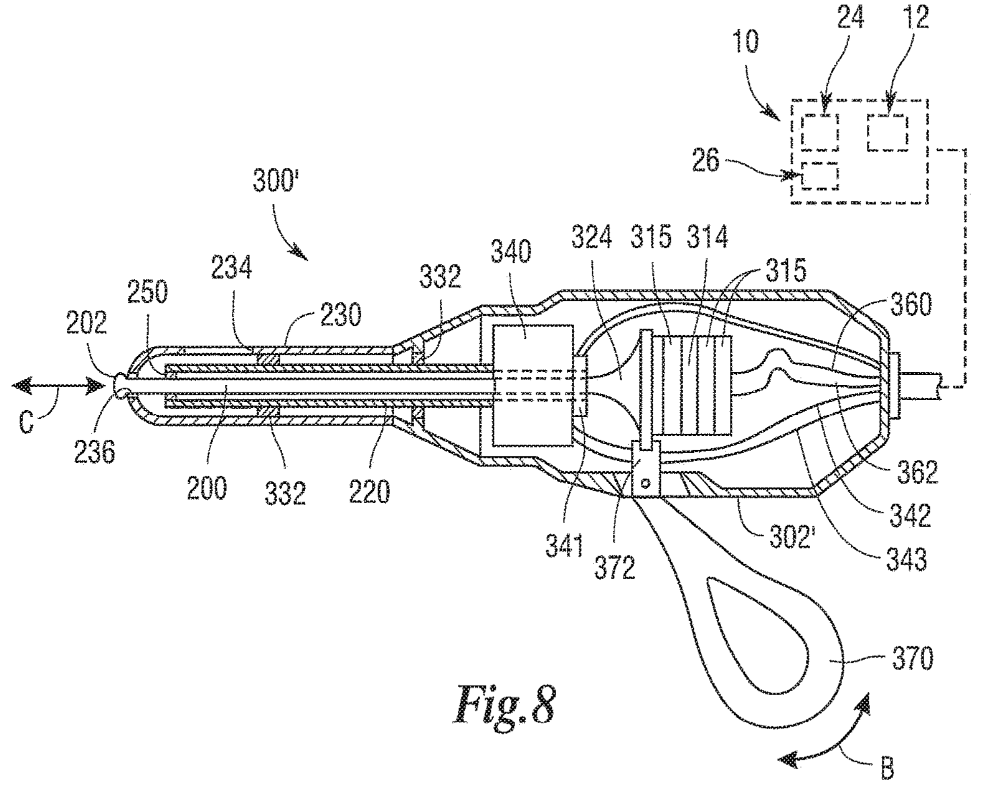
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Fig.8

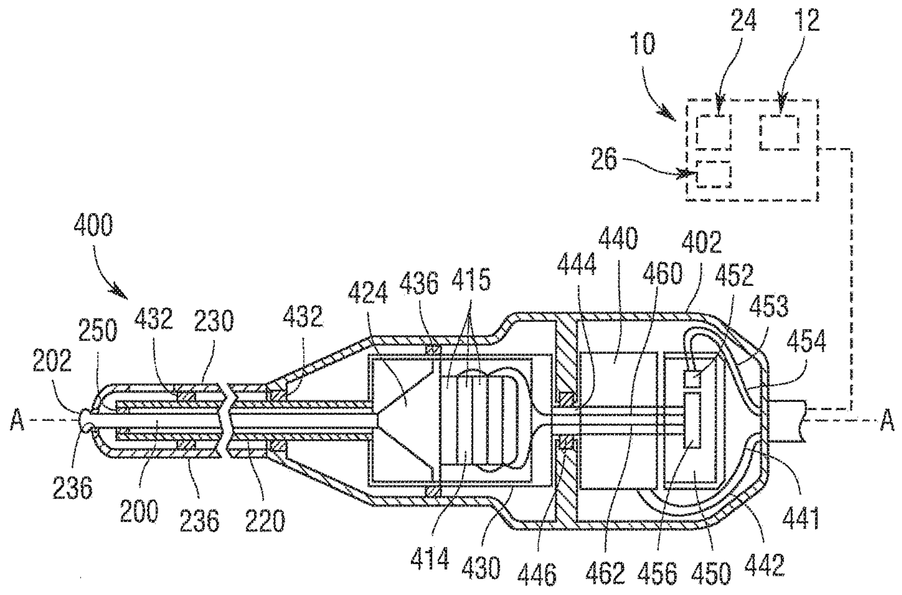
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Fig.9

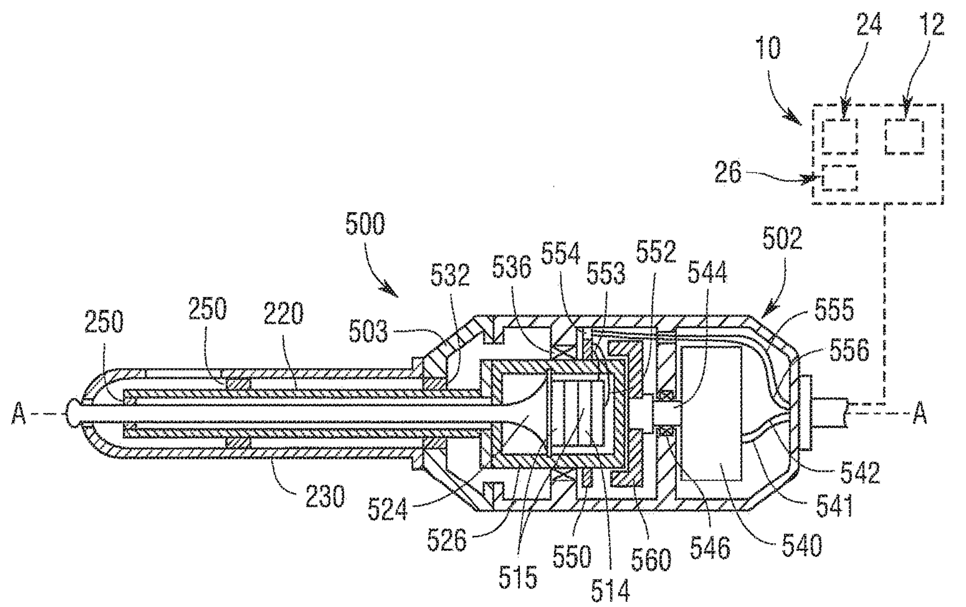
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Fig.10

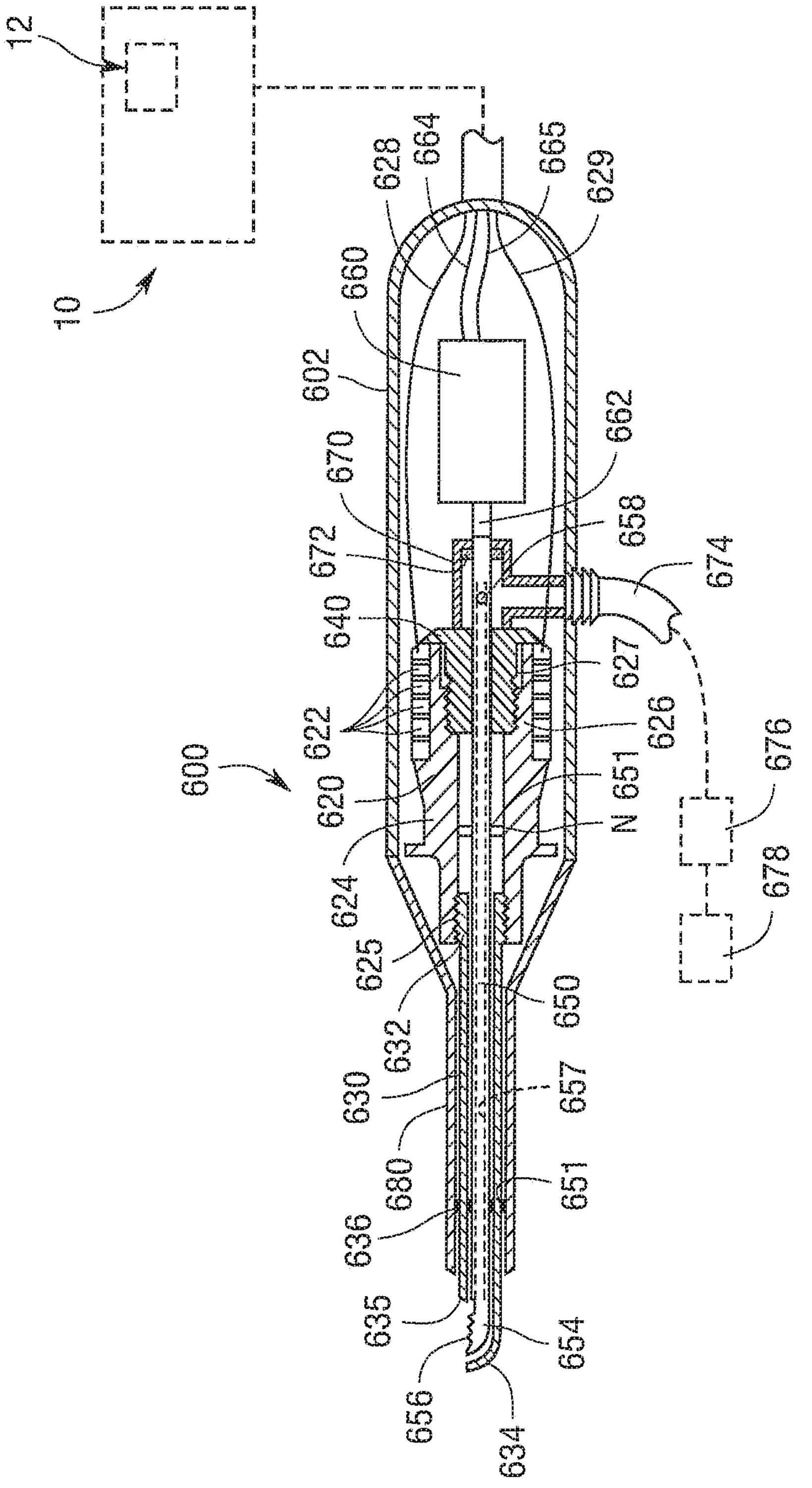
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Fig. 11

