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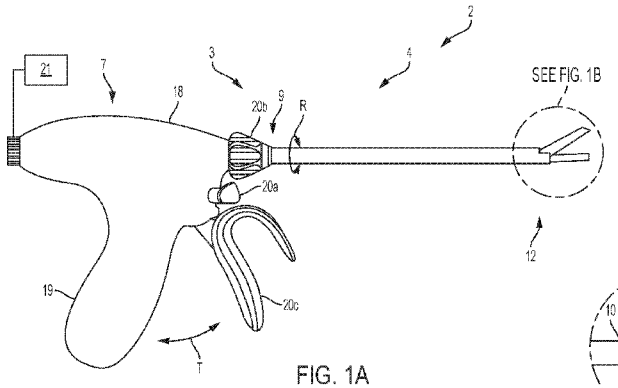



FIG. 1A

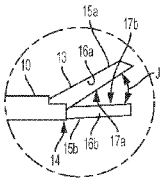



FIG. 1B

(57) Abstract: Aspects of the present disclosure are presented for a single surgical instrument configured for grasping tissue, performing sealing procedures using electrosurgical or ultrasonic energy, suctioning fluid, and providing irrigation. An end effector of the surgical instrument may include multiple members arranged in various configurations to collectively perform the aforementioned functions. The suction and irrigation elements may comprise one or more fluid paths configured to deliver fluid to or evacuate fluid from a surgical field. In this way, a user, such as a clinician or surgeon, may rely on a single surgical instrument to perform these tasks typical in surgery while having an extra hand available and so as to not need to divert his or her concentration away from the surgical site in order to access multiple devices. Further, the timing for performing each of the functions may be made quicker, due to not needing to switch using multiple devices.

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# SUCTION AND IRRIGATION SEALING GRASPER

## STATEMENT OF PRIORITY

**[0001]** This application claims the benefit of United States Provisional Application Serial No. 62/285,019, entitled "Suction and Irrigation Sealing Grasper," which was filed on October 16, 2015, the entirety of which is incorporated herein by reference and for all purposes.

## TECHNICAL FIELD

**[0002]** The present disclosure is related generally to medical devices with various mechanisms for grasping and sealing tissue. In particular, the present disclosure is related to medical devices with grasping instruments that perform sealing procedures and also include suction and irrigation functionality in the same device.

## BACKGROUND

**[0003]** In many surgeries, multiple devices are used to perform grasping of tissue, sealing of said tissue (e.g., using electrosurgical energy or in other cases ultrasonic energy), suctioning of nearby fluids and irrigation for flushing the surgical area. A surgeon may hold at least one device for performing at least one of these functions in the offhand. Assistance is typically needed to enable the surgeon to perform these multiple functions without losing concentration on the surgical site. It may desirable to provide a single surgical instrument configured to perform these multiple functions to aide the surgeon and increase performance, accuracy and safety during the surgery.

**[0004]** While several devices have been made and used, it is believed that no one prior to the inventors has made or used the device described in the appended claims.

## BRIEF SUMMARY

**[0005]** In some aspects, a surgical instrument is provided.

**[0006]** 1. In one example, the surgical instrument may include: a handle assembly, a shaft coupled to a distal end of the handle assembly, and an end effector coupled to a distal end of the shaft. The end effector may include: a first jaw, a second jaw, wherein

the first jaw and the second jaw cooperate to capture tissue therebetween; wherein at least one of the first and second jaws is configured to transmit electrosurgical energy to seal the tissue, a suction mechanism configured to suction fluid, and an irrigation mechanism configured to transmit fluid.

**[0007]** 2. In another example of the surgical instrument, the first jaw comprises the suction mechanism and the irrigation mechanism, and the second jaw comprises a surface configured to transmit the electrosurgical energy upon contact with the tissue.

**[0008]** 3. In another example of the surgical instrument, the first jaw comprises a tube running a longitudinal length of the first jaw, a distal end of the tube defining a suction and irrigation outlet on a distal end of the first jaw whereby fluid passes in or out of the first jaw.

**[0009]** 4. In another example of the surgical instrument, the tube comprises at least one irrigation and suction outlet positioned on a lateral side of the first jaw.

**[0010]** 5. In another example of the surgical instrument, the first jaw is configured to transmit electrosurgical energy at a first polarity and the second jaw is configured to transmit electrosurgical energy at a second polarity.

**[0011]** 6. In another example of the surgical instrument, the first jaw or the second jaw comprises at least one insulating pin protruding on an inner side of said first or second jaw facing the other second or first jaw such that the at least one insulating pin is configured to touch the other second or first jaw upon closure of the first and second jaws and prevent direct contact between the first and second jaws, the at least one insulating pin configured to prevent energy transfer between the first and second jaws.

**[0012]** 7. In another example of the surgical instrument, the end effector further comprises an insulated member positioned between the first and second jaws and is configured to isolate energy transfer between the first and second jaws.

**[0013]** 8. In another example of the surgical instrument, the insulated member comprises a suction and irrigation channel configured to suction fluid entering the end effector and transmit fluid into the end effector.

**[0014]** 9. In another example of the surgical instrument, the first and second jaws define an elongated fluid channel therebetween upon closure of the first and second jaws, wherein: a distal end of the elongated channel defines a suction and irrigation

outlet on a distal end of the first and second jaws whereby fluid passes in or out of the first and second jaws, and a proximal end of the elongated channel is fluidically coupled to the suction and irrigation channel of the insulated member.

**[0015]** 10. In another example of the surgical instrument, the suction mechanism and the irrigation mechanism are defined in part by the elongated fluid channel upon closure of the first and second jaws.

**[0016]** 11. In another example of the surgical instrument, the insulated member is configured to be translatable along a longitudinal axis of the shaft.

**[0017]** 12. In another example of the surgical instrument, translation of the insulated member in a distal direction along the longitudinal axis is configured to cause the first and second jaws to open, and translation of the insulated member in a proximal direction along the longitudinal axis is configured to cause the first and second jaw to close.

**[0018]** 13. In another example of the surgical instrument, the electrosurgical energy is monopolar.

**[0019]** 14. In another example of the surgical instrument, the electrosurgical energy is bipolar.

**[0020]** 15. In another example of the surgical instrument, the first jaw comprises a backside positioned on a far side from the second jaw, the backside comprising an electrosurgical pad configured to transmit electrosurgical energy for coagulating tissue upon contact with the tissue.

**[0021]** 16. In another example, a surgical instrument is presented. The surgical instrument may include: a handle assembly, a shaft coupled to a distal end of the handle assembly, and an end effector coupled to a distal end of the shaft. The end effector may include: an ultrasonic grasping member configured to contact tissue at a surgical site and transmit ultrasonic energy to the tissue upon contact, a suction mechanism configured to suction fluid, and an irrigation mechanism configured to transmit fluid.

**[0022]** 17. In another example of the surgical instrument, the end effector further comprises a suction and irrigation tube, the suction and irrigation tube partially defining the suction mechanism and the irrigation mechanism.

**[0023]** 18. In another example of the surgical instrument, at least one of the ultrasonic grasping member, the suction mechanism and the irrigation mechanism is configured to retract into the shaft.

**[0024]** 19. In another example, a surgical instrument is presented. The surgical instrument may include: a handle assembly, a shaft coupled to a distal end of the handle assembly, and an end effector coupled to a distal end of the shaft. The end effector may comprise: an outer tube coupled to the shaft, an inner tube positioned within the outer tube and coupled to an inner tube of the shaft; the inner tube comprising a grasping and sealing mechanism configured to grasp tissue and transmit energy to seal the tissue upon contact, the end effector further comprising a suction and irrigation mechanism defined in part by a space in between the inner tube and the outer tube. The suction and irrigation mechanism is configured to: suction fluid from a distal end of the end effector through the space in between the inner tube and the outer tube, and transmit fluid through the distal end of the effector from the space in between the inner tube and the outer tube.

**[0025]** 20. In another example of the surgical instrument, the outer tube is configured to retract to dispose the grasping and sealing mechanism during a grasping or sealing procedure, and the outer tube is further configured to extend during a suction or irrigation procedure.

**[0026]** 21. In some examples, a non-transitory computer readable medium is presented. The computer readable medium may include instructions that, when executed by a processor, cause the processor to perform operations comprising any of the operations described in examples 1–20.

**[0027]** 22. In some examples, a method for sealing tissue is presented. The method may include any of the procedures described in examples 1–21.

**[0028]** The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, examples, and features described above, further aspects, examples, and features will become apparent by reference to the drawings and the following detailed description.

## BRIEF DESCRIPTION OF THE DRAWINGS

**[0029]** The novel features of the aspects described herein are set forth with particularity in the appended claims. The aspects, however, both as to organization and methods of operation may be better understood by reference to the following description, taken in conjunction with the accompanying drawings as follows.

**[0030]** FIG. 1A shows a medical device, configurable with a fluid control system according to various aspects.

**[0031]** FIG. 1B shows a more detailed description of the end effector of the medical device in FIG. 1A.

**[0032]** FIG. 1C shows a schematic of one aspect of a fluid control system.

**[0033]** FIG. 1D shows an example of further details of the suction and irrigation mechanisms of the medical device.

**[0034]** FIG. 1E shows a perspective view of the semi transparent view in FIG. 1D.

**[0035]** FIG. 1F shows further example details of the interconnection between the fluid tube and the grasping jaws at the end effector.

**[0036]** FIG. 1G shows an example illustration of suction and irrigation tubes, as well as a power cable connected to the surgical device.

**[0037]** FIG. 2 shows one example design of an end effector including jaw members for grasping and applying sealing energy and according to some aspects, including first and second jaw members and a suction and irrigation path included in one of the first and second jaw members.

**[0038]** FIG. 3 shows the end effector of FIG. 2 in an open position.

**[0039]** FIG. 4 shows the end effector of FIG. 2 with a semi transparent view, in order to show some further details of performing opening and closing of the jaws, according to some aspects.

**[0040]** FIG. 5 shows a longitudinal cross-sectional view of the end effector in FIG. 2 to provide illustration of additional detail, according to some aspects.

**[0041]** FIGS. 6-8 show the end effector of FIG. 2 in various exploded views to isolate the individual parts.

**[0042]** FIG. 9 shows another example implementation for an end effector, this time including two jaws forming a lumen when in a closed position and including an insulated member to separate the two jaws, according to some aspects.

**[0043]** FIG. 10 shows the end effector of FIG. 10 in a closed position, according to some aspects.

**[0044]** FIG. 11 shows a semi transparent view of the end effector of FIG. 9 to provide additional details of its operation.

**[0045]** FIG. 12 shows another semi transparent view of the end effector of FIG. 9, this time demonstrating further details for opening the jaws.

**[0046]** FIG. 13 shows a close-up and semi transparent view of the distal end of the insulated member of FIG. 9 to provide closer detail of how the closure wheel interacts with the jaw members.

**[0047]** FIG. 14 shows a longitudinal cross-sectional view of the end effector in FIG. 9, according to some aspects.

**[0048]** FIG. 15 shows an illustration of utilizing the suctioning functionality through closure of the jaws in FIG. 9.

**[0049]** FIG. 16 shows an exploded view of the end effector according to FIG. 9.

**[0050]** FIG. 17 shows another example of an end effector having grasping and sealing functionality, as well as suction and irrigation functionality, this time including ridges or teeth, according to some aspects.

**[0051]** FIG. 18 provides an illustration of the jaws in FIG. 17 in an open formation.

**[0052]** FIG. 19 illustrates a closed position of the jaws in FIG. 17.

**[0053]** FIG. 20 shows another variation of an end effector with jaws having ridges or teeth, this time showing one of the jaws as part of a rigid member with the rest of the shaft, according to some aspects.

**[0054]** FIG. 21 shows a semitransparent profile view of the end effector of FIG. 20, including outlines of how some components may be configured within the shaft to achieve the various functions of this end effector.

**[0055]** FIG. 22 provides another variant of an end effector configured to grasp and seal tissue, along with providing sealing and functionality, according to some aspects,

this time with the jaws configured to supply electrosurgical energy on either or both between the jaws or on the outsides of the jaws.

**[0056]** FIG. 23 shows the end effector of FIG. 22 to have the jaws separated from the bottom jaw in a perspective view.

**[0057]** FIGS 24 and 25 provide yet another variation for the end effector, this time including the suction and irrigation tube in between two movable jaws, according to some aspects.

**[0058]** FIG. 26 shows yet another variation for an end effector having both suction and irrigation functionality along with grasping and sealing functionality, this time showing how the irrigation and suction channels may be encased around the grasping member.

**[0059]** FIGS. 27–28 provide perspective views of the retractable grasping member of FIG. 26.

**[0060]** FIG. 29 provides a schematic of yet another variation for an end effector, this time including grasping members protruding beyond the distal end of a tube configured to grasp tissue at the distal ends, and may also be configured to supply sealing energy through ultrasonic vibrations.

**[0061]** FIG. 30 shows another example design of grasping members protruding beyond the distal end of a tube where an upper member includes an energized backside that may be configured to supply electrosurgical energy.

**[0062]** FIG. 31 is a block diagram describing further details of power supply elements of a surgical system comprising a motor-driven grasping and sealing instrument with suction and irrigation mechanisms, the surgical instrument coupled to a generator, according to some aspects.

## DETAILED DESCRIPTION

**[0063]** In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, similar symbols and reference characters typically identify similar components throughout the several views, unless context dictates otherwise. The illustrative examples described in the detailed description, drawings, and claims are not meant to be limiting. Other examples may be

utilized, and other changes may be made, without departing from the scope of the subject matter presented here.

**[0064]** The following description of certain examples of the technology should not be used to limit its scope. Other examples, features, aspects, examples, and advantages of the technology will become apparent to those skilled in the art from the following description, which is by way of illustration, one of the best modes contemplated for carrying out the technology. As will be realized, the technology described herein is capable of other different and obvious aspects, all without departing from the technology. Accordingly, the drawings and descriptions should be regarded as illustrative in nature and not restrictive.

**[0065]** It is further understood that any one or more of the teachings, expressions, aspects, examples, etc., described herein may be combined with any one or more of the other teachings, expressions, aspects, examples, etc., that are described herein. The following-described teachings, expressions, aspects, examples, etc., should therefore not be viewed in isolation relative to each other. Various suitable ways in which the teachings herein may be combined will be readily apparent to those of ordinary skill in the art in view of the teachings herein. Such modifications and variations are intended to be included within the scope of the claims.

**[0066]** Also, in the following description, it is to be understood that terms such as front, back, inside, outside, top, bottom, and the like are words of convenience and are not to be construed as limiting terms. Terminology used herein is not meant to be limiting insofar as devices described herein, or portions thereof, may be attached or utilized in other orientations. The various aspects will be described in more detail with reference to the drawings. Throughout this disclosure, the term “proximal” is used to describe the side of a component, e.g., a shaft, a handle assembly, etc., closer to a user operating the surgical instrument, e.g., a surgeon, and the term “distal” is used to describe the side of the component further from the user operating the surgical instrument.

**[0067]** Aspects of the present disclosure are presented for a single surgical instrument configured for grasping tissue, performing sealing procedures using electrosurgical or ultrasonic energy, suctioning, and providing irrigation. An end effector of the surgical instrument may include multiple members arranged in various configurations to

collectively perform the aforementioned functions. The suction and irrigation elements may comprise one or more fluid paths configured to deliver fluid to or evacuate fluid from a surgical field. In certain aspects, the fluid may comprise any fluid, including a gas, liquid, combination of the two, as well as fluids that may further include particulates, e.g., electrosurgical smoke. In this way, a user, such as a clinician or surgeon, may rely on a single surgical instrument to perform these tasks typical in surgery while having an extra hand available and so as to not need to divert his or her concentration away from the surgical site in order to access multiple devices. Further, the timing for performing each of the functions may be made quicker due to not needing to switch using multiple devices.

**[0068]** In some aspects, an end effector of a surgical instrument includes a pair of jaws for grasping and applying electrosurgical (e.g., radio frequency ("RF")) energy to tissue at a surgical site. A first jaw may also include a suction and irrigation path. An insulating layer or over mold may be included in between the two jaws to allow for one jaw to supply energy at a first pole and the other jaw to supply energy at a second pole. In some aspects, the jaw including the suction and irrigation path may also include small holes on the sides or top to allow for suction through the sides or top. These features may allow for spot sealing and suctioning.

**[0069]** In some aspects, an end effector of a surgical instrument includes a pair of jaws for grasping and applying electrosurgical energy to tissue at the surgical site. The pair of jaws may also form a suction and irrigation path when the jaws are closed. An insulated member may be included in between the pair of jaws and may also include an irrigation and suction path within. In some aspects, the insulated member may be shaped like a wedge such that translation of the insulated member in a longitudinal direction parallel to the shaft coupled to the end effector may cause the jaws to open and close.

**[0070]** In some aspects, an end effector of a surgical instrument includes an ultrasonic member and an irrigation and suction tube. The ultrasonic member may be implemented in various different shapes, such as a shape configured to grab or grasp tissue. The ultrasonic member may be configured to deliver ultrasonic energy through being vibrated at an ultrasonic frequency. The irrigation and suction tube may be

located near to the ultrasonic member at the end effector. In some aspects, one or both of the ultrasonic member and the irrigation and suction tube may be retracted into a closure tube to allow for focused use of one or the other members. In other cases, the irrigation and suction tube may be built into the ultrasonic member, such as by having a hole carved out of part of the ultrasonic member and a tube connected therefrom.

**[0071]** Other various features may include cameras or lights coupled to one or more of the members of the end effector, and monopolar or bipolar options for the electrosurgical devices.

**[0072]** Various features described herein may be incorporated in electrosurgical devices for applying electrical energy to tissue in order to treat and/or destroy the tissue are also finding increasingly widespread applications in surgical procedures. An electrosurgical device typically includes a hand piece, an instrument having a distally-mounted end effector (e.g., one or more electrodes). The end effector can be positioned against the tissue such that electrical current is introduced into the tissue. Electrosurgical devices can be configured for bipolar or monopolar operation. During bipolar operation, current is introduced into and returned from the tissue by active and return electrodes, respectively, of the end effector. During monopolar operation, current is introduced into the tissue by an active electrode of the end effector and returned through a return electrode (e.g., a grounding pad) separately located on a patient's body. Heat generated by the current flowing through the tissue may form hemostatic seals within the tissue and/or between tissues and thus may be particularly useful for sealing blood vessels, for example. The end effector of an electrosurgical device may also include a cutting member that is movable relative to the tissue and the electrodes to transect the tissue.

**[0073]** Electrical energy applied by an electrosurgical device can be transmitted to the instrument by a generator in communication with the hand piece. The electrical energy may be in the form of radio frequency ("RF") energy. RF energy is a form of electrical energy that may be in the frequency range of 200 kilohertz (kHz) to 1 megahertz (MHz). In application, an electrosurgical device can transmit low frequency RF energy through tissue, which causes ionic agitation, or friction, in effect resistive heating, thereby increasing the temperature of the tissue. Because a sharp boundary is created

between the affected tissue and the surrounding tissue, surgeons can operate with a high level of precision and control, without sacrificing un-targeted adjacent tissue. The low operating temperatures of RF energy is useful for removing, shrinking, or sculpting soft tissue while simultaneously sealing blood vessels. RF energy works particularly well on connective tissue, which is primarily comprised of collagen and shrinks when contacted by heat.

**[0074]** Referring to FIG. 1A, a medical device 2 is illustrated, configurable with a fluid control system 3 according to various aspects. The medical device 2 comprises an elongate member 4, such as a shaft, having a proximal portion 9 coupled to a handle assembly 7. A distal portion 12 of the elongate member 4 comprises an end effector 14 (see FIG. 1B) coupled to a distal end 14 of the shaft 10. In some aspects, the end effector 14 comprises a first jaw 15a and a second jaw 15b, each having an outer portion or surface 16a, 16b. At least one of the first jaw 15a and the second jaw 15b is rotatably movable relative to the other along a path shown by arrow J to transition the jaws 15a, 15b between open and closed positions. In operation, the jaws 15a, 15b may be transitioned from the open position to a closed position to capture tissue therebetween. Captured tissue may contact one or more working portions of the jaw set, indicated generally as 17a, 17b, configured to apply energy, e.g., bipolar energy, to treat target tissue. In some aspects, the first jaw 15a or the second jaw 15b may include an irrigation and suction path.

**[0075]** The handle assembly 7 comprises a housing 18 defining a grip 19. In various aspects, the handle includes one or more control interfaces 20a–c, e.g., a button or switch 20a, rotation knob 20b rotatable along arrow R, and a trigger 20c movable relative to the grip 19 along arrow T, configured to provide operation instructions to the end effector 13. Multiple buttons, knobs, or triggers described may also be included as part of the housing 18 in order to manipulate one or more of the functioning members at the end effector 14. In some examples, the handle assembly 7 is further configured to electrically couple to an energy source 21 to supply the medical device 2 with energy. While the energy source 21 is illustrated as generally coupled to the handle assembly 7, e.g., with a cord, it is to be understood that in some examples the energy source 21 may be positioned within the elongate member 4. For example, in one aspect, the

energy source 21 comprises one or more direct current batteries positioned in the handle 7, shaft 10, or a portion thereof.

**[0076]** As introduced above, the medical device 2 includes or is configurable with the fluid control system 3 to control fluid, e.g., smoke, steam, or other fluid. FIG. 1C shows a schematic of one aspect of a fluid control system 3. The fluid control system 3 includes a fluid path element 22 comprising one or more fluid paths 23. The one or more fluid paths 23 may be fluidically coupled to one or more proximal fluid ports 24 and one or more distal fluid ports 25. With further reference to FIG. 1A, the one or more fluid paths 23 may extend along a portion of the shaft 10 and, in various aspects, may further extend along the handle 7, end effector 14, or only along a portion of the end effector 14 or shaft 10. In certain aspects, the fluid paths 23 may be defined by lumens, lines, channels, voids, ducts, cavities, or tubing which may be externally or internally positioned relative to the handle 7, shaft 10, or end effector 14 or may be integrally formed within such components of the medical device 2. For example, the fluid paths 23 may be integrated into the housing 18 of the handle 7, shaft 10, or end effector 14 or may comprise fluid paths configured as accessory features such as a cover, mold, attachment, sleeve, coating, or the like, that may be positioned on or associated with the handle 7, shaft 10, or end effector 14.

**[0077]** As introduced above, the fluid control system 3 may further comprise or be configured to fluidically couple to a fluid supply and transport element 28 comprising a supply component 30 and a transport component 31. The supply component 30 is configured to supply or receive fluid from the fluid path element 22 and may comprise a fluid source to supply fluid to a fluid path element 23 or a fluid reservoir, which may comprise an environment external to the fluid path element 23 to receive fluid from the fluid path element 22. The transport component 31 is configured to move fluid through the one or more fluid paths of the fluid path element 22. In various examples, the transport component 31 is configured to move fluid passively through the fluid path element 23 via gravity or diffusion, for example, and thus may not comprise a physical structure. In various examples, the transport component 31 comprises a pump or pressure differential configured to actively move or transport fluid through the fluid path element 22. For example, the transport component 31 may include a pressurized or

compressed fluid supply or a pump to pressurize or compress the fluid supply. In one example, the fluid supply system 3 includes a valve positioned between the supply component 30 and the fluid path element 22. Fluid path through the valve may be controlled to control transport of fluid through the one or more fluid paths. For example, the transport component 31 may comprise or generate a pressure differential between two outlets of the valve such that fluid is motivated to flow through the valve when the valve is open.