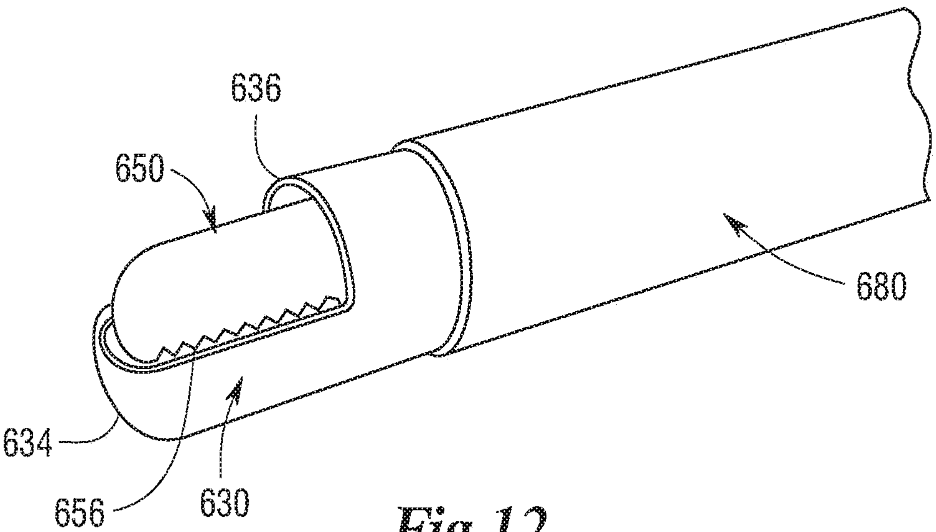

Fig.12

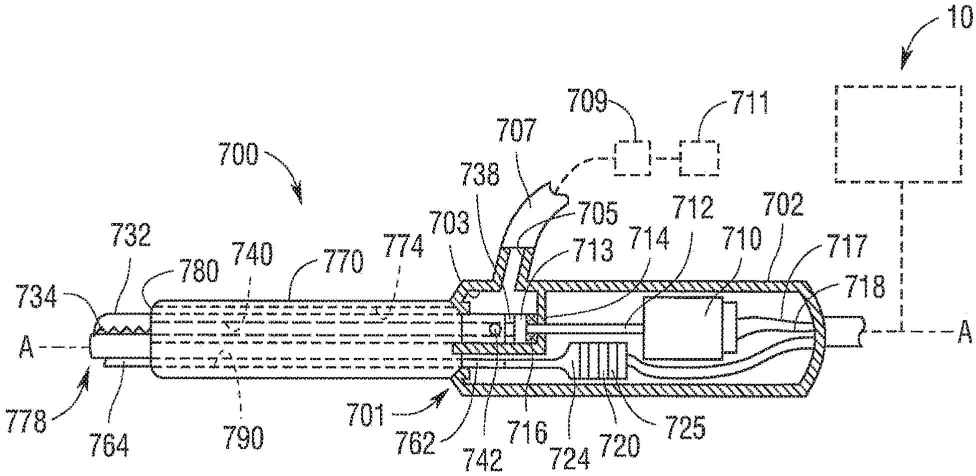

Fig.13

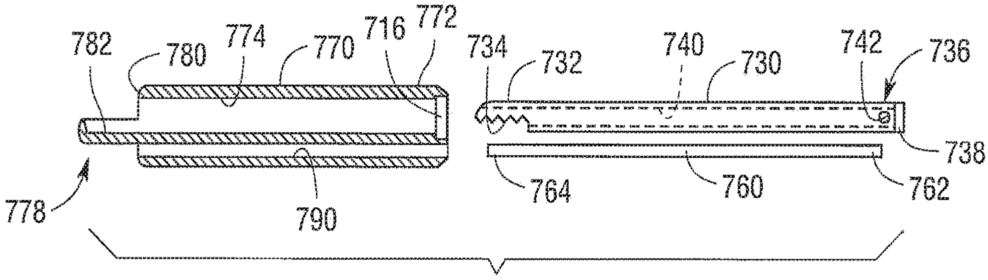

Fig.14

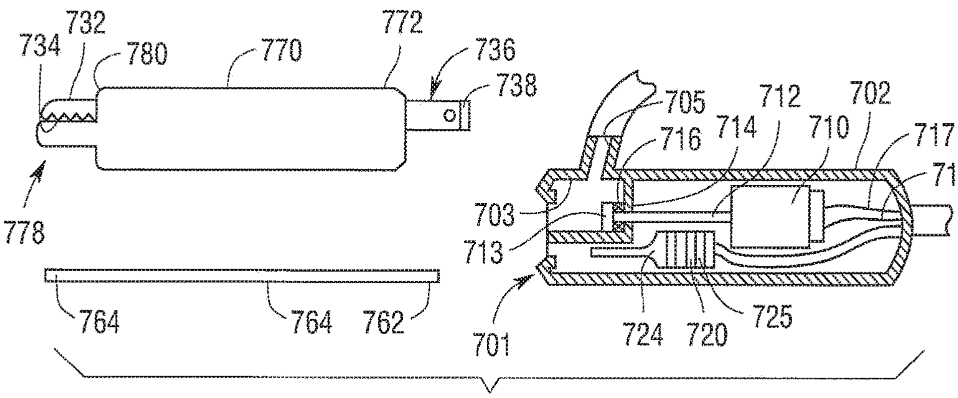

Fig.15

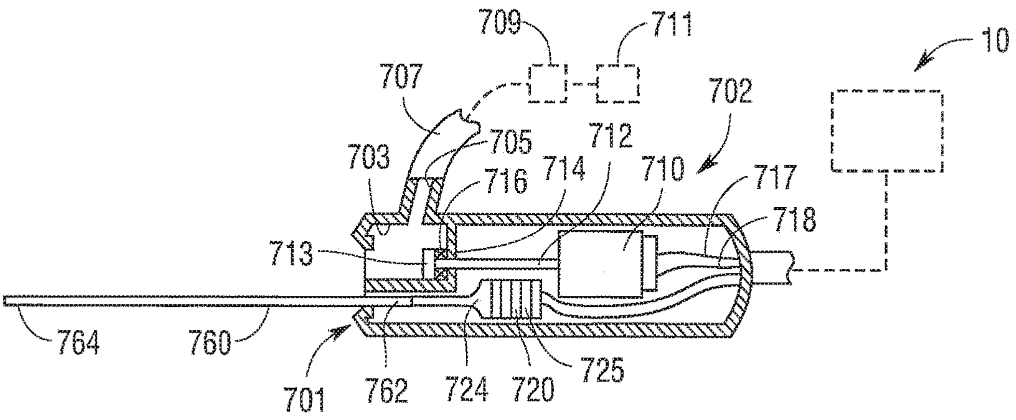
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Fig.16

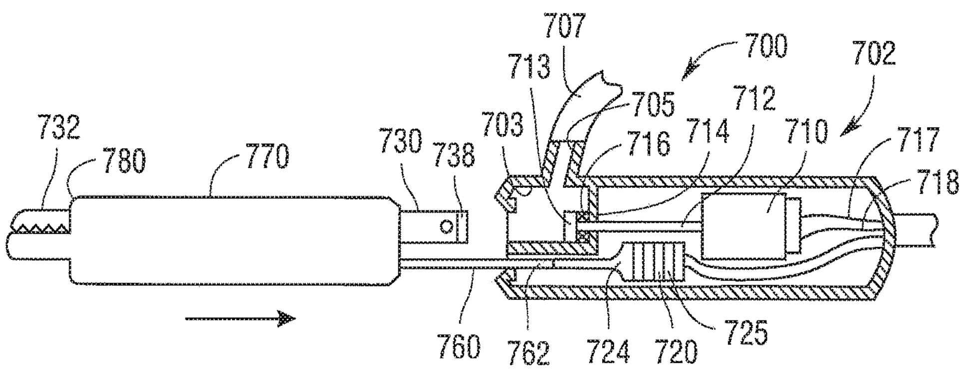
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Fig.17

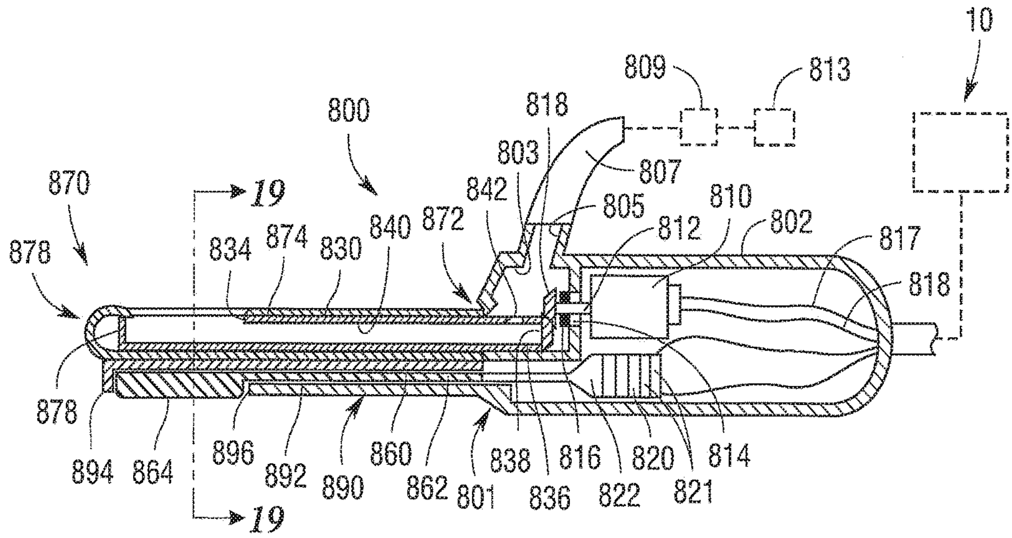
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Fig.18

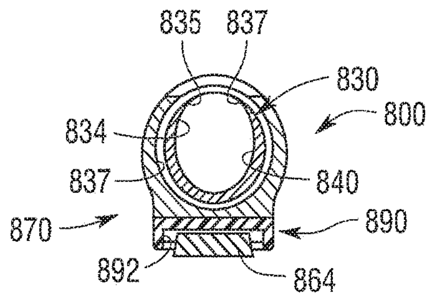
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Fig.19

DUAL PURPOSE SURGICAL INSTRUMENT FOR CUTTING AND COAGULATING TISSUE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation application claiming priority under 35 U.S.C. § 120 to U.S. patent application Ser. No. 14/827,764, entitled DUAL PURPOSE SURGICAL INSTRUMENT FOR CUTTING AND COAGULATING TISSUE, filed Aug. 17, 2015, now U.S. Patent Application Publication No. 2015/0351789, which is a continuation application claiming priority under 35 U.S.C. § 120 to U.S. patent application Ser. No. 13/942,103, entitled DUAL PURPOSE SURGICAL INSTRUMENT FOR CUTTING AND COAGULATING TISSUE, filed Jul. 15, 2013, which issued on Aug. 18, 2015 as U.S. Pat. No. 9,107,689, which is a divisional application claiming priority under 35 U.S.C. § 121 to U.S. patent application Ser. No. 12/703,879, entitled DUAL PURPOSE SURGICAL INSTRUMENT FOR CUTTING AND COAGULATING TISSUE, filed Feb. 11, 2010, which issued on Jul. 16, 2013 as U.S. Pat. No. 8,486,096, the entire disclosures of which are hereby incorporated by reference herein.