**[0078]** As previously described, the one or more fluid paths 23 may be fluidically coupled to one or more proximal fluid ports 24 and one or more distal fluid ports 25. The proximal fluid ports 24 may be positioned along the elongate member 4, e.g., within or adjacent to the handle 7, shaft 10, or end effector 14. The distal fluid ports 25 may be configured and positioned to deliver or intake fluid from the surgical field or tissue treatment site adjacent the distal portion 12 of the elongate member 4, e.g., the distal end of the shaft 10, the end effector 14, or working portion thereof 17a, 17b.

**[0079]** In various examples, the fluid control system 3 includes or is configured to associate with an activation element 32. The activation element 32 may be operatively coupled to the fluid supply and transport element 28 to activate the transport component 31 to, for example, provide power to a pump or to open a valve or port. In some examples, the activation element 32 comprises a switch electrically coupled to the energy source 21. The switch may be associated with the elongate member 4, e.g., the handle 7, or may be operatively coupled to the elongate member 4, such as a foot switch, to selectively activate the fluid control system 3. In some examples, the activation element 32 comprises a movable mechanical component, such as a switch or actuator, configured to open a valve to allow fluid to be transported through the one or more fluid paths 23. For example, the activation element 32 may include a switch or actuator operatively coupled to a piston or plunger that may be driven within or against a supply component 30 or fluid path element 23. Pressure resulting from movement of the piston or plunger may induce fluid transport, thus, operating as a transport component 31 to push or pull fluid through the one or more fluid paths 23. In some examples, the handle 7 includes a switch or actuator, which may be associated with the switch 20a or trigger 20c, that is coupled to the energy source 21 or valve to activate

transport of fluid through the one or more fluid paths 23. In various examples, the activation element 32 may be configured to open a proximal fluid port 24 or a distal fluid port 25. The power may be manual or electrical, e.g., activation of the energy source 21 to provide energy to the end effector 13 may further activate the fluid control system 3. In some aspects, the transport component 31 may, for example, comprise a bulb that may be squeezed to evacuate fluid from within the bulb or to expel or suction another fluid through one or more fluid paths 23. In various aspects, the activation element 32 may be coupled to a valve fluidically coupled to the supply component 30 or the fluid path element 23. The activation element 32 may be configured to selectively operate the valve via an electrical or manual switch such that the valve may be opened or closed to control movement of fluid between the outlets of the valve.

**[0080]** Referring to FIG. 1D, an example of further details of the suction and irrigation mechanisms of the medical device 2 is shown. The example fluid pathways and connections may be consistent with the block diagram descriptions in FIG. 1C. Here, an inner fluid tube 130 within the shaft 10 is coupled at the proximal end at direct connection 120 to a fluid manifold 50. The fluid manifold 50 may include a fluid extraction port 115 and a fluid intake port 125, although in this profile view only one of the ports are shown. The fluid extraction port 115 may allow for evacuation of fluids being suctioned out of a surgical site from the end effector at the distal end of the shaft 10, while the fluid intake port 125 may allow for transmission of fluids to be applied to the surgical site through the shaft 10 and to the end of the end effector at the distal end of the shaft 10. Also shown are a suction activation button 110 and an irrigation activation button 105. Again, only one button is shown due to the profile view of this figure. For reference, the grasping trigger 20c, the energy activation button 20a, and the rotation knob 20b are also shown, to provide an example of how the suction and irrigation mechanisms may interact with the additional features of the surgical device 2.

**[0081]** Referring to FIG. 1E, a perspective view of the semi transparent view in FIG. 1D is shown. In this view, both the fluid extraction port 115 and fluid intake port 125 are clearly illustrated. These ports may connect to hoses or other valves to supply and extract fluid through the surgical device 2. Also shown are the irrigation activation button 105 and the suction activation button 110. The buttons 105 and 110 may be spring

biased and coupled to rotating valves within the fluid manifold 50. When un-pressed, the rotating valves within the fluid manifold 50 may be rotated to block passageway through the fluid manifold 50 between the shaft 10 and the ports 115 and 125. Then, when one of the buttons 105 or 110 are pressed, the rotating valves associated therewith may rotate 90° to complete fluid passage between the respective port 125 or 115 to the shaft 110. In some examples, a latching mechanism coupled between the buttons 105 and 110 and is the fluid manifold 50 may be configured to latch the buttons 105 and 110 into a stable or fixed position to allow continual irrigation or suction, respectively, during a surgical procedure. In this way, a user may press down on one of the buttons 105 or 110 to latch said button into place so as to not have to continually press on the button or to maintain the irrigation or suction functionality. To unlatch, in some examples, the user may then press down again on the latch to button, and the associated spring may then extend the button. Other example implementations for providing a latching and unlatching mechanism known to those with skill in the art are possible, and examples are not so limited.

**[0082]** Referring to FIG. 1F, further example details of the interconnection between the fluid tube and the grasping jaws at the end effector 14 are shown. In some examples, a fluid tube 130 is positioned within the shaft 10 and on the inner side of actuation tubes that connect to one or more of the jaws 15a and/or 15b. While it is mentioned that the end effector 14 may be configured to rotate upon rotation of the knob 20b, the inner fluid tube 130 may be configured to not rotate at the same time. For example, the inner fluid tube 130 may be spaced within the shaft 10 and away from the actuation tubes guiding the jaws 15a and/or 15b so as to not touch during rotation. In other cases, the fluid inner tube 130 may comprise a low friction insulation, film, or other material to allow smooth rotation around it and to minimize disruption of the inner tube 130 during said rotation. In other cases, a rotating valve may be included around the fluid inner tube 130 and coupled to the fluid manifold 50, for example, to allow rotation of the inner tube 130 during rotation of the rest of the shaft 10. Also shown are electrical shorts 135 to help electrically isolate the jaws 15a and 15b.

**[0083]** Referring to FIG. 1G, an example illustration of suction and irrigation tubes 150 and 155, as well as a power cable 160, is shown. The ports described in the previous

figures provide examples of how the illustrated tubes and cables may be coupled to the surgical instrument 2. The example power cable 160 may supply wire to power to the surgical instrument 2, while in other cases, the surgical instrument 2 may be powered internally, such as through the use of batteries. Example power systems coupled to the power cable 160 are described in FIG. 49, for example. The suction and irrigation tubes 150 and 155 may be configured to be connected to other extension cables or valves.

**[0084]** The following descriptions and related figures provide examples of more detailed designs of the end effector 14, including one or more members for grasping and applying sealing energy, and one or more members with a fluid path for suction and irrigation. The following are merely examples, and it may be apparent to those with skill in the art how the various examples may be combined or interchanged to be included in various other aspects, and examples are not so limited.

**[0085]** Referring to FIG. 2, illustration 200 shows one example design of an end effector including jaw members for grasping and applying sealing energy and according to some aspects. Here, a bottom jaw 205 may interact with a top jaw 220 to grasp tissue. The bottom jaw 205 also may include a suction and irrigation path that opens or ends principally from the distal end 210 of the bottom jaw 205 and runs through a tubing system through the shaft 10, not shown. In some aspects, the bottom jaw 205 also may include one or more suction and irrigation holes 215 located on the lateral sides of the bottom jaw 205. The holes 215 may allow for additional suction and irrigation to occur on the sides of the end effector.

**[0086]** In some aspects, the top jaw 220 and the bottom jaw 205 may be configured to supply electrosurgical energy, such as RF energy, to tissue at a surgical site. The end effector may be configured to supply monopolar electrosurgical energy, in that both jaws 220 and 205 supply energy at a first pole. In other cases, the end effector may be configured in a bipolar arrangement, such that the jaw 205 may supply RF energy at a first pole, while the other jaw 220 may be configured to supply RF energy at a second pole.

**[0087]** As shown, the end effector also may include a closure saddle 235, a closure tube 225, and a shrink tube 230 and may be used for insulation. In illustration 200, the jaws 205 and 220 are shown in a closed position, which may be achieved by translation

of the closure saddle 235 moved back in the proximal direction, as indicated by the arrow PD.

**[0088]** Referring to FIG. 3, the end effector of the example illustration 200 is now shown in an open position, where the closure saddle has been translated in the distal direction toward the end of the end effector, as indicated by the arrow DD. Also shown are insulated pins 305, in this case coupled to the top jaw 220. The insulated pins 305 may provide separation and insulation between the top jaw 220 and the bottom jaw 205, such that only the insulated pins 305 touch the bottom jaw 205 when the jaws are in a closed position. In this way, the top jaw 220 and the bottom jaw 205 may be configured to supply RF energy at different polarities, due to the insulated pins 305 physically separating the jaws 205 and 220 even in the closed position. Also shown is movement by the top jaw 220 at the pivot pin 310.

**[0089]** Referring to FIG. 4, the example end effector of illustration 200 is shown with a semi transparent view, in order to show some further details of performing opening and closing of the jaws, according to some aspects. As shown, while the top jaw 220 pivots based on the pivot pin 310, movement is driven by a cam 405 connected to the closure saddle 235 and movable within closure slot 410. That is, while the closure saddle 235 is translated along the shaft 10 in the distal direction DD, the cam 405 slides within the closure slot 410 to the distal end of the closure slot 410. Due to the lower position of the cam 405 relative to the pivot pin 310, this motion causes the top jaw 222 pivot upward to the open position. Conversely, as the closure saddle 235 is translated along the shaft 210 and the proximal direction PD, the cam 405 slides back within the closure slot 410 to cause movement of the top jaw 220 to rotate to the closed position.

**[0090]** Referring to FIG. 5, a longitudinal cross-sectional view of the end effector in illustration 200 is shown to provide illustration of additional detail, according to some aspects. For example, a longitudinal cross-sectional cutout of the bottom jaw 205 is shown to reveal the irrigation path 505 running the length of the bottom jaw 205, including the suction and irrigation holes 215 and ending at the distal end 210. The proximal end of the irrigation path 505 connects to an irrigation ground tube 515. Also shown is the top jaw 220 with the insulated pins 305 substantially embedded into the top jaw 220. Various layers of insulation are also shown, such as insulating layer 510,

an insulating tube 520 insulating the irrigation ground tube 515, and the shrink tube 230 providing insulation over the entire contents of the shaft 10. Also shown are the closure tube 225 and the closure saddle 235.

**[0091]** Referring to FIGS. 6–8, the end effector of illustration 200 is shown in various exploded views to isolate the individual parts. In FIG. 6, the top jaw 220 is shown with the insulated pins 305 and the pivot pin 310 being separated. In FIG. 7, examples are shown of the shrink tube 230 and the insulating tube 520. In FIG. 8, example components are shown of the bottom jaw 205, the closure saddle 235, the closure tube 225, and the irrigation ground tube 525. It may be apparent to those with skill in the art how the various components in these exploded views may be assembled to complete the end effector of the example illustration 200.

**[0092]** Referring to FIG. 9, illustration 900 shows another example implementation for an end effector having grasping and sealing functionality, as well as suction and irrigation functionality, according to some aspects. In the example of illustration 900, the end effector is shown to have two jaws, a top jaw 905 and a bottom jaw 910, both movable along independent pivot points 920 and 925, respectively. As in the previous example, the jaws 905 and 910 may be configured to supply electrosurgical energy to tissue at a surgical site when the jaws are in a closed and grasping position. In addition, the end effector may be arranged in a monopolar design or bipolar design. For example, one or more insulated pins also may be embedded into one or more of the jaws 905 or 910 two physically separate connection of the jaws 905 and 910 even when closed, similar to the previous example.

**[0093]** In this example, movement of the jaws 905 and 910 may be guided by an insulated member 915 that also includes an irrigation and suction path in the middle, as shown. The insulated member 915 may include a connection to an insulated closure wheel or pin, not shown, that rolls within a closure slot to open the jaws 905 and 910 when the insulated member 915 is translated longitudinally in the distal direction DD. The insulated member 915 also provides insulation between the jaws 905 and 910 to physically isolate any electrical connections between the jaws 905 and 910. In this way, the end effector of illustration 900 may have electrosurgical bipolar properties. Also, the

jaws 905 and 910 may be pivotally coupled to an insulated clevis 930, which is also configured to allow the insulated member 915 to slide back and forth in between.

**[0094]** Referring to FIG. 10, the end effector in illustration 900 is now shown in a closed position, according to some aspects. In addition to the jaws 905 and 910 being configured to supply electrosurgical energy upon touching tissue, the jaws 905 and 910 may both be shaped in a half cylinder like configuration, such that when the jaws 905 and 910 close, a lumen 1005 is formed within the jaws 905 and 910. Therefore, when closed, an irrigation and suction path is formed along the length in between the jaws 905 and 910, connecting to the irrigation and suction path of the insulated member 915. The jaws 905 and 910 may be closed upon translation of the insulated member 915 in the proximal direction PD.

**[0095]** Referring to FIG. 11, a semi transparent view of the end effector of illustration 900 is shown to provide additional details of its operation. For example, the lumen path 1105 formed by the closure of the jaws 905 and 910 is more clearly shown. In addition, insulated pins may be available to be placed within the slots 1115. In addition, a translation cavity 1110 is shown to be formed within the proximal ends of the jaws 905 and 910 when the jaws 905 and 910 are closed. The cavity 1110 allows for the insulated member 915 to translate more freely to perform any suction and irrigation functions.

**[0096]** Referring to FIG. 12, another semi transparent view of the end effector of illustration 900 is shown, this time demonstrating further details for opening the jaws 905 and 910. A semi transparent view of the jaws 905 and 910 show the exposure of an insulated closure pin/wheel 1205 slidably connected to the bottom jaw 910 within a closure slot 1210. The wheel 1205 may be connected to the insulated member 915, such that translation of the insulated member 915 in the longitudinal direction of the shaft 10 causes the wheel 1205 to roll within the closure slot 1210. Because the insulated member 915 translates only in a horizontal direction, the angled nature of the closure slot 1210 causes the bottom jaw 910 to open.

**[0097]** While not shown, similar mechanical principles may be applied to cause the top jaw 905 to open in a similar manner. That is, for example, on the opposite side of the end effector in illustration 900, another closure pin/wheel connected to the insulated

member 915 may be slidably connected to the top jaw 905 within a similar closure slot like the closure slot 1210 but formed at a different angle. Thus, translation of the insulated member 915 will slidably move the closure wheels within their respective closure slots to cause the jaws 905 and 910 to open.

**[0098]** Referring to FIG. 13, a close-up and semi transparent view of the distal end of the insulated member 915 is shown to provide closer detail of how the closure wheel 1205 interacts with the jaw members. Also shown are the pivot points 920 and 925 of the jaws 905 and 910, respectively. As previously discussed, the angled nature of the closure slot 1210 causes the bottom jaw 910 to pivot open around the pivot .925 when the closure wheel 1205 is translated due to movement by the insulated member 915.

**[0099]** Referring to FIG. 14, a longitudinal cross-sectional view of the end effector in illustration 900 is shown to provide illustration of additional detail, according to some examples. For example, a longitudinal cross-sectional cutout of the jaws 905 and 910 are shown to reveal the irrigation and suction path 1105 running the length of the jaws 905 and 910. The proximal end of the irrigation and suction path 1105 connects to irrigation and suction channel 1425 of the insulated member 915. Also shown are the jaws 905 and 910 connected to the insulated clevis 1405 pivotally coupled at the pivot points 920 and 925, respectively. Within the shrink tube 920 portion of the shaft 10 are additional components. For example, a suction adapter 1410 is stably connected to a closure tube 415 and provides airtight suction at the distal end of the closure tube 415. The suction adapter 1410 also is stably connected to the proximal end of the insulated member 915. As shown, a suction and irrigation path is thereby formed all the way through the closure tube 415 to the distal end of the jaws 905 and 910. An insulating tube 1420 may be housed within the outer insulating shrink tubing 920 and may house the closure tube 1415, the suction adapter 1410, a proximal portion of the insulated clevis 1405, and a proximal portion of the insulating member 915. A space 1430 allows movement of the closure tube 1415 and the insulated member 915.

**[0100]** Referring to FIG. 15, in some examples, closure of the jaws 905 and 910 may not form a complete airtight closure on the lateral sides. As such, suction through a small slit 1505 may be possible, which may allow for suction to be achieved on the lateral sides that are useful during certain surgical procedures.

**[0101]** Referring to FIG. 16, an exploded view of the end effector according to illustration 900 is shown. The various components include the upper jaw 905, the insulated member 915 and an example of a closure ring 1605 news to slide within the closure slots of the jaws 905 or 910. Also shown is the outer insulating shrink tubing 920, the suction adapter 1410, and the closure tube 1415. A layer around those components includes the insulated clevis 1405 and the insulating tube 1420. Finally, other components include the lower jaw 910 and in some cases, an outer tube 1605 that may be wrapped around the insulating shrink tubing or just within it.

**[0102]** Referring to FIG. 17, illustration 1700 shows another example of an end effector having grasping and sealing functionality, as well as suction and irrigation functionality, according to some aspects. Similar to previous examples, the example in illustration 1700 includes two jaws 1705 and 1710. The jaws may be configured to supply electrosurgical energy to tissue when grasping the tissue at a surgical site. In this case, the jaw 1705 and 1710 include ridges or teeth, which may be used to more securely grasp tissue and to more securely connect the two jaws when closing. In this example, both the jaws 1705 and 1710 may be configured to open and close. FIG. 18 provides an illustration of the jaw 1705 and 1710 in an open formation. In contrast, FIG. 19 illustrates a closed position, which also allows for the jaws to form an opening and lumen 1905 when utilizing the suction and irrigation functionality. Due to the shape and alignment of the ridges or teeth of the jaws 1705 and 1710, the closure of the jaws and 1705 and 1710 may help ensure closure between the ridges or the teeth with a small gap to allow suction (e.g., 0.002 to 0.02 inches). This may allow for suction on the lateral sides of the jaws to provide versatility to the user for where to apply suction. Methods for opening and closing the jaw 1705 and 1710 may be consistent with the descriptions in previous examples.

**[0103]** Referring to FIG. 20, illustration 2000 shows another variation of an end effector with jaws having ridges or teeth, this time showing one of the jaws as part of a rigid member 2010 with the rest of the shaft, according to some examples. Thus, a single articulable jaw 2005 may be used to open and close the end effector.

**[0104]** Referring to FIG. 21, a semitransparent profile view of this example end effector of illustration 2000 is shown, including outlines of how to being may be configured within

the shaft 10 to achieve the various functions of this end effector. For example, an outer mechanical tube 2010 may encase various other tubes. The outer mechanical tube 2010 also includes the rigid bottom jaw and therefore may act as an electrical grounding surface. Within the mechanical tube 2010 is an actuation tube 2105 that is pivotally coupled to a pivot hinge 2120. The upper jaw 2005 may be pivotally coupled to the pivot hinge 2120 as well. The actuation tube 2105 may be translated longitudinally to move the upper jaw 2005 via the pivot hinge 2120, such that the upper jaw 2005 rotates about the fulcrum 2115. Within the actuation tube is a suction and irrigation tube or liner 2110. The suction and irrigation tube 2110 may provide a channel for fluid suction and irrigation up to the proximal end of the jaws, where the closure of the jaws the rest of the channel for the fluid to pass through.

**[0105]** Referring to FIG. 22, illustration 2400 provides another variant of an end effector configured to grasp and seal tissue, along with providing sealing and functionality, according to some examples. In this case, the jaws 2405 and 2415 may be configured to supply electrosurgical energy on either or both between the jaws or on the outsides of the jaws. The curved nature of the outside of the jaws 2405 and 2415 may allow for the end effector to be wiped or brushed along tissue at the surgical site. Thus, the top side of the upper jaw 2405 and the bottom side of the bottom jaw 2415 may be configured to supply sealing energy. Also shown is a suction and irrigation tube 2410, which projects outwards to the distal end of the jaws 2405 and 2415. In this configuration, the suction and irrigation functionality may be possible regardless of whether the jaws 2405 and 2415 are open or closed.

**[0106]** Referring to FIG. 23, the end effector of illustration 2400 is shown to have the jaws 2405 separated from the bottom jaw 2415 in a perspective view. Shown more clearly here is the suction and irrigation tube 2410. In addition, in some aspects, a suction and irrigation cavity 2405 may be included into one or more of the jaws 2405 and 2415 to allow more space for the suction irrigation tube 2410 to be applied to the surgical site. Also, in some aspects, an insulating lip or pad 2510 may be included in between the jaws 2405 and 2415 to allow for bipolar electrosurgical output of the jaws.

**[0107]** Referring to FIG. 24, illustration 2800 provides yet another variation for the end effector, this time including the suction and irrigation tube 2815 in between two movable

jaws 2805 and 2810, according to some aspects. This example may be similar to the examples provided in FIGS. 17–19, only in this case a retractable or translatable suction and irrigation tube 2815 also may be included. The mechanical motion of the jaws 2805 and 2810 may be synchronized with the retracted ability of the tube 2815. FIG. 25 provides an example of how far the suction irrigation tube 2815 may translate outward when the jaws 2805 and 2810 are closed.

**[0108]** Referring to FIG. 26, illustration 3000 shows yet another variation for an end effector having both suction and irrigation functionality along with grasping and sealing functionality. In this case, the grasping member 3005 also used to provide sealing functionality is contained on the inside of an outer tube 3020, while the suction and irrigation functionality is formed on the outside portion 3015 of the grasping member 3005, within the outer tube 3020. This example shows how the irrigation and suction channels may be encased around the grasping member, while previous examples have provided illustrations for the opposite. In some aspects, the grasping member 3005 may be retractable, such as being configured to translate along a distance of 3010. Also, bipolar ring electrodes 3030 may be included at the distal end of the outer tube. The bipolar ring electrodes 3030 may be coupled to opposite poles of a bipolar RF generator and can be used to seal tissue located between the bipolar ring electrode 3030 using electrosurgical energy.

**[0109]** FIGS. 27–28 provide perspective views of the retractable grasping member 3005 of illustration 3000. The inner grasping member may be translatable out just beyond the distal end of the outer tube 3020, as shown. When the suction and irrigation functionality is to be used, the grasping member 3005 may be retracted the distance 3010 to allow for suction and irrigation holes 3205 to come into effect as well. Therefore, in this case, the outer tube 3020 also acts as tubing for the suction and irrigation functionality.

**[0110]** Referring to FIG. 29, illustration 3400 provides a schematic of yet another variation for an end effector. Here, grasping members 3405 and 3410 protruding beyond the distal end of a tube 3420 may be configured to grasp tissue at the distal ends, and also may be configured to supply sealing energy through ultrasonic vibrations. For example, the grasping members 3405 and 3410 may be configured to

vibrate across an overall span or fan space 3415, as shown. Various examples of a suction and irrigation two or member may be built into the outer tube 3420, consistent with any of the previous examples described herein, and aspects are not so limited.