BACKGROUND

[0002] The present disclosure generally relates to ultrasonic surgical systems and, more particularly, to ultrasonic systems that allow surgeons to perform cutting and coagulation of tissue.

[0003] Over the years, a variety of different types of non-ultrasonically powered cutters and shaving devices for performing surgical procedures have been developed. Some of these devices employ a rotary cutting instrument and other devices employ a reciprocating cutting member. For example, shavers are widely used in arthroscopic surgery. These devices generally consist of a power supply, a handpiece, and a single-use end effector. The end effector commonly has an inner and outer tube. The inner tube rotates relative to the outer tube and will cut tissue with its sharpened edges. The inner tube can rotate continuously or oscillate. In addition, such device may employ a suction channel that travels through the interior of the inner tube. For example, U.S. Pat. No. 4,850,354 to McGurk-Burleson, et al., discloses a non-ultrasonically powered surgical cutting instrument that comprises a rotary cutter for cutting material with a shearing action. It employs an inner cutting member which is rotatable within an outer tube. Those devices lack the ability to coagulate tissue.

[0004] U.S. Pat. No. 3,776,238 to Peyman et al. discloses an ophthalmic instrument in which tissue is cut by a chopping action set-up by the sharp end of an inner tube moving against the inner surface of the end of an outer tube. U.S. Pat. No. 5,226,910 to Kajiyama et al. discloses another surgical cutting instrument that has an inner member which moves relative to an outer member to cut tissue entering through an aperture in the outer member. Again each of those devices lack the ability to coagulate tissue.

[0005] U.S. Pat. No. 4,922,902 to Wuchinich et al. discloses a method and apparatus for endoscopic removal of tissue utilizing an ultrasonic aspirator. The device uses an ultrasonic probe which disintegrates compliant tissue and aspirates it through a narrow orifice. U.S. Pat. No. 4,634,420 to Spinosa et al. discloses an apparatus and method for removing tissue from an animal and includes an elongated instrument having a needle or probe, which is vibrated at an ultrasonic frequency in the lateral direction. The ultrasonic movement of the needle breaks-up the tissue into fragments. Pieces of tissue can be removed from the area of treatment by aspiration through a conduit in the needle. U.S. Pat. No. 3,805,787 to Banko discloses yet another ultrasonic instrument that has a probe that is shielded to narrow the beam of ultrasonic energy radiated from the tip of the probe. In one embodiment the shield extends past the free-end of the probe to prevent the probe from coming into contact with the tissue. U.S. Pat. No. 5,213,569 to Davis discloses a phacoemulsification needle which focuses the ultrasonic energy. The focusing surfaces can be beveled, curved or faceted. U.S. Pat. No. 6,984,220 to Wuchinich and U.S. Patent Publication No. US 2005/0177184 to Easley disclose ultrasonic tissue dissection systems that provide combined longitudinal and torsional motion through the use of longitudinal-torsional resonators. U.S Patent Publication No. US 2006/0030797 A1 to Zhou et al. discloses an orthopedic surgical device that has a driving motor for driving an ultrasound transducer and horn. An adapter is provided between the driving motor and transducer for supplying ultrasonic energy signals to the transducer.

[0006] While the use of ultrasonically powered surgical instruments provide several advantages over traditional mechanically powered saws, drills, and other instruments, temperature rise in bone and adjacent tissue due to frictional heating at the bone/tissue interface can still be a significant problem. Current arthroscopic surgical tools include punches, reciprocating shavers and radio frequency (RF) devices. Mechanical devices such as punches and shavers create minimal tissue damage, but can sometimes leave behind ragged cut lines, which are undesirable. RF devices can create smoother cut lines and also ablate large volumes of soft tissue; however, they tend to create more tissue damage than mechanical means. Thus, a device which could provide increased cutting precision while forming smooth cutting surfaces without creating excessive tissue damage would be desirable.

[0007] It would be desirable to provide an ultrasonic surgical instrument that overcomes some of the deficiencies of current instruments. The ultrasonic surgical instruments described herein overcome many of those deficiencies.

[0008] The foregoing discussion is intended only to illustrate some of the shortcomings present in the field of the invention at the time, and should not be taken as a disavowal of claim scope.

SUMMARY

[0009] In one general aspect, various embodiments are directed to an ultrasonic surgical instrument that may include a motor. A cutting blade may be coupled to the motor and the cutting blade may include a longitudinally extending lumen. The ultrasonic surgical instrument may further include an ultrasonic transducer. An ultrasonic blade may be coupled to the ultrasonic transducer and the ultrasonic blade may be disposed within the longitudinally extending lumen.

[0010] In connection with another general aspect of the present invention, there is provided an ultrasonic surgical instrument that may include a motor. A cutting blade may be coupled to the motor. The ultrasonic surgical instrument may further include an ultrasonic transducer. An ultrasonic blade may be coupled to the ultrasonic transducer and the ultrasonic blade may include a longitudinally extending lumen. The cutting blade may be disposed within the longitudinally extending lumen.

[0011] In connection with still another general aspect of the present invention, there is provided an ultrasonic surgical instrument that may include a motor. A cutting blade may be coupled to the motor. The ultrasonic surgical instrument may further include an ultrasonic transducer. An ultrasonic blade may be protruding from the ultrasonic transducer and the ultrasonic blade may be substantially parallel to the cutting blade. The ultrasonic surgical instrument may further include a lumen extending longitudinally through at least one of the cutting blade and the ultrasonic blade.

FIGURES

[0012] The features of 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.

[0013] FIG. **1** is a schematic view of a surgical control system embodiment of the present invention in use with a non-limiting surgical instrument embodiment of the present invention;

[0014] FIG. **2** is a partial perspective view of a portion of the outer sheath and blade arrangement of the surgical instrument depicted in FIG. **1**;

[0015] FIG. **3** is a cross-sectional view of the outer sheath and blade arrangement of FIG. **2** taken along line **3-3** in FIG. **2**;

[0016] FIG. **4** is a partial side elevational view of the outer sheath and blade arrangement of FIGS. **2** and **3**;

[0017] FIG. **5** is a partial perspective view of another non-limiting outer sheath and blade arrangement of the present invention;

[0018] FIG. **6** is a partial cross-sectional view of the outer sheath and ultrasonic blade of the arrangement depicted in FIG. **5**;

[0019] FIG. **7** is a cross-sectional view of another non-limiting surgical instrument embodiment of the present invention;

[0020] FIG. **8** is a cross-sectional view of another non-limiting surgical instrument embodiment of the present invention;

[0021] FIG. **9** is a cross-sectional view of another non-limiting surgical instrument embodiment of the present invention;

[0022] FIG. **10** is a cross-sectional view of another non-limiting surgical instrument embodiment of the present invention;

[0023] FIG. **11** is a cross-sectional view of another non-limiting surgical instrument embodiment of the present invention;

[0024] FIG. **12** is a perspective view of a portion of the outer sheath and blade arrangement employed by the surgical instrument embodiment of FIG. **11**;

[0025] FIG. **13** is a side elevational view of another non-limiting surgical instrument embodiment of the present invention with portions thereof shown in cross-section;

[0026] FIG. **14** is an exploded assembly view of an outer sheath assembly and a shaver blade and an ultrasonic blade of various non-limiting embodiments of the present invention with the outer sheath shown in cross-section;

[0027] FIG. **15** is an exploded assembly view of the surgical instrument of FIG. **13**;

[0028] FIG. **16** is a cross-sectional view of a portion of the surgical instrument of FIGS. **13** and **15** with the ultrasonic blade attached thereto;

[0029] FIG. **17** is another view of the surgical instrument of FIG. **16** with the outer sheath assembly being slid over the ultrasonic blade;

[0030] FIG. **18** is a cross-sectional view of another non-limiting surgical instrument embodiment of the present invention; and

[0031] FIG. **19** is a cross-sectional end view of the surgical instrument of FIG. **18** taken along line **19-19** in FIG. **18**.

DESCRIPTION

[0032] The owner of the present application also owns the following U.S. Patent Applications that were filed on even date herewith and which are herein incorporated by reference in their respective entireties:

[0033] U.S. patent application Ser. No. 12/703,860, entitled ULTRASONICALLY POWERED SURGICAL INSTRUMENTS WITH ROTATING CUTTING IMPLEMENT, now U.S. Pat. No. 8,531,064;

[0034] U.S. patent application Ser. No. 12/703,864, entitled METHODS OF USING ULTRASONICALLY POWERED SURGICAL INSTRUMENTS WITH ROTATABLE CUTTING IMPLEMENTS, now U.S. Pat. No. 8,323,302;

[0035] U.S. patent application Ser. No. 12/703,866, entitled SEAL ARRANGEMENTS FOR ULTRASONICALLY POWERED SURGICAL INSTRUMENTS, now U.S. Pat. No. 8,951,272;

[0036] U.S. patent application Ser. No. 12/703,870, entitled ULTRASONIC SURGICAL INSTRUMENTS WITH ROTATABLE BLADE AND HOLLOW SHEATH ARRANGEMENTS, now U.S. Pat. No. 9,259,234;

[0037] U.S. patent application Ser. No. 12/703,875, entitled ROTATABLE CUTTING IMPLEMENT ARRANGEMENTS FOR ULTRASONIC SURGICAL INSTRUMENTS, now U.S. Pat. No. 8,469,981;

[0038] U.S. patent application Ser. No. 12/703,877, entitled ULTRASONIC SURGICAL INSTRUMENTS WITH PARTIALLY ROTATING BLADE AND FIXED PAD ARRANGEMENT, now U.S. Pat. No. 8,382,782;

[0039] U.S. patent application Ser. No. 12/703,885, entitled OUTER SHEATH AND BLADE ARRANGEMENTS FOR ULTRASONIC SURGICAL INSTRUMENTS, now U.S. Pat. No. 8,579,928;

[0040] U.S. patent application Ser. No. 12/703,893, entitled ULTRASONIC SURGICAL INSTRUMENTS WITH MOVING CUTTING IMPLEMENT, now U.S. Pat. No. 8,961,547; and

[0041] U.S. patent application Ser. No. 12/703,899, entitled ULTRASONIC SURGICAL INSTRUMENT WITH COMB-LIKE TISSUE TRIMMING DEVICE, now U.S. Pat. No. 8,419,759.