**[0111]** Referring to FIG. 30, illustration 3500 shows another example design of grasping members 3505 and 3510 protruding beyond the distal end of a tube 3525. Here, upper member 3505 includes an energized backside 3515 that may be configured to supply electrosurgical energy and may be used for painting or wiping on the top side of the member 3505. In addition, the lower member 3510 can also include an energized portion 3520, which also may be included on the lower side of the top member 3505, not shown. Various examples of a suction and irrigation two or member may be built into the outer tube 3420, consistent with any of the previous examples described herein, and aspects are not so limited.

**[0112]** FIG. 31 is a block diagram of a surgical system 4900 comprising a motor-driven surgical grasping instrument 2 (FIG. 1) with suction and irrigation mechanisms, the surgical instrument coupled to a generator 4935 (4940), according to some aspects. The motor-driven surgical cutting and fastening instrument 2 described in the present disclosure may be coupled to a generator 4935 (4940) configured to supply power to the surgical instrument through external or internal means. While previous figures describe examples of how the irrigation and suction mechanisms may be implemented in the surgical instrument 2, FIG. 31 describes examples of the portions for how electrosurgical energy may be delivered to the end effector. In certain instances, the motor-driven surgical instrument 2 may include a microcontroller 4915 coupled to an external wired generator 4935 or internal generator 4940. Either the external generator 4935 or the internal generator 4940 may be coupled to A/C mains or may be battery operated or combinations thereof. The electrical and electronic circuit elements associated with the motor-driven surgical instrument 2 and/or the generator elements 4935, 4940 may be supported by a control circuit board assembly, for example. The microcontroller 4915 may generally comprise a memory 4910 and a microprocessor 4905 ("processor") operationally coupled to the memory 4910. The processor 4905 may control a motor driver 4920 circuit generally utilized to control the position and velocity of the motor 4925. The motor 4925 may be configured to control transmission of energy

to the electrodes at the end effector of the surgical instrument. In certain instances, the processor 4905 can signal the motor driver 4920 to stop and/or disable the motor 4925, as described in greater detail below. In certain instances, the processor 4905 may control a separate motor override circuit which may comprise a motor override switch that can stop and/or disable the motor 4925 during operation of the surgical instrument in response to an override signal from the processor 4905. It should be understood that the term processor as used herein includes any suitable microprocessor, microcontroller, or other basic computing device that incorporates the functions of a computer's central processing unit (CPU) on an integrated circuit or at most a few integrated circuits. The processor is a multipurpose, programmable device that accepts digital data as input, processes it according to instructions stored in its memory, and provides results as output. It is an example of sequential digital logic, as it has internal memory. Processors operate on numbers and symbols represented in the binary numeral system.

**[0113]** In some cases, the processor 4905 may be any single core or multicore processor such as those known under the trade name ARM Cortex by Texas Instruments. In some cases, any of the surgical instruments of the present disclosures may comprise a safety processor such as, for example, a safety microcontroller platform comprising two microcontroller-based families such as TMS570 and RM4x known under the trade name Hercules ARM Cortex R4, also by Texas Instruments. Nevertheless, other suitable substitutes for microcontrollers and safety processor may be employed, without limitation. In one instance, the safety processor may be configured specifically for IEC 61508 and ISO 26262 safety critical applications, among others, to provide advanced integrated safety features while delivering scalable performance, connectivity, and memory options.

**[0114]** In certain instances, the microcontroller 4915 may be an LM 4F230H5QR, available from Texas Instruments, for example. In at least one example, the Texas Instruments LM4F230H5QR is an ARM Cortex-M4F Processor Core comprising on-chip memory 4910 of 256 KB single-cycle flash memory, or other non-volatile memory, up to 40 MHz, a prefetch buffer to improve performance above 40 MHz, a 32 KB single-cycle serial random access memory (SRAM), internal read-only memory (ROM) loaded with

StellarisWare® software, 2KB electrically erasable programmable read-only memory (EEPROM), one or more pulse width modulation (PWM) modules, one or more quadrature encoder inputs (QEI) analog, one or more 12-bit Analog-to-Digital Converters (ADC) with 12 analog input channels, among other features that are readily available for the product datasheet. Other microcontrollers may be readily substituted for use in the motor-driven surgical instrument 2. Accordingly, the present disclosure should not be limited in this context.

**[0115]** Referring again to FIG. 31, the surgical system 4900 may include a wired generator 4935, for example. In certain instances, the wired generator 4935 may be configured to supply power through external means, such as through electrical wire coupled to an external generator. In some cases, the surgical system 4900 also may include or alternatively include an internal generator 4940. The internal generator 4940 may be configured to supply power through internal means, such as through battery power or other stored capacitive source. Further descriptions of the internal generator 4940 and the wired generator 4935 are described below.

**[0116]** In certain instances, the motor-driven surgical instrument 2 may comprise one or more embedded applications implemented as firmware, software, hardware, or any combination thereof. In certain instances, the motor-driven surgical instrument 2 may comprise various executable modules such as software, programs, data, drivers, and/or application program interfaces (APIs), for example.

**[0117]** In some cases, various examples may be implemented as an article of manufacture. The article of manufacture may include a computer readable storage medium arranged to store logic, instructions and/or data for performing various operations of one or more examples. In various examples, for example, the article of manufacture may comprise a magnetic disk, optical disk, flash memory or firmware containing computer program instructions suitable for execution by a general purpose processor or application specific processor. The examples, however, are not limited in this context.

**[0118]** The functions of the various functional elements, logical blocks, modules, and circuits elements described in connection with the examples disclosed herein may be implemented in the general context of computer executable instructions, such as

software, control modules, logic, and/or logic modules executed by the processing unit. Generally, software, control modules, logic, and/or logic modules comprise any software element arranged to perform particular operations. Software, control modules, logic, and/or logic modules can comprise routines, programs, objects, components, data structures, and the like that perform particular tasks or implement particular abstract data types. An implementation of the software, control modules, logic, and/or logic modules and techniques may be stored on and/or transmitted across some form of computer-readable media. In this regard, computer-readable media can be any available medium or media useable to store information and accessible by a computing device. Some examples also may be practiced in distributed computing environments where operations are performed by one or more remote processing devices that are linked through a communications network. In a distributed computing environment, software, control modules, logic, and/or logic modules may be located in both local and remote computer storage media including memory storage devices.

**[0119]** Additionally, it is to be appreciated that the aspects described herein illustrate example implementations, and that the functional elements, logical blocks, modules, and circuits elements may be implemented in various other ways which are consistent with the described aspects. Furthermore, the operations performed by such functional elements, logical blocks, modules, and circuits elements may be combined and/or separated for a given implementation and may be performed by a greater number or fewer number of components or modules. As will be apparent to those of skill in the art upon reading the present disclosure, each of the individual aspects described and illustrated herein has discrete components and features which may be readily separated from or combined with the features of any of the other several aspects without departing from the scope of the present disclosure. Any recited method can be carried out in the order of events recited or in any other order which is logically possible.

**[0120]** Unless specifically stated otherwise, it may be appreciated that terms such as "processing," "computing," "calculating," "determining," or the like, refer to the action and/or processes of a computer or computing system, or similar electronic computing device, such as a general purpose processor, a DSP, ASIC, FPGA, or other programmable logic device, discrete gate or transistor logic, discrete hardware

components, or any combination thereof designed to perform the functions described herein that manipulates and/or transforms data represented as physical quantities (e.g., electronic) within registers and/or memories into other data similarly represented as physical quantities within the memories, registers, or other such information storage, transmission, or display devices.

**[0121]** It is worthy to note that some examples may be described using the expression "coupled" and "connected" along with their derivatives. These terms are not intended as synonyms for each other. For example, some aspects may be described using the terms "connected" and/or "coupled" to indicate that two or more elements are in direct physical or electrical contact with each other. The term "coupled," however, also may mean that two or more elements are not in direct contact with each other, but yet still co-operate or interact with each other. With respect to software elements, for example, the term "coupled" may refer to interfaces, message interfaces, and application program interface, exchanging messages, and so forth.

**[0122]** 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.

**[0123]** Although various examples have been described herein, many modifications, variations, substitutions, changes, and equivalents to those examples may be implemented and will occur to those skilled in the art. Also, where materials are disclosed for certain components, other materials may be used. It is therefore to be

understood that the foregoing description and the appended claims are intended to cover all such modifications and variations as falling within the scope of the disclosed examples. The following claims are intended to cover all such modification and variations.

## CLAIMS

1. A surgical instrument comprising:
a handle assembly;
a shaft coupled to a distal end of the handle assembly; and
an end effector coupled to a distal end of the shaft, the end effector comprising:
a first jaw;
a second jaw, wherein the first jaw and the second jaw cooperate to capture tissue therebetween;
wherein at least one of the first and second jaws is configured to transmit electrosurgical energy to seal the tissue;
a suction mechanism configured to suction fluid; and
an irrigation mechanism configured to transmit fluid.

2. The surgical instrument of claim 1, wherein the first jaw comprises the suction mechanism and the irrigation mechanism, and the second jaw comprises a surface configured to transmit the electrosurgical energy upon contact with the tissue.

3. The surgical instrument of claim 2, wherein the first jaw comprises a tube running a longitudinal length of the first jaw, a distal end of the tube defining a suction and irrigation outlet on a distal end of the first jaw whereby fluid passes in or out of the first jaw.

4. The surgical instrument of claim 3, wherein the tube comprises at least one irrigation and suction outlet positioned on a lateral side of the first jaw.

5. The surgical instrument of claim 1, wherein the first jaw is configured to transmit electrosurgical energy at a first polarity and the second jaw is configured to transmit electrosurgical energy at a second polarity.

6. The surgical instrument of claim 5, wherein the first jaw or the second jaw comprises at least one insulating pin protruding on an inner side of said first or second jaw facing the other second or first jaw such that the at least one insulating pin is configured to touch the other second or first jaw upon closure of the first and second jaws and prevent direct contact between the first and second jaws, the at least one insulating pin configured to prevent energy transfer between the first and second jaws.

7. The surgical instrument of claim 1, wherein the end effector further comprises an insulated member positioned between the first and second jaws and is configured to isolate energy transfer between the first and second jaws.

8. The surgical instrument of claim 7, wherein the insulated member comprises a suction and irrigation channel configured to suction fluid entering the end effector and transmit fluid into the end effector.

9. The surgical instrument of claim 8, wherein the first and second jaws define an elongated fluid channel therebetween upon closure of the first and second jaws, wherein:

a distal end of the elongated channel defines a suction and irrigation outlet on a distal end of the first and second jaws whereby fluid passes in or out of the first and second jaws, and

a proximal end of the elongated channel is fluidically coupled to the suction and irrigation channel of the insulated member.

10. The surgical instrument of claim 9, wherein the suction mechanism and the irrigation mechanism are defined in part by the elongated fluid channel upon closure of the first and second jaws.

11. The surgical instrument of claim 8, wherein the insulated member is configured to be translatable along a longitudinal axis of the shaft.

12. The surgical instrument of claim 9, wherein translation of the insulated member in a distal direction along the longitudinal axis is configured to cause the first and second jaws to open, and translation of the insulated member in a proximal direction along the longitudinal axis is configured to cause the first and second jaw to close.

13. The surgical instrument of claim 1, wherein the electrosurgical energy is monopolar.

14. The surgical instrument of claim 1, wherein the electrosurgical energy is bipolar.

15. The surgical instrument of claim 1, wherein the first jaw comprises a backside positioned on a far side from the second jaw, the backside comprising an electrosurgical pad configured to transmit electrosurgical energy for coagulating tissue upon contact with the tissue.

16. A surgical instrument comprising:

a handle assembly;

a shaft coupled to a distal end of the handle assembly; and

an end effector coupled to a distal end of the shaft, the end effector comprising:

an ultrasonic grasping member configured to contact tissue at a surgical site and transmit ultrasonic energy to the tissue upon contact;

a suction mechanism configured to suction fluid; and

an irrigation mechanism configured to transmit fluid.

17. The surgical instrument of claim 16, wherein the end effector further comprises a suction and irrigation tube, the suction and irrigation tube partially defining the suction mechanism and the irrigation mechanism.

18. The surgical instrument of claim 16, wherein at least one of the ultrasonic grasping member, the suction mechanism and the irrigation mechanism is configured to retract into the shaft.

19. A surgical instrument comprising:

a handle assembly;

a shaft coupled to a distal end of the handle assembly; and

an end effector coupled to a distal end of the shaft, the end effector comprising:

an outer tube coupled to the shaft;

an inner tube positioned within the outer tube and coupled to an inner tube of the shaft, the inner tube comprising a grasping and sealing mechanism configured to grasp tissue and transmit energy to seal the tissue upon contact;

a suction and irrigation mechanism defined in part by a space in between the inner tube and the outer tube, wherein the suction and irrigation mechanism is configured to:

suction fluid from a distal end of the end effector through the space in between the inner tube and the outer tube, and

transmit fluid through the distal end of the effector from the space in between the inner tube and the outer tube.

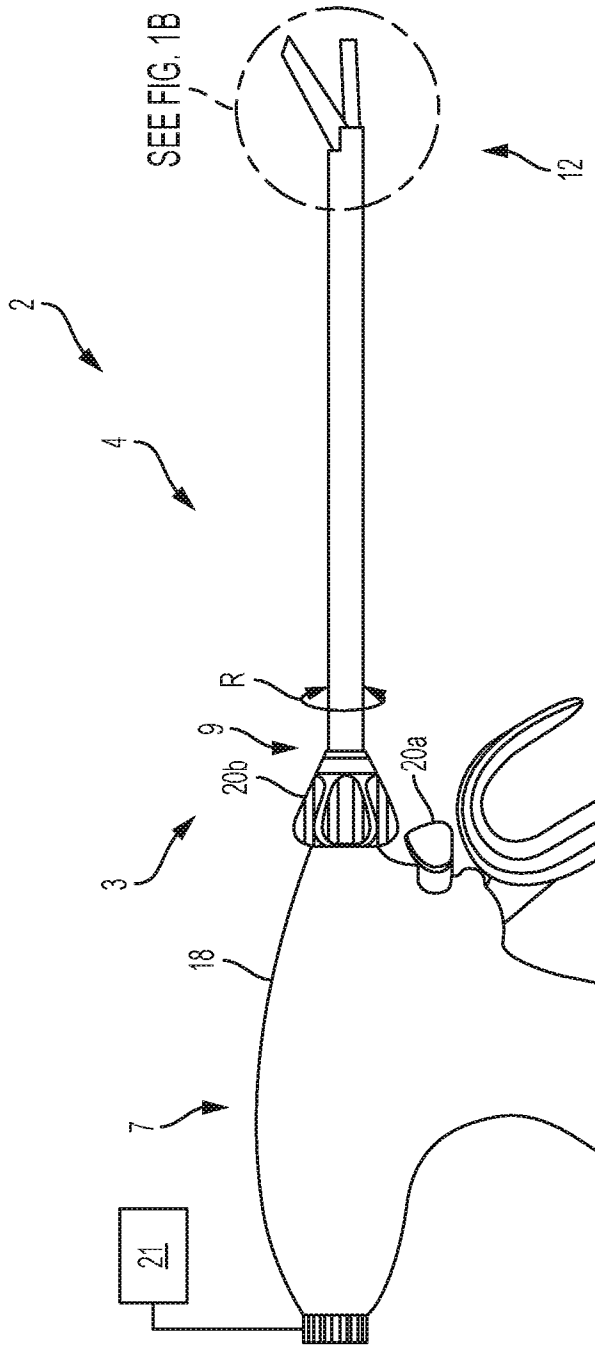

SEE FIG. 1B
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20b
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20c
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FIG. 1A

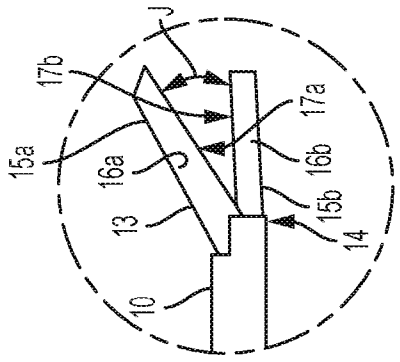

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15a
16a
16b
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15b
14
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FIG. 1B