[0042] Various embodiments are directed to apparatuses, systems, and methods for the treatment of tissue Numerous specific details are set forth to provide a thorough understanding of the overall structure, function, manufacture, and use of the embodiments as described in the specification and illustrated in the accompanying drawings. It will be understood by those skilled in the art, however, that the embodiments may be practiced without such specific details. In other instances, well-known operations, components, and elements have not been described in detail so as not to obscure the embodiments described in the specification. Those of ordinary skill in the art will understand that the embodiments described and illustrated herein are non-limiting examples, and thus it can be appreciated that the specific structural and functional details disclosed herein may be representative and do not necessarily limit the scope of the embodiments, the scope of which is defined solely by the appended claims.

[0043] Reference throughout the specification to "various embodiments," "some embodiments," "one embodiment," or "an embodiment", or the like, means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment. Thus, appearances of the phrases "in various embodiments," "in some embodiments," "in one embodiment," or "in an embodiment", or the like, in places throughout the specification are not necessarily all referring to the same embodiment. Furthermore, the particular features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. Thus, the particular features, structures, or characteristics illustrated or described in connection with one embodiment may be combined, in whole or in part, with the features structures, or characteristics of one or more other embodiments without limitation.

[0044] Various embodiments are directed to improved ultrasonic surgical systems and instruments configured for effecting tissue dissecting, cutting, and/or coagulation during surgical procedures as well as the cutting implements employed thereby. In one embodiment, an ultrasonic surgical instrument apparatus is configured for use in open surgical procedures, but has applications in other types of surgery, such as arthroscopic, laparoscopic, endoscopic, and robotic-assisted procedures. Versatile use is facilitated by selective use of ultrasonic energy and the selective rotation of the cutting/coagulation implement and/or protective sheaths.

[0045] It will be appreciated that the terms "proximal" and "distal" are used herein with reference to a clinician gripping a handpiece assembly. Thus, an end effector is distal with respect to the more proximal handpiece 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 handpiece assembly. However, surgical instruments are used in many orientations and positions, and these terms are not intended to be limiting and absolute.

[0046] FIG. **1** illustrates in schematic form one embodiment of a surgical control system **10** of the present invention that may be employed to control various surgical instrument embodiments of the present invention. For example, the surgical control system **10** may include an ultrasonic generator **12** for supplying ultrasonic control signals to an ultrasonic surgical instrument **100**. The ultrasonic generator **12** may be connected by a cable **14** to an ultrasonic transducer assembly **114** that is non-rotatably supported within a housing **102** of the ultrasonic surgical instrument **100**. In one embodiment, the system **10** may further include a motor control system **20** that includes a conventional power supply **22** that is coupled to a control module **24** by cable **23** to supply, for example, 24VDC thereto. The motor control module **24** may comprise a control module manufactured by National Instruments of Austin, Tex. under Model No. NI cRIO-9073. However, other conventional motor control modules may be employed. The power supply **22** may be coupled to a motor drive **26** by cable **25** to also supply 24VDC thereto. The motor drive **26** may comprise a motor drive manufactured by National Instruments. However, other conventional motor drives may be employed. Control module **24** may also be coupled to the motor drive **26** by cable **27** for supplying power thereto. A conventional foot pedal **30** or other control switch arrangement may be attached to the control module **24** by a cable **31**. As will be discussed in further detail below, the ultrasonic surgical instrument **100** may include a motor **190** that has an encoder **194** associated therewith. The motor **190** may comprise a motor manufactured by National Instruments under Model No. CTP12ELF10MAA00. The encoder **194** may comprise an encoder manufactured by U.S. Digital of Vancouver, Wash. under Model No. 197-I-D-D-B. However, other conventional motors and conventional encoders may be used. The encoder **194** may be coupled to the motor control module **24** by an encoder cable **32** and the motor **190** may be coupled to the motor drive **26** by cable **33**. The surgical system **10** may also include a computer **40** that may communicate by Ethernet cable **42** with the motor control module **24**.

[0047] As can also be seen in FIG. **1**, the motor control system **20** may be housed in an enclosure **21**. To facilitate easy portability of the system, various components may be attached to the motor control system **20** by removable cable connectors. For example, foot pedal switch **30** may be attached to a detachable cable connector **37** by cable **35** to facilitate quick attachment of the foot pedal to the control system **20**. A/C power may be supplied to the power supply **22** by a conventional plug/cable **50** that is attached to a detachable cable connector **54** that is attached to cable **52**. The computer **40** may have a cable **60** that is attached to detachable cable connector **62** that is coupled to cable **42**. The encoder **194** may have an encoder cable **70** that is attached to a detachable connector **72**. Likewise, the motor **190** may have a cable **74** that is attached to the detachable connector **72**. The detachable connector **72** may be attached to the control module **24** by cable **32** and the connector **72** may be attached to the motor drive **26** by cable **33**. Thus, cable connector **72** serves to couple the encoder **194** to the control module **24** and the motor **190** to the motor drive **26**. The cables **70** and **74** may be housed in a common sheath **76**.

[0048] In various embodiments, the ultrasonic generator **12** may include an ultrasonic generator module **13** and a signal generator module **15**. See FIG. **1**. The ultrasonic generator module **13** and/or the signal generator module **15** each may be integrated with the ultrasonic generator **12** or may be provided as a separate circuit module electrically coupled to the ultrasonic generator **12** (shown in phantom to illustrate this option). In one embodiment, the signal generator module **15** may be formed integrally with the ultrasonic generator module **13**. The ultrasonic generator **12** may comprise an input device **17** located on a front panel of the generator **12** console. The input device **17** may comprise any suitable device that generates signals suitable for programming the operation of the generator **12** in a known manner. Still with reference to FIG. **1**, the cable **14** may comprise multiple electrical conductors for the application of electrical energy to positive (+) and negative (−) electrodes of an ultrasonic transducer assembly **114**. In alternative embodiments, the ultrasonic drive module and/or the motor drive module may be supported within the surgical instrument **100**.

[0049] Various forms of ultrasonic generators, ultrasonic generator modules and signal generator modules are known. For example, such devices are disclosed in commonly owned U.S. patent application Ser. No. 12/503,770, now U.S. Pat. No. 8,461,744, entitled Rotating Transducer Mount For Ultrasonic Surgical Instruments, filed Jul. 15, 2009, which is herein incorporated by reference in its entirety. Other such devices are disclosed in one or more of the following U.S. Patents, all of which are incorporated by reference herein: U.S. Pat. No. 6,480,796 (Method for Improving the Start Up of an Ultrasonic System Under Zero Load Conditions); U.S. Pat. No. 6,537,291 (Method for Detecting a Loose Blade in a Handle Connected to an Ultrasonic Surgical System); U.S. Pat. No. 6,626,926 (Method for Driving an Ultrasonic System to Improve Acquisition of Blade Resonance Frequency at Startup); U.S. Pat. No. 6,633,234 (Method for Detecting Blade Breakage Using Rate and/or Impedance Information); U.S. Pat. No. 6,662,127 (Method for Detecting Presence of a Blade in an Ultrasonic System); U.S. Pat. No. 6,678,621 (Output Displacement Control Using Phase Margin in an Ultrasonic Surgical Handle); U.S. Pat. No. 6,679,899 (Method for Detecting Transverse Vibrations in an Ultrasonic Handle); U.S. Pat. No. 6,908,472 (Apparatus and Method for Altering Generator Functions in an Ultrasonic Surgical System); U.S. Pat. No. 6,977,495 (Detection Circuitry for Surgical Handpiece System); U.S. Pat. No. 7,077,853 (Method for Calculating Transducer Capacitance to Determine Transducer Temperature); U.S. Pat. No. 7,179,271 (Method for Driving an Ultrasonic System to Improve Acquisition of Blade Resonance Frequency at Startup); and U.S. Pat. No. 7,273, 483 (Apparatus and Method for Alerting Generator Function in an Ultrasonic Surgical System).

[0050] In various embodiments, the housing **102** may be provided in two or more sections that are attached together by fasteners such as screws, snap features, etc. and may be fabricated from, for example, plastics such as polycarbonate, polyetherimide (GE Ultem®) or metals such as aluminum, titanium or stainless steel. As indicated above, the housing **102** non-rotatably supports a piezoelectric ultrasonic transducer assembly **114** for converting electrical energy to mechanical energy that results in longitudinal vibrational motion of the ends of the transducer assembly **114**. The ultrasonic transducer assembly **114** may comprise at least one and preferably a stack of, for example, four to eight ceramic piezoelectric elements **115** with a motion null point located at some point along the stack. The ultrasonic transducer assembly **114** may further include an ultrasonic horn **124** that is attached at the null point on one side and to a coupler **126** on the other side. An ultrasonic blade **200** that may be fabricated from, for example, titanium may be fixed to the coupler **126**. In alternative embodiments, the ultrasonic blade **200** is integrally formed with the ultrasonic horn **124**. In either case, the ultrasonic blade **200** will vibrate in the longitudinal direction at an ultrasonic frequency rate with the ultrasonic transducer assembly **114**. The ends of the ultrasonic transducer assembly **114** achieve maximum motion with a portion of the stack constituting a motionless node, when the ultrasonic transducer assembly **114** is driven at maximum current at the transducer's resonant frequency. However, the current providing the maximum motion will vary with each instrument and is a value stored in the non-volatile memory of the instrument so the system can use it.

[0051] The parts of the ultrasonic instrument **100** may be designed such that the combination will oscillate at the same resonant frequency. In particular, the elements may be tuned such that the resulting length of each such element is one-half wavelength or a multiple thereof. Longitudinal back and forth motion is amplified as the diameter closer to the ultrasonic blade **200** of the acoustical mounting horn **124** decreases. This phenomenon is greatest at the node and essentially non-existent when the diameteral change is made at an anti-node. Thus, the ultrasonic horn **124**, as well as the blade/coupler, may be shaped and dimensioned so as to amplify blade motion and provide ultrasonic vibration in resonance with the rest of the acoustic system, which produces the maximum back and forth motion of the end of the acoustical mounting horn **124** close to the ultrasonic blade **200**. Motions of approximately 10 microns may be achieved at the piezoelectric elements **115**. Motions of approximately 20-25 microns may be achieved at the end of the acoustical horn **124** and motions of approximately 40-100 microns may be achieved at the end of the ultrasonic blade **200**.

[0052] When power is applied to the ultrasonic instrument **100** by operation of the foot pedal **30** or other switch arrangement, the ultrasonic generator **12** may, for example, cause the ultrasonic blade **200** to vibrate longitudinally at approximately 55.5 kHz, and the amount of longitudinal movement will vary proportionately with the amount of driving power (current) applied, as adjustably selected by the user. When relatively high power is applied, the ultrasonic blade **200** may be designed to move longitudinally in the range of about 40 to 100 microns at the ultrasonic vibrational rate. Such ultrasonic vibration of the blade **200** will generate heat as the blade contacts tissue, i.e., the acceleration of the ultrasonic blade **200** through the tissue converts the mechanical energy of the moving ultrasonic blade **200** to thermal energy in a very narrow and localized area. This localized heat creates a narrow zone of coagulation, which will reduce or eliminate bleeding in small vessels, such as those less than one millimeter in diameter. The cutting efficiency of the ultrasonic blade **200**, as well as the degree of hemostasis, will vary with the level of driving power applied, the cutting rate or force applied by the surgeon to the blade, the nature of the tissue type and the vascularity of the tissue.

[0053] As indicated above, the surgical instrument **100** may further include a motor **190** which is employed to apply rotational motion to a tissue cutting blade **220** that is coaxially aligned with the ultrasonic blade **200**. More particularly, the tissue cutting blade **220** has an axial lumen **221** therethrough through which the ultrasonic blade **200** extends. The tissue cutting blade **220** may be fabricated from, for example, stainless steel. In various embodiments, one or more seals **250** of the type described in co-pending U.S. patent application Ser. No. 12/703,866, entitled SEAL ARRANGEMENTS FOR ULTRASONICALLY POWERED SURGICAL INSTRUMENTS, now U.S. Pat. No. 8,951,272, which has been herein incorporated by reference inn its entirety may be employed. However, other seal arrangements could also be employed. The motor **190** may comprise, for example, a conventional stepper motor. When used with an encoder **194**, the encoder **194** converts the mechanical rotation of the motor shaft **192** into electrical pulses that provide speed and other motor control information to the control module **24**.

[0054] As can also be seen in FIG. **1**, a drive gear **196** may be attached to the motor shaft **195**. The drive gear **196** may be supported in meshing engagement with a driven gear **222** that may be attached to the tissue cutting blade **220**. Such arrangement serves to facilitate the rotation of the tissue cutting blade **220** about the longitudinal axis A-A when the motor **190** is powered. The tissue cutting blade **220** may also be rotatably supported within an outer sheath **230** by one or more bearings **224**. The outer sheath **230** may be fixed to the housing **102** and have a substantially blunt distal end **232**. A hole or opening **236** may be provided through the blunt distal end **232** to enable at least a portion of a distal end **202** of the ultrasonic blade **200** to protrude therethrough. See FIGS. **1** and **2**. The distal end **202** of the ultrasonic blade **200** may have a ball-like shape as shown in FIGS. **1-3** or, in other embodiments for example, the distal end **202** may have a somewhat flattened portion **206** with an arcuate or rounded distal surface **208** as shown in FIGS. **5** and **6**.

[0055] The tissue cutting blade **220** may have various configurations. In the embodiment depicted in FIGS. **2-4**, the tissue cutting blade **220** has two opposed arcuate portions **221** that serve to form four tissue cutting edges **223**. As can be seen in FIG. **2**, one portion of the tissue cutting blade **220** is exposed through the distal tissue opening **234**. Because in this embodiment, the tissue cutting blade **220** is not ultrasonically active, the blade **220** may be fabricated from a material that will facilitate holding sharp edges. For example, the tissue cutting blade **220** may be fabricated from, for example, stainless steel or other suitable materials. In use, the surgeon could use the portion of the rotating tissue cutting blade **220** that is exposed through the distal tissue cutting opening **234** to cut tissue and then activate the ultrasonic blade **200** when it is needed for coagulation purposes. The surgeon would simply contact the target tissue with the exposed portion of the distal end **202** of the ultrasonic blade **200** while activating the ultrasonic transducer assembly **114**.

[0056] FIG. **7** illustrates another surgical instrument **300** of the present invention. The surgical instrument **300** includes a housing **302** that may house a transducer assembly **314** that includes an ultrasonic horn **324**. The ultrasonic transducer assembly **314** may comprise at least one and preferably a stack of, for example, four to eight ceramic piezoelectric elements **315** with a motion null point located at some point along the stack. In this embodiment, the transducer assembly **314** is non-rotatably supported within the housing **302**. Power may be transmitted to the ultrasonic transducer assembly **314** by conductors **360**, **362** which are coupled to the ultrasonic generator **12** in the control system **10**. The surgical instrument **300** may include a control arrangement of the type described above and be used in the various modes described above. The motor **340** may have an encoder **341** associated therewith that communicates with the control module **24** as was described above. The motor **340** may receive power from the motor drive **26** through conductors **342**, **343** that comprise motor cable **74** that extends through the common sheath **76**.

[0057] An ultrasonic blade **200** of the types and construction described above may be attached to the ultrasonic horn **324** in a manner described above and may extend through a bore **342** in a motor **340** that is mounted within the housing **302**. In alternative embodiments, however, the ultrasonic blade **200** may be integrally formed with the ultrasonic horn **324**. A tissue cutting blade **220** of the various types and constructions described above may be attached to a rotatable portion/shaft of the motor **340**. For example, those motors manufactured by National Instruments may be used. However, other motors may also be successfully employed. The tissue cutting blade **220** may coaxially extend through an outer sheath **230** that is attached to the housing **302**. The outer sheath **230** may be fabricated from, for example, aluminum, titanium, aluminum alloys, steels, ceramics, etc. The tissue cutting blade **220** may be rotatably supported by one or more bearings **332** mounted between the housing **302** and/or the outer sheath **230**. One or more seals **250** of the type and construction described in one of the aforementioned patent applications or others may be mounted between the ultrasonic blade **200** and the tissue cutting blade **220**. The ultrasonic horn **324** may be coupled to the proximal end of the ultrasonic blade **200** in the manner described above. In use, the surgeon may use the portion of the rotating tissue cutting blade **220** that is exposed through the distal tissue cutting opening **234** in the outer sheath **230** to cut tissue and then activate the ultrasonic blade **200** when it is needed for coagulation purposes. The surgeon would simply contact the target tissue with the distal end **202** of the ultrasonic blade **200** while activating the ultrasonic transducer assembly **314**. It will be understood that the instrument **300** may be used in a tissue cutting rotation mode, an ultrasonic mode, or tissue cutting and ultrasonic mode ("duel mode").

[0058] FIG. **8** illustrates an alternative surgical instrument **300'** that is substantially identical to surgical instrument **300** described above, except for the following differences. As can be seen in FIG. **8**, the ultrasonic transducer assembly **314** and the ultrasonic blade **200** are capable of being moved axially by a trigger **370** that is pivotally coupled to the housing **302'**. In various embodiments, the trigger **370** may have a yoke **372** that is configured to engage a portion of the transducer assembly **314** such that when the trigger **370** is pivoted (arrow "B") , the ultrasonic transducer assembly **314**, and ultrasonic blade **200** move axially along axis A-A (represented by arrow "C"). This "gross" axial motion is distinguishable from ultrasonic axial motion achieved when the ultrasonic transducer assembly **314** is powered.

[0059] FIG. **9** illustrates another surgical instrument **400** of the present invention. The surgical instrument **400** includes a housing **402** that may house an ultrasonic transducer assembly **414** that includes an ultrasonic horn **424**. The ultrasonic transducer assembly **414** may comprise at least one and preferably a stack of, for example, four to eight PZT-8 (Lead Zirconium Titanate) ceramic piezoelectric elements **415** with a motion null point located at some point along the stack. In this embodiment, the ultrasonic transducer assembly **414** is attached to a transducer housing **430** that is rotatably supported within the housing **402** by a distal bearing **436**. The ultrasonic transducer assembly **414** may be substantially ultrasonically insulated from the transducer housing **430** by, for example, epdm elastomeric materials or by a flange placed at a Node and damped by a dampening member such that ultrasonic motion from the ultrasonic transducer assembly **414** is not passed to the transducer housing. A tissue cutting blade **220** of the various types and constructions described above may be attached to the transducer housing **430** for rotatable travel therewith. The tissue cutting blade **220** may coaxially extend through an outer sheath **230** that is attached to the housing **402**. The tissue cutting blade **220** may be rotatably supported by one or more bearings **432** mounted between the housing **402** and/or the outer sheath **230**. One or more seals **250** may be mounted between the ultrasonic blade **200** and the tissue cutting blade **200**. The ultrasonic horn **424** may be coupled to the proximal end of the ultrasonic blade **200** in the manner described above. In alternative embodiments, the ultrasonic blade **200** may be integrally formed with the ultrasonic horn **424**.

[0060] This embodiment may include a conventional stepper motor **440**. The motor **440** may have an encoder associated therewith that communicates with the control module **24** as was described above. The motor **440** may receive power from the motor drive **26** through conductors **441**, **442** that comprise motor cable **74** that extends through the common sheath **76**. The motor **440** may have a hollow motor shaft **444** attached thereto that extends through a slip ring assembly **450**. The hollow motor shaft **444** may be rotatably supported within the housing **402** by a proximal bearing **446**.