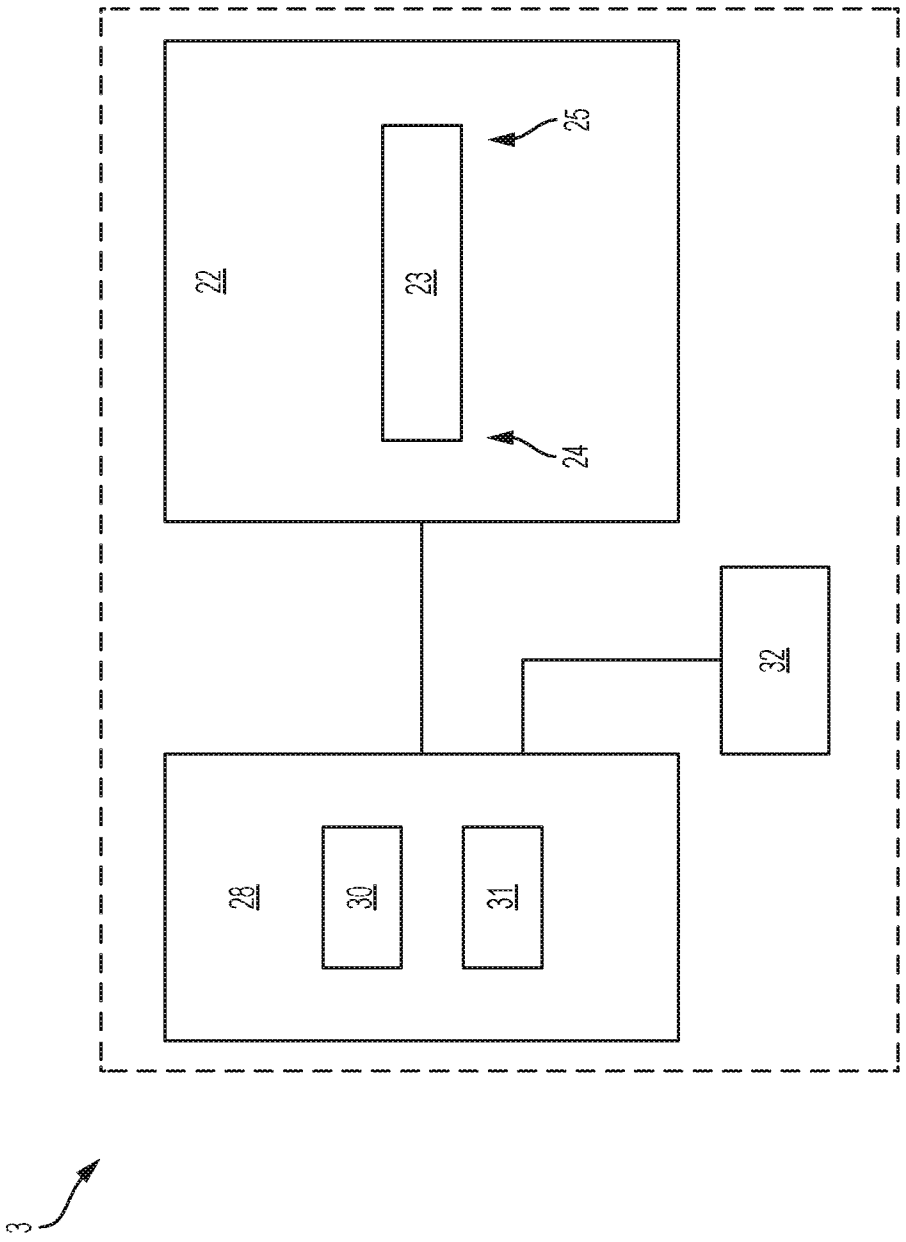



FIG. 1C

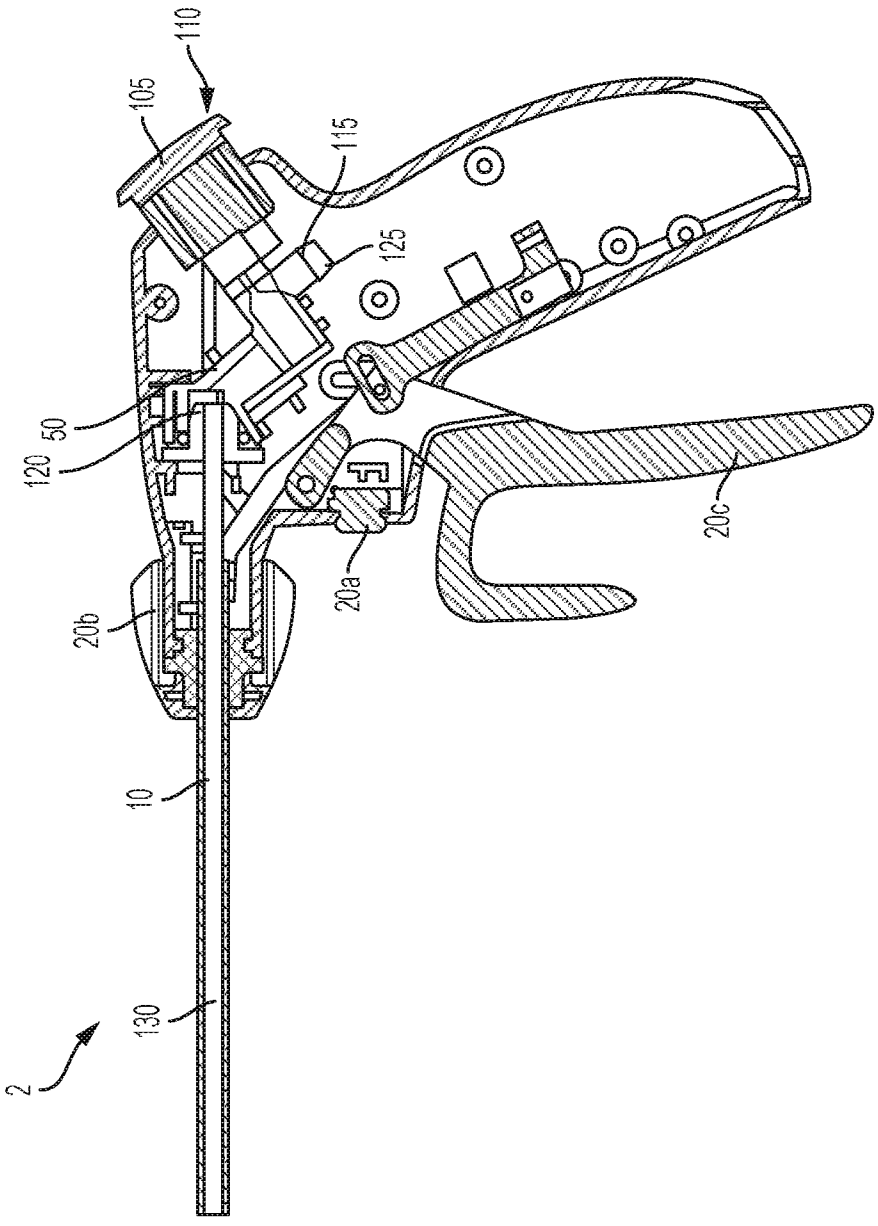



FIG. 1D

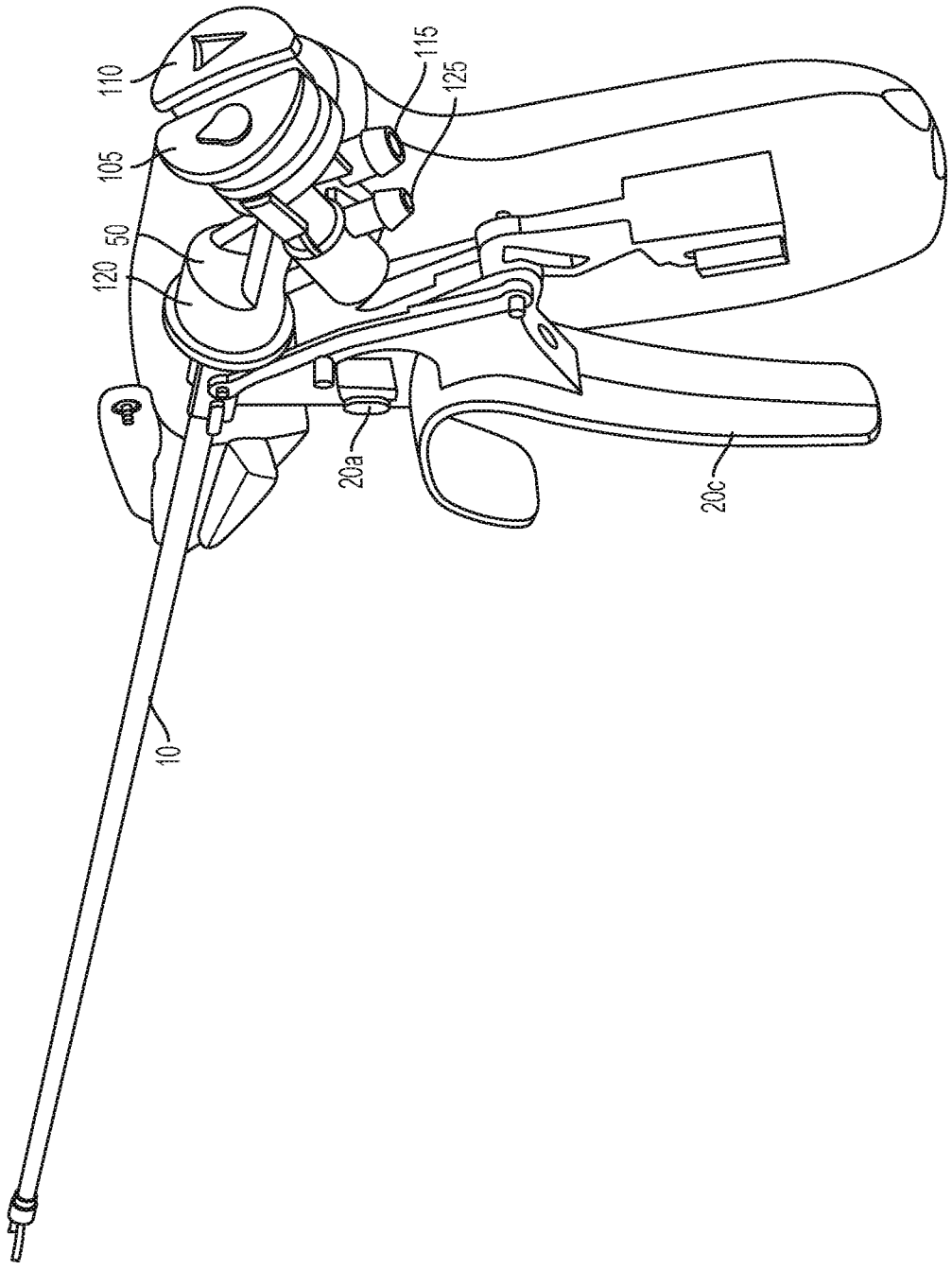



FIG. 1E

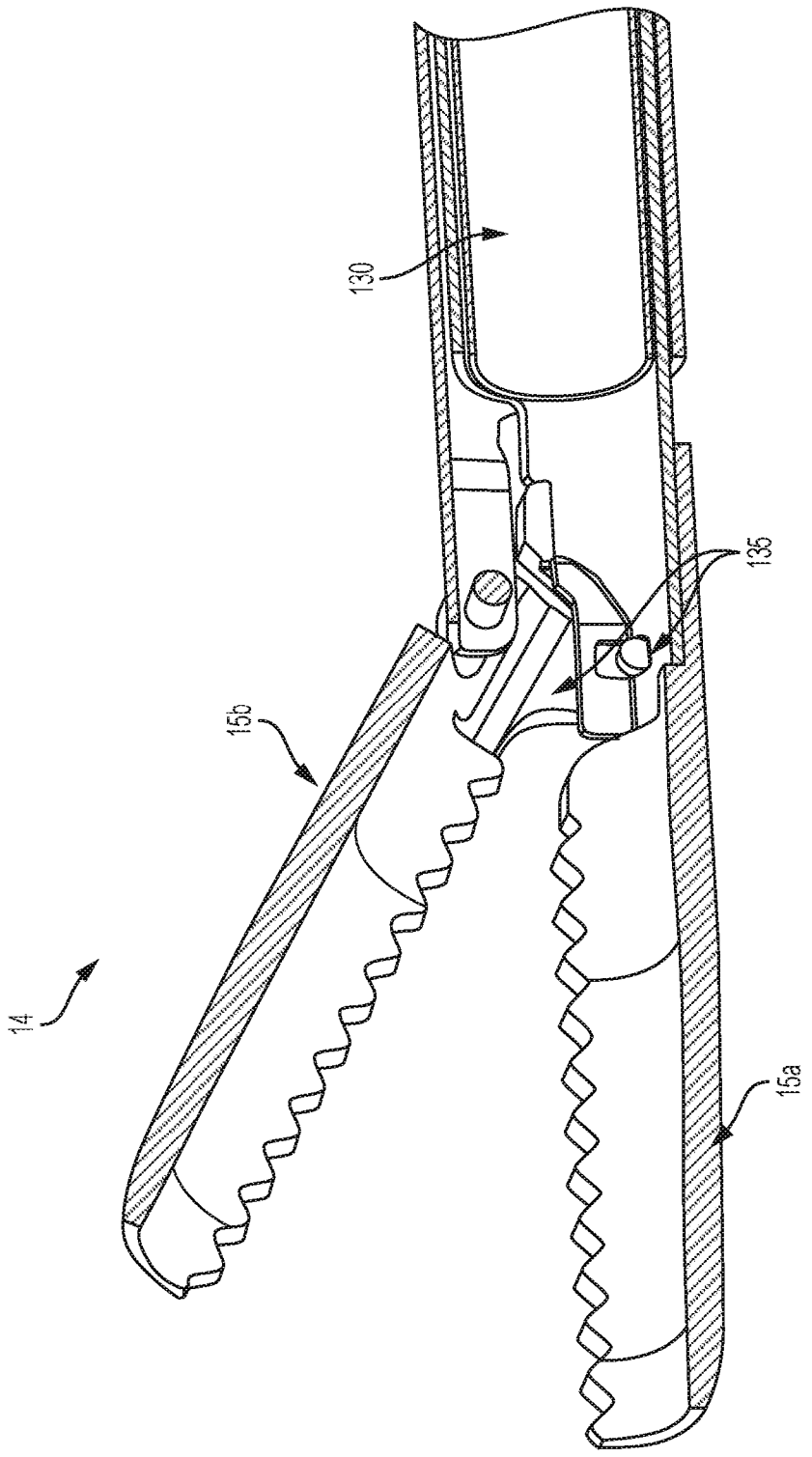



FIG. 1F

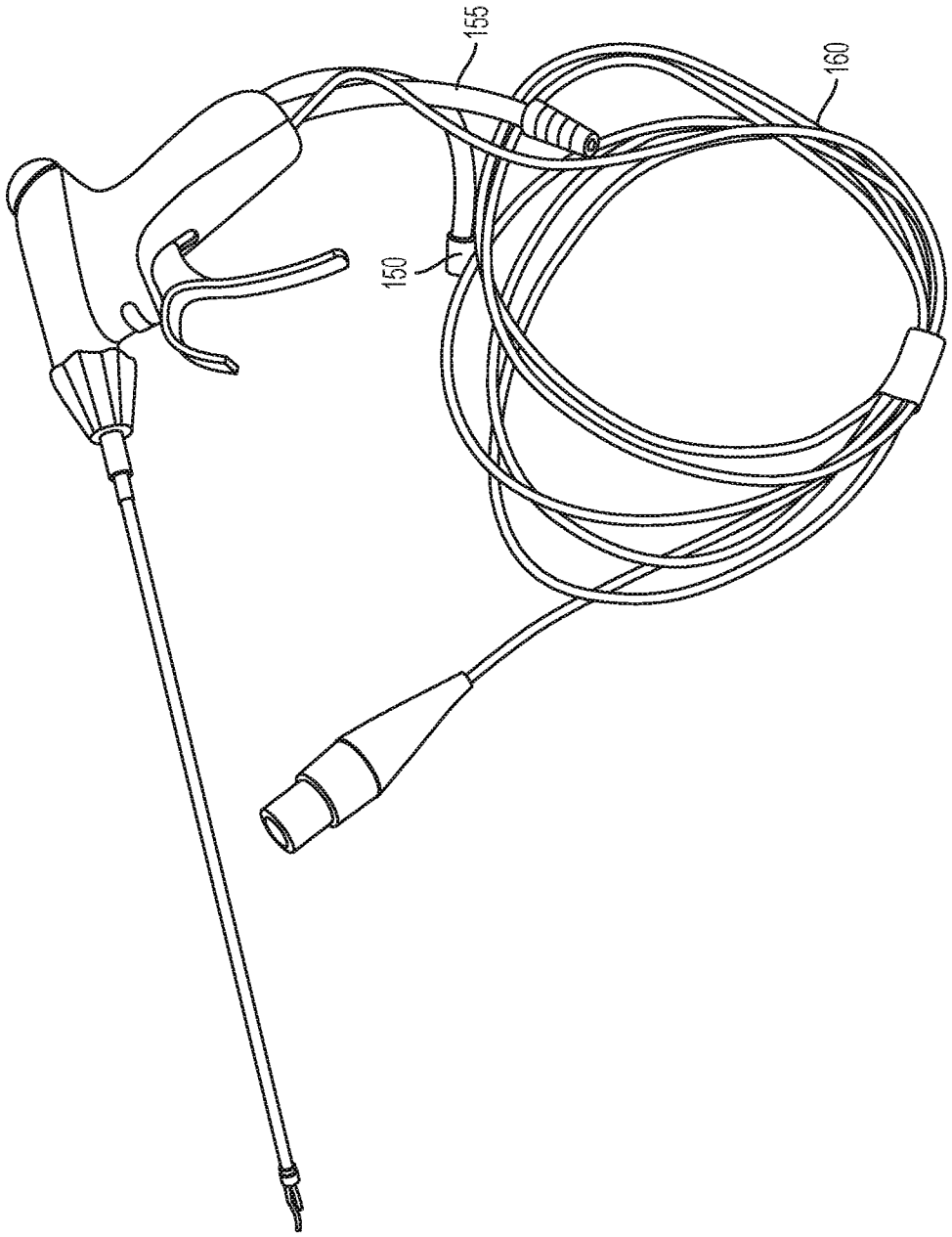



FIG. 1G

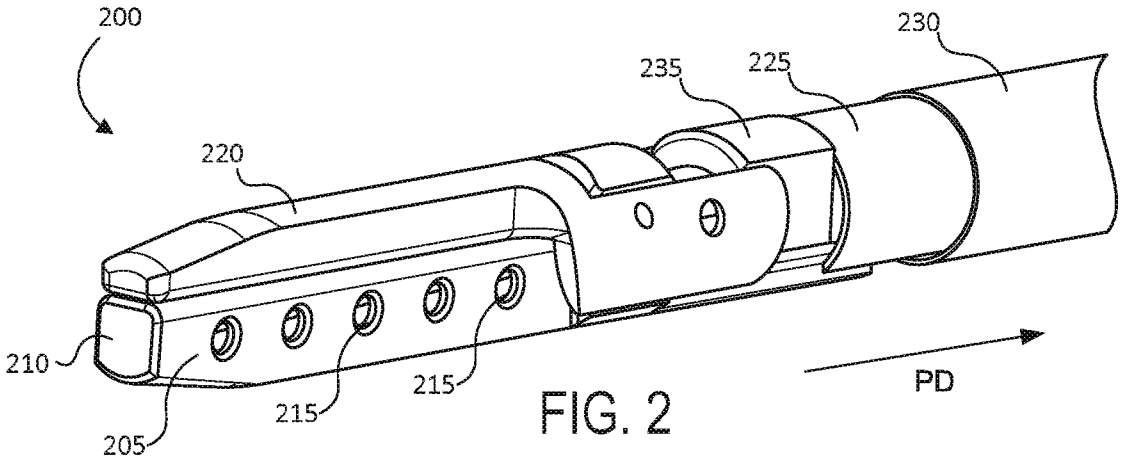