[0061] The slip ring assembly **450** may be fixed (i.e., non-rotatable) within the housing **402** and may include a fixed outer contact **452** that is coupled to conductors **453**, **454** that form generator cable **14** as was described above. An inner contact **456** may be mounted on the rotatable hollow drive shaft **444** such that it is in electrical contact or communication with outer contact **452**. Conductors **453**, **454** are attached to the inner contact **456** and extend through the hollow motor shaft **444** to be coupled to the ultrasonic transducer assembly **414**. In various embodiments, to facilitate ease of assembly and also acoustically isolate the motor **440** from the ultrasonic transducer assembly **414**, the hollow motor shaft **444** may be detachably coupled to the transducer **430** by one of the various coupling assemblies disclosed in copending U.S. patent application Ser. No. 12/703,860, entitled ULTRASONICALLY POWERED SURGICAL INSTRUMENTS WITH ROTATING CUTTING IMPLEMENT, now U.S. Pat. No. 8,531,064, the disclosure of which has been herein incorporated by reference in its entirety.

[0062] When power is supplied to the motor **440**, the drive shaft **444** rotates about axis A-A which also causes the transducer housing **430** to rotate about axis A-A. Because ultrasonic transducer assembly **414** and the tissue cutting blade **220** are attached to the transducer housing **430**, they, too, rotate about axis A-A. When the clinician desires to power the ultrasonic transducer assembly **414**, power is supplied from the ultrasonic generator **12** to the fixed contact **452** in the slip ring assembly **450**. Power is transmitted to the ultrasonic transducer assembly **414** by virtue of rotational sliding contact or electrical communication between the inner contact **456** and the fixed contact **452**. Those signals are transmitted to the ultrasonic transducer assembly **414** by conductors **460**, **462**. The surgical instrument **400** may include a control arrangement of the type described above and be used in the various modes described above. It will be understood that the instrument **400** may be used in rotation mode, ultrasonic mode, or rotation and ultrasonic mode ("duel mode").

[0063] FIG. **10** illustrates another surgical instrument **500** of the present invention. The surgical instrument **500** includes a housing **502** that may house an ultrasonic transducer assembly **514** that includes an ultrasonic horn **524**. The ultrasonic transducer assembly **514** may comprise at least one and preferably a stack of, for example, four to eight PZT-8 (Lead Zirconium Titanate) ceramic piezoelectric elements **515** with a motion null point located at some point along the stack. In this embodiment, the ultrasonic transducer assembly **514** is contained within a sealed transducer chamber **526** that is rotatably supported within the housing **502** by a distal bearing **536**. In various embodiments, the sealed transducer chamber **526** may be fabricated from magnetic material such as, for example, iron, rare earth magnetic materials, etc. A tissue cutting blade **220** of the various types and constructions described above may be attached to the transducer chamber **526** for rotatable travel therewith. The tissue cutting blade **220** may coaxially extend through an outer sheath **230** that is attached to the housing **502**. The outer sheath **230** may be fabricated from, for example, aluminum, titanium, aluminum alloys, steels, ceramics, etc. The tissue cutting blade **220** may be rotatably supported by one or more bearings **532** mounted between a nosepiece portion **503** of the housing **502** and/or the outer sheath **230**. One or more seals **250** may be mounted between the ultrasonic blade **200** and the tissue cutting blade **220**. The ultrasonic horn **524** may be coupled to the proximal end of the ultrasonic blade **200** in the manner described above. In alternative embodiments, the ultrasonic blade **200** may be integrally formed with the ultrasonic horn **524**.

[0064] This embodiment includes a motor **540** that may comprise a stepper motor of the type and construction described above. The motor **540** may have an encoder associated therewith that communicates with the control module **24** as was described above. The motor **540** may receive power from the motor drive **26** through conductors **541**, **542** that comprise motor cable **74** that extends through the common sheath **76** (FIG. **1**). The motor **540** has a motor shaft **544** attached thereto that is coupled to a magnetic yoke **560** which is magnetically coupled to the transducer chamber **526**. The motor shaft **544** may be rotatably supported within the housing **502** by a proximal bearing **546**.

[0065] A movable contact **550** may be fixed to the sealed transducer chamber **526** and is coupled to the transducer assembly **514** by conductors **552** and **553**. A fixed outer contact **554** may be attached to the housing **502** and is coupled to conductors **555**, **556** that form generator cable **14** as was described above. When power is supplied to the motor **540**, the motor shaft **544** rotates about axis A-A which also causes the transducer chamber **526** to rotate about axis A-A. Because ultrasonic transducer assembly **514** and the tissue cutting blade **220** are attached to the transducer chamber **526**, they, too, rotate about axis A-A. When the clinician desires to power the ultrasonic transducer assembly **514**, power is supplied from the ultrasonic generator **12** to the fixed contact **554**. Power is transmitted to the ultrasonic transducer assembly **514** by virtue of rotational sliding contact or electrical communication between the fixed contact **554** and the movable contact **550**. Those signals are transmitted to the ultrasonic transducer assembly **514** by conductors **553**, **554**. The surgical instrument **500** may include a control arrangement of the type described above and be used in the various modes described above. It will be understood that the instrument **500** may be used in rotation mode, ultrasonic mode, or rotation and ultrasonic mode ("duel mode").

[0066] FIGS. **11** and **12** illustrate another surgical instrument **600** of the present invention. The surgical instrument

600 includes a housing **602** that may support a hollow transducer housing **620**. The hollow transducer housing **620** may support a plurality of (e.g., four to eight) piezoceramic elements **622** and may have an ultrasonic horn portion **624** integrally formed therewith. A series of internal threads **625** may be formed on the distal end portion of the horn portion **624** for attachment to a hollow ultrasonic blade **630**. Ultrasonic blade **630** may be fabricated from, for example, aluminum, titanium, aluminum alloys, steels, ceramics, etc. and have a threaded proximal end **632** for threaded attachment to the threads **625** on the ultrasonic horn portion **624**. As can be further seen in FIG. **11**, a proximal end **626** of the transducer housing **620** may have threads **627** formed thereon for threaded attachment to a threaded bushing **640**. Threaded bushing **640** may have an axial passage **642** therethrough for receiving a rotatable tissue cutting or "shaver" blade **650** therethrough. In various embodiments, the shaver blade **650** may be fabricated from, for example, aluminum, titanium, aluminum alloys, steels, ceramics, etc. and be rotatably supported within the transducer housing **620** by a bearing **651** that is located at a node "N" in the housing **620**. The proximal end **652** of the shaver blade **650** may be attached to a motor **660**. The shaver blade **650** may for example, be attached to a drive shaft **662** of the motor **660** by threads (not shown) or other suitable coupling arrangement. The transducers **622** may receive power from the ultrasonic generator **12** in the control system **10** through conductors **628**, **629**. Motor **660** may communicate with the various components in the control system **10** through conductors **664**, **665**.

[0067] In various embodiments, the shaver blade **650** may have a distal end **654** that may be configured to cut tissue when the blade **650** is rotated about axis A-A. In one embodiment, for example, the distal end **654** has a series of teeth **656** formed thereon. See FIG. **12**. Also in various embodiments, the shaver blade **650** may have an axial suction lumen **657** therethrough. At least one discharge hole **658** is provided through the shaver blade **650** to enable the suction lumen **657** to discharge cut tissue and fluids therethrough into a suction chamber **670** located within the housing **602**. The suction chamber **670** may be sealingly attached to the bushing **640** or be otherwise supported within the housing **602** such that the shaver blade **650** extends therethrough. Because the bushing **640** is part of the acoustic system and attachment of the suction chamber **670** to the bushing **640** would make it part of the acoustic system as well, it is desirable for the connection between the suction chamber **670** and the bushing **640** to be located at a Node of vibration. In the embodiment depicted in FIG. **11**, a shaft seal **672** may be provided on the shaver blade **650** to establish a substantially fluid-tight seal between the shaver blade **650** and the suction chamber **670**. In various embodiments, the shaft seal **672** may be fabricated from, for example, silicone rubber, epdm rubber, Teflon®, Ultem®, etc. The suction chamber **670** may discharge through a flexible hose **674** that communicates with a collection receptacle **676** and a source of suction **678**.

[0068] The instrument **600** may further have an acoustically isolated hollow sheath **680** that extends from the housing **602** to cover a substantial portion of the ultrasonic blade **630**. That is, in various embodiments, the hollow sheath **680** may cover all of the ultrasonic blade **630** except for a distal end portion **634** that has a blade opening **635** therein. See FIG. **12**. The hollow sheath **680** may be fabricated from flouroethylene-propelene (FEP), silicon or similar materials that can acoustically isolate or acoustically insulate the outside of the ultrasonic blade **630**. At least one seal **636** may be employed between the outer sheath **680** and the ultrasonic blade **630**. Similarly, the ultrasonic blade **630** may be isolated from the shaver blade **650** by at least one seal **651**. In various embodiments, the seals **636**, **651** may comprise one or more seals of the type described in co-pending U.S. patent application Ser. No. 12/703,866, entitled SEAL ARRANGEMENTS FOR ULTRASONICALLY POWERED SURGICAL INSTRUMENTS, now U.S. Pat. No. 8,951,272, which has been herein incorporated by reference in its entirety. As can also be seen in FIGS. **11** and **12**, the distal end portion **634** of the ultrasonic blade **630** may be substantially blunt or rounded.

[0069] When power is supplied to the motor **660**, the drive shaft **662** rotates about axis A-A which also causes the shaver blade **650** to rotate about axis A-A. Activation of the source of suction **678** causes suction to be applied to the suction lumen **657** in the shaver blade **650** to draw tissue into the opening **635** in the hollow sheath **680** and into contact with the rotating shaver blade **650**. The source of suction **678** may communicate with and be controlled by the control system **10** such that suction is only applied to the lumen **657** when the shaver blade **650** is being rotated by motor **660**.

[0070] The surgical instrument **600** may have two primary modes of operation. One mode is the shaver mode, in which the shaver blade **650** rotates in concert with suction to cut tissue that enters the opening **636**. The other mode is the ultrasonic coagulation mode. As an ultrasonic instrument, the ultrasonic blade **630** is driven in a linear ultrasonic vibration mode by the transducers **622**. The user is able to coagulate bleeders and tissue as needed with the exposed distal end **634** of the ultrasonic blade **630**. In use, the instrument **600** can be activated in shaver modes independently or in ultrasonic mode independently. Both modes can also be activated together and suction can be turned on and off at any time. When using the instrument **600** in one of the ultrasonic modes, the distal end **634** of the ultrasonic blade **630** can be used to coagulate tissue while the remainder of the device can safely come in contact with tissue outside of the targeted site because it is not ultrasonically active.

[0071] FIGS. **13-17** illustrate another surgical instrument **700** of the present invention. The surgical instrument **700** may include a housing **702** that may be manufactured in multiple pieces from, for example, plastics such as polycarbonate, polyetherimide (GE Ultem®) or metals such as aluminum, titanium or steel that are coupled together by fasteners such as screws, bolts, snap features or may be retained together by adhesive, welding, etc. As can be seen in FIGS. **13** and **15-17**, the housing **702** may define a suction chamber **703** that communicates with a suction port **705**. A flexible tube or other suitable conduit **707** may be coupled to the suction port **705** as well as to a collection receptacle **709** that may be located within the surgical suite. The collection receptacle **709** may be coupled to a source of suction **711** to apply suction to the suction chamber **703** through the flexible tube **707** and suction port **705**. A motor **710** of the type and construction described above may also be supported within the housing **702**. The motor **710** has a drive shaft **712** that extends into the suction chamber **703**. The drive shaft **712** may be supported by a bearing **714** in a wall of the suction chamber **703**. A seal **716** may also be employed to achieve a substantially fluid-tight seal between the drive shaft **712** and the wall of the suction chamber **703**. The motor **710** may communicate with the various components of the control system **10** through conductors **717**, **718** in the manner discussed above.

[0072] An ultrasonic transducer assembly **720** that has an ultrasonic horn portion **722** attached thereto or integrally formed therewith may also be supported within the housing **702**. The ultrasonic transducer assembly **720** may comprise at least one and preferably a stack of, for example, four to eight lead zirconate titanate (PZT-8) ceramic piezoelectric elements **725** with a motion null point located at some point along the stack. In various embodiments, for example, a series of internal threads (not shown) may be formed on the distal end portion of the horn portion **722** for attachment to an ultrasonic blade **760**. Ultrasonic blade **760** may have a threaded proximal end **762** for threaded attachment to the horn portion **722** as will be discussed in further detail below. The surgical instrument **700** may further include a hollow tissue cutting or "shaver" blade **730** that may be fabricated from, for example, aluminum, titanium, aluminum alloys, titanium alloys, steels, ceramics, etc. A distal end **732** of the shaver blade **730** may have serrations **734** formed thereon or, in other embodiments, the serrations may be omitted. In some embodiments, a proximal end **736** of the shaver blade **730** may be fabricated for removable attachment to the drive shaft **712** of the motor **710**. In one embodiment, for example, a "quarter-twist" or bayonet-type coupling **738** may be employed to couple the proximal end **736** of the shaver blade **730** to a corresponding coupling portion **713** that is attached to the drive shaft **712**. Such bayonet coupling arrangements are known and may facilitate coupling of the shaver blade **730** to the drive shaft **712** by engaging the coupling portions **738**, **713** and rotating the blade **730** while the drive shaft **712** remains stationary. Other forms of coupling arrangements could also be successfully employed without departing from the spirit and scope of the present invention. The shaver blade **730** may further have a suction lumen **740** that extends therethrough. At least one suction hole **742** may provided in the proximal end **736** of the shaver blade **730** to enable the suction lumen **740** extending therethrough to discharge into the suction chamber **703** when the proximal end **736** is coupled to the drive shaft **712** as illustrated in FIG. **13**.

[0073] In various embodiments, the surgical instrument **700** may further include an outer sheath assembly **770** that may be fixedly attached to the housing **702**. In one embodiment, for example, the proximal end **772** of the outer sheath assembly **770** may include a quarter-turn or bayonet-type coupling arrangement that is configured for attachment to the distal end **701** of the housing **702**. However, other known coupling arrangements may be employed for removably coupling the outer sheath assembly **770** to the housing **702** without departing from the spirit and scope of the present invention. As can be most particularly seen in FIG. **14**, the outer sheath assembly **770** may have a shaver blade lumen **774** that extends therethrough and which is sized to rotatably receive the shaver blade **730** therein. Various embodiments may also employ a bearing **776** in the proximal end **772** of the outer sheath assembly **770** for rotatably supporting the shaver blade **730** therein. Additional bearing and/or seal arrangements may be employed to rotatably support the shaver blade **730** within the outer sheath assembly **770**. The distal end **778** of the outer sheath assembly **770** may also have an opening **780** therein to expose the distal end **732** of the shaver blade **730**. The distal end **778** of the outer sheath assembly **770** may also form a cutting board surface **782** upon which the distal end **732** of the shaver blade **730** may oscillate. The outer sheath assembly **770** may further have an ultrasonic blade lumen **790** for receiving the ultrasonic blade **760** therein. The ultrasonic blade lumen **790** may be substantially parallel to the shaver blade lumen **774**. One or more seal members (not shown) of the type and construction described in the aforementioned pending patent applications that have been incorporated herein by reference or others may be employed to support the ultrasonic blade **760** within the ultrasonic blade lumen **790** while achieving a substantially fluid tight seal between the blade **760** and the lumen **790**.

[0074] Assembly of the instrument **700** will now be explained with reference to FIGS. **16** and **17**. As can be seen in FIG. **16**, for example, the proximal end **762** of the ultrasonic blade **760** is attached to the ultrasonic horn **722**. In one embodiment, the proximal end **762** of the ultrasonic blade **760** is threaded onto the ultrasonic horn **722**. In still other embodiments, however, the ultrasonic blade **760** may be integrally formed with the ultrasonic horn **722**. After the ultrasonic blade **760** is coupled to the ultrasonic horn **722**, the outer sheath assembly **770** with the shaver blade **730** supported therein is oriented such that the distal end **764** of the ultrasonic blade **760** is introduced into the lumen **790**. The outer sheath assembly **770** is then slid over the ultrasonic blade **760** to bring the proximal end **772** of the outer sheath assembly **770** into engagement with the distal end **701** of the housing **702**. The outer sheath assembly **770** may then be manipulated in a known manner to couple the bayonet-type coupling arrangement together. In other embodiments, the outer sheath assembly **770** may be permanently fixed to the housing **702** with adhesive, welding, etc. In still other arrangements, the outer sheath assembly **770** may be attached to the housing **702** with removable fasteners such as screws, bolts, etc.

[0075] In use, the control system **10** components may be employed to control motor **710** such that the drive shaft **712** is caused to oscillate back and forth about axis A-A which also causes the shaver blade **730** to rotate about axis A-A. Activation of the source of suction **711** may cause suction to be applied to the suction lumen **740** in the shaver blade **730** to draw tissue into contact with the oscillating distal end **732** of the shaver blade **730**. Pieces of severed tissue may be drawn in through the suction lumen **740** and ultimately be collected in the collection receptacle **709**. If hemostasis is desired, the surgeon can activate the ultrasonic transducer assembly **720** to ultrasonically power the ultrasonic blade **760**. The distal end **764** of the ultrasonic blade **760** that protrudes out of the outer sheath assembly **770** (FIG. **13**) may then be pressed against the bleeding tissue to utilize the ultrasonic energy to stop the bleeding.

[0076] FIGS. **18** and **19** illustrate another surgical instrument **800** of the present invention. The surgical instrument **800** may include a housing **802** that may be manufactured in multiple pieces from, for example, plastics such as polycarbonate, polyetherimide (GE Ultem®) or metals such as aluminum, titanium or steel that are coupled together by fasteners such as screws, bolts, snap features or may be retained together by adhesive, welding, etc. As can be seen in FIG. **18**, the housing **802** may define a suction chamber **803** that communicates with a suction port **805**. A flexible tube or other suitable conduit **807** may be coupled to the suction port **805** as well as to a collection receptacle **809**.

The collection receptacle **809** may be coupled to a source of suction **811** for applying suction to the suction chamber **803** through the flexible tube **807** and suction port **805**. A motor **810** of the type and construction described above may also be supported within the housing **802**. The motor **810** has a motor drive shaft **812** that extends into the suction chamber **803**. The motor drive shaft **812** may be supported by a bearing **814** in a wall of the suction chamber **803**. A seal **816** may also be employed to achieve a substantially fluid-tight seal between the drive shaft **812** and the wall of the suction chamber **803**. The motor **810** may communicate with the various components of the control system **10** through conductors **817**, **818** in the various manners described above.

[0077] Also supported in the housing **802** is an ultrasonic transducer assembly **820** that has an ultrasonic horn portion **822** attached thereto or integrally formed therewith. The ultrasonic transducer assembly **820** may comprise at least one and preferably a stack of, for example, four to eight lead zirconate titanate (PZT-8) ceramic piezoelectric elements **821** with a motion null point located at some point along the stack. In various embodiments, the ultrasonic blade **860** may be attached to the distal end of the horn portion **822** by, for example, a screw fitting. The surgical instrument **800** may further include a hollow shaver blade **830** that may be fabricated from, for example, aluminum, titanium, aluminum alloys, titanium alloys, steels, ceramics, etc. A distal end **832** of the shaver blade **830** may have an opening **834** therein that forms two sharp tissue cutting edges **835**, **837** as shown in FIG. **19**. A proximal end **836** of the shaver blade **830** may have a driven gear **838** that is retained in meshing engagement with a drive gear **818** attached to the drive shaft **812** of the motor **810**. The shaver blade **830** may further have a suction lumen **840** that extends therethrough. At least one suction hole **882** may be provided in the proximal end **836** of the shaver blade **830** to discharge into the suction chamber **803** when the proximal end **836** is coupled to the drive shaft **812** as illustrated in FIG. **18**.

[0078] In various embodiments, the surgical instrument **800** may further include a shaver blade sheath **870** that may be fixedly attached to the housing **802**. In one embodiment the proximal end **872** of the shaver blade sheath **870** may be fabricated from, for example, a metal material such as aluminum, titanium, steels, titanium alloys or aluminum alloys and include a quarter-turn or bayonet-type coupling arrangement that is configured for attachment to the distal end **801** of the housing **802**. However, other known coupling arrangements may be employed for removably coupling the shaver blade sheath **870** to the housing **802** without departing from the spirit and scope of the present invention. As can be most particularly seen in FIG. **18**, the shaver blade sheath **870** may have a shaver blade lumen **874** extending therethrough that is sized to rotatably receive the shaver blade **830** therein. Various embodiments may also employ a bearing (not shown) in the proximal end of the shaver blade sheath **870** for rotatably supporting the shaver blade **830** within the shaver blade sheath **870**. Additional bearing and/or seal arrangements may be employed to rotatably support the shaver blade **830** within the shaver blade sheath **870**. The distal end **878** of the shaver blade sheath **870** may for a substantially blunt closed end that has an opening **880** therein to expose the distal end **832** of the shaver blade **830**.

[0079] Also in this embodiment, an ultrasonic blade sheath **890** may be attached to the housing **802**. In various embodiments, for example, the ultrasonic blade sheath **890** may be fabricated from a polymer material such as polyetherimide, liquid crystal polymers, polycarbonate, nylon or ceramic material and be attached to the housing **802** by screw threads, bonding, press fitting, crimping, etc. The ultrasonic blade sheath **890** may further have an ultrasonic blade lumen **892** extending therethrough for receiving the ultrasonic blade **860** therein. One or more seal members (not shown) of the type and construction described in the aforementioned pending patent applications that have been incorporated by reference or others may be employed to support the ultrasonic blade **860** within the lumen **892** while achieving a substantially fluid-tight seal between the blade **860** and the lumen **892**. The ultrasonic blade sheath **890** may further have an opening **896** in a distal end **894** to expose a distal end **864** of the ultrasonic blade **860**.

[0080] In use, the control system **10** components may be used to control motor **810** such that the drive shaft **812** is rotated about axis A-A which also causes the shaver blade **830** to rotate about axis A-A. Activation of the source of suction **811** will cause suction to be applied to the suction lumen **840** in the shaver blade **830** to draw tissue in through the opening **880** in the distal end **878** of the shaver blade sheath **870** and into the opening **834** in the shaver blade **830**. Pieces of severed tissue may be drawn in through the suction lumen **840** and ultimately be collected in the collection receptacle **809**. If hemostasis is desired, the surgeon can activate the ultrasonic transducer assembly **820** to ultrasonically power the ultrasonic blade **860**. The distal end **864** that protrudes out of the ultrasonic sheath assembly **890** (FIG. **19**) may then be pressed against the bleeding tissue to utilize the ultrasonic energy to stop the bleeding.

[0081] 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 can 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 pieces, and subsequent reassembly. In particular, the device can be disassembled, and any number of the particular pieces or parts of the device can be selectively replaced or removed in any combination. Upon cleaning and/or replacement of particular parts, the device can 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 can 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.

[0082] 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. Sterilization can also be done by any number of ways known to those skilled in the art including beta or gamma radiation, ethylene oxide, and/or steam.

[0083] In various embodiments, an ultrasonic surgical instrument can be supplied to a surgeon with a waveguide and/or end effector already operably coupled with a transducer of the surgical instrument. In at least one such embodiment, the surgeon, or other clinician, can remove the ultrasonic surgical instrument from a sterilized package, plug the ultrasonic instrument into a generator, as outlined above, and use the ultrasonic instrument during a surgical procedure. Such a system can obviate the need for a surgeon, or other clinician, to assemble a waveguide and/or end effector to the ultrasonic surgical instrument. After the ultrasonic surgical instrument has been used, the surgeon, or other clinician, can place the ultrasonic instrument into a sealable package, wherein the package can be transported to a sterilization facility. At the sterilization facility, the ultrasonic instrument can be disinfected, wherein any expended parts can be discarded and replaced while any reusable parts can be sterilized and used once again. Thereafter, the ultrasonic instrument can be reassembled, tested, placed into a sterile package, and/or sterilized after being placed into a package. Once sterilized, the reprocessed ultrasonic surgical instrument can be used once again.

[0084] 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.

[0085] All of the above U.S. Patents and U.S. Patent applications, and published U.S. Patent Applications referred to in this specification are incorporated herein by reference in their entirety, but only to the extent that the incorporated material does not conflict with existing definitions, statements, or other disclosure material set forth in this disclosure. As such, and to the extent necessary, the disclosure as explicitly set forth herein supersedes any conflicting material incorporated herein by reference. Any material, or portion thereof, that is said to be incorporated by reference herein, but which conflicts with existing definitions, statements, or other disclosure material set forth herein will only be incorporated to the extent that no conflict arises between that incorporated material and the existing disclosure material.

1-20. (canceled)

21. An ultrasonic surgical instrument, comprising:

a housing;

a motor assembly supported by the housing;

a cutting blade, wherein a proximal end of the cutting blade is configured to be removably coupled to the motor assembly;

an ultrasonic transducer assembly supported by the housing;

an ultrasonic blade, wherein a proximal end of the ultrasonic blade is configured to be removably coupled to the ultrasonic transducer assembly; and

an outer sheath configured to support the cutting blade and the ultrasonic blade, wherein a proximal end of the outer sheath is configured to be removably coupled to the housing.

22. The ultrasonic surgical instrument of claim **21**, wherein the outer sheath defines a longitudinally extending lumen, the longitudinally extending lumen configured to receive the cutting blade.

23. The ultrasonic surgical instrument of claim **22**, wherein the outer sheath further defines a distal aperture, the distal aperture configured to expose at least a portion of a distal end of the cutting blade.

24. The ultrasonic surgical instrument of claim **23**, wherein the distal end of the cutting blade is configured to cut tissue.

25. The ultrasonic surgical instrument of claim **21**, wherein the outer sheath defines a longitudinally extending lumen, the longitudinally extending lumen configured to receive the ultrasonic blade.

26. The ultrasonic surgical instrument of claim **25**, wherein the outer sheath further defines a distal aperture, the distal aperture positioned for a distal portion of the ultrasonic blade to protrude from the outer sheath.

27. The ultrasonic surgical instrument of claim **21**, wherein the proximal end of the ultrasonic blade defines threads to removably couple the ultrasonic blade to the ultrasonic transducer assembly.

28. The ultrasonic surgical instrument of claim **21**, wherein the housing defines a suction chamber fluidically coupled to a suction port, wherein the cutting blade defines a suction lumen extending between the proximal end and an opening at a distal end of the cutting blade, and wherein the cutting blade further defines a suction aperture at a proximal portion of the cutting blade to fluidically couple the suction lumen to the suction chamber.

29. The ultrasonic surgical instrument of claim **21**, wherein the motor assembly comprises a drive shaft, wherein a first coupling portion is positioned at a distal end of the drive shaft, wherein the proximal end of the cutting blade comprises a second coupling portion, and wherein the second coupling portion is configured to engage the first coupling portion to couple the cutting blade to the motor assembly.

30. An ultrasonic surgical instrument, comprising:

a housing;

a motor assembly contained within the housing;

a cutting blade, wherein a proximal end of the cutting blade is configured to be detachable from and reattachable to the motor assembly;

an ultrasonic transducer assembly contained within the housing;

an ultrasonic blade coupled to and extending distally from the ultrasonic transducer assembly; and

an outer sheath, wherein a proximal end of the outer sheath is configured to be detachable from and reattachable to the housing, and wherein the outer sheath:

defines a first longitudinally extending lumen configured to rotatably support the cutting blade; and

defines a second longitudinally extending lumen configured to support axial motion of the ultrasonic blade.

31. The ultrasonic surgical instrument of claim **30**, wherein the outer sheath further defines a first distal aperture, the first distal aperture configured to expose at least a portion of a distal end of the cutting blade.

32. The ultrasonic surgical instrument of claim **31**, wherein the distal end of the cutting blade is configured to cut tissue.

33. The ultrasonic surgical instrument of claim **31**, wherein the outer sheath further defines a second distal aperture, the second distal aperture positioned for a distal portion of the ultrasonic blade to protrude from the outer sheath.

34. The ultrasonic surgical instrument of claim **30**, wherein the housing defines a suction chamber, wherein the cutting blade defines a suction lumen extending within the cutting blade between the proximal end and an opening at a distal end of the cutting blade, and wherein the cutting blade further defines an aperture at a proximal portion of the cutting blade to fluidically couple the suction lumen to the suction chamber.

35. The ultrasonic surgical instrument of claim **30**, wherein the proximal end of the cutting blade comprises a portion of a coupling arrangement configured such that the cutting blade is detachable from and reattachable to the motor assembly.

36. An ultrasonic surgical instrument, comprising:

a housing, comprising:

a motor assembly; and

an ultrasonic transducer assembly;

an ultrasonic blade, wherein a proximal end of the ultrasonic blade is configured to be removably attached to the ultrasonic transducer assembly; and

an outer sheath assembly, comprising:

a cutting blade, wherein a proximal end of the cutting blade is configured to be removably attached to the motor assembly; and

an outer sheath, wherein a proximal end of the outer sheath is configured to be removably attached to the housing, and wherein the outer sheath:

defines a first axial lumen configured to support the cutting blade; and

defines a second axial lumen configured to receive the ultrasonic blade.

37. The ultrasonic surgical instrument of claim **36**, wherein the outer sheath further defines a first distal aperture, the first distal aperture configured to expose at least a portion of a distal end of the cutting blade.

38. The ultrasonic surgical instrument of claim **37**, wherein the distal end of the cutting blade is configured to cut tissue.

39. The ultrasonic surgical instrument of claim **37**, wherein the outer sheath further defines a second distal aperture, the second distal aperture positioned for a distal portion of the ultrasonic blade to protrude from a distal portion of the outer sheath.

40. The ultrasonic surgical instrument of claim **36**, wherein the housing defines a suction chamber, wherein the cutting blade defines an axial suction lumen fluidically coupled with an opening at a distal end of the cutting blade, and wherein the cutting blade further defines an aperture at a proximal portion of the cutting blade to fluidically couple the axial suction lumen to the suction chamber within the housing.

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专利名称(译)	用于切割和凝固组织的两用手术器械		
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[标]申请(专利权)人(译)	ETHICON , LLC		
申请(专利权)人(译)	ETHICON LLC		
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摘要(译)

公开了一种超声外科手术器械。超声外科手术器械可包括：壳体，由壳体支撑的马达组件，切割刀片，其中切割刀片的近端构造成可拆卸地连接到马达组件，超声换能器组件由壳体支撑，超声刀，其中超声刀的近端构造成可拆卸地连接到超声换能器组件，和外护套，构造成支撑切割刀和超声刀，其中外护套的近端构造成可拆卸地连接到壳体上。