FIG. 2

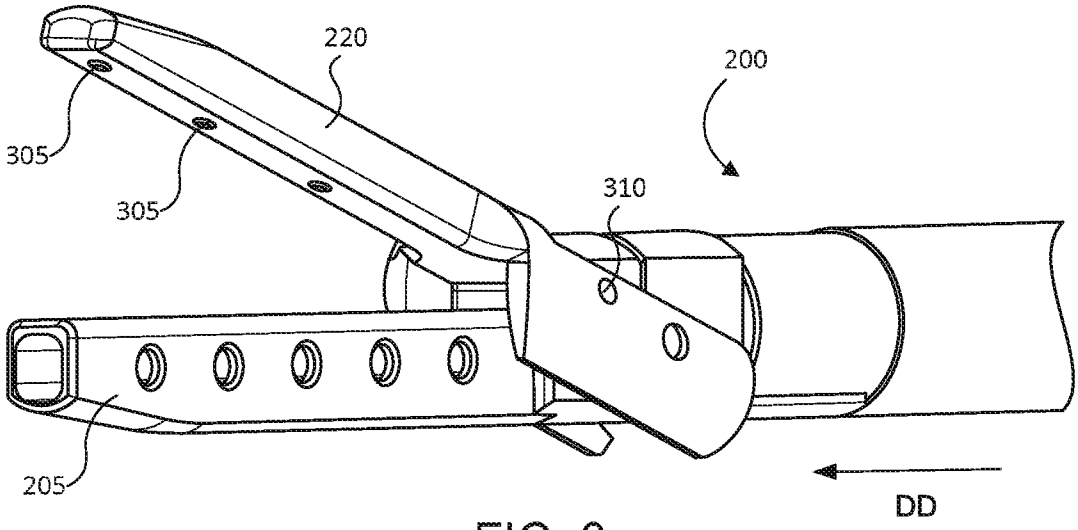



FIG. 3

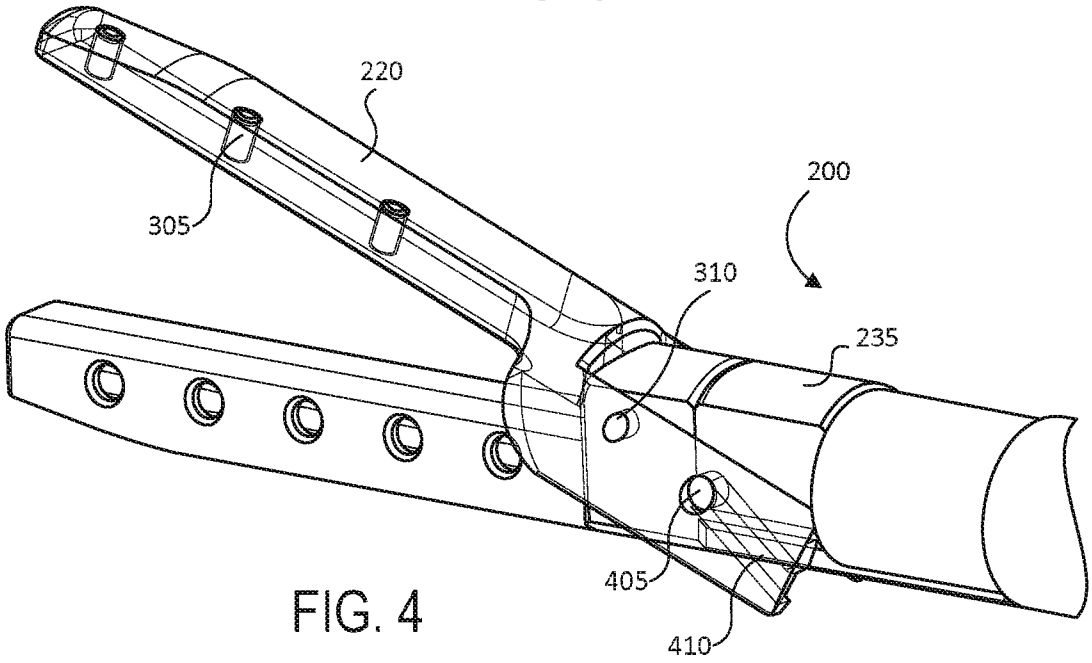



FIG. 4

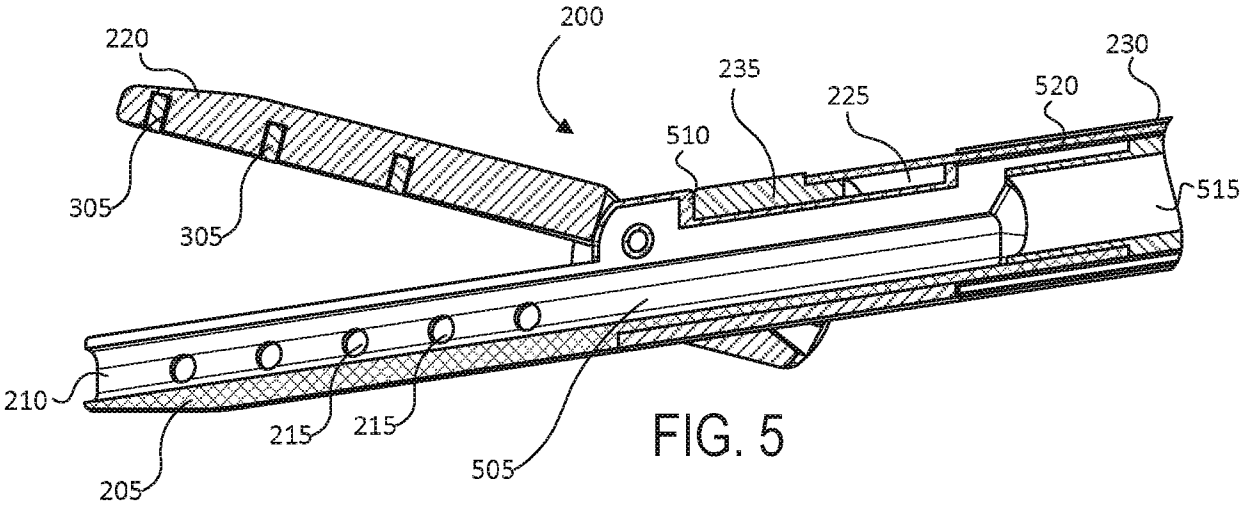



FIG. 5

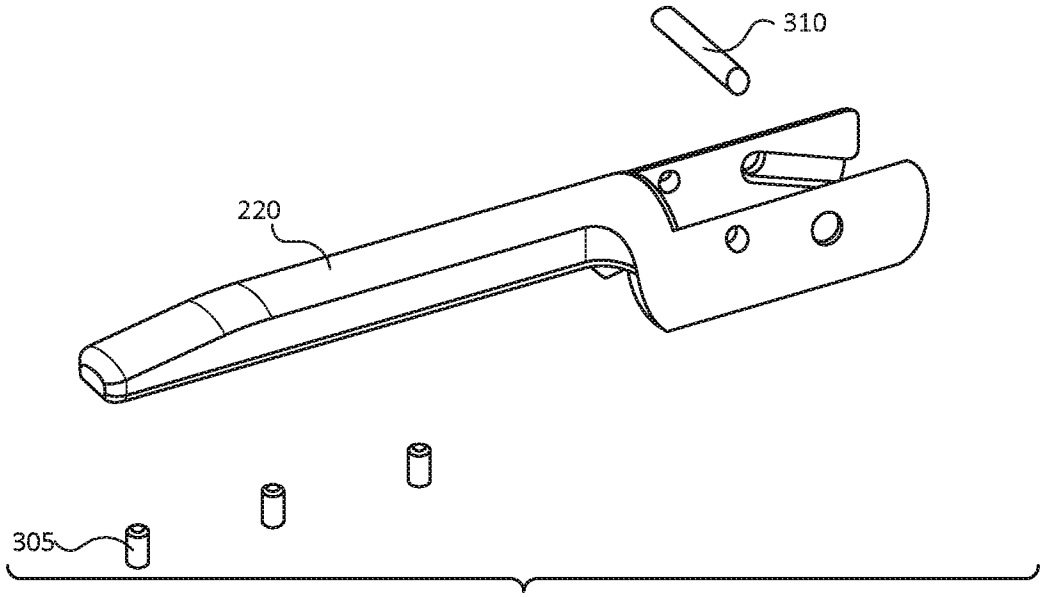



FIG. 6

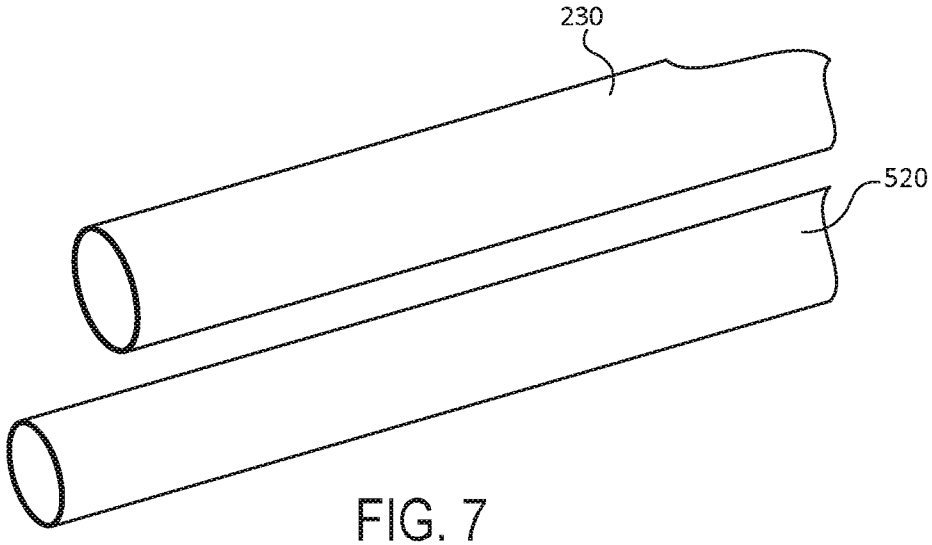



FIG. 7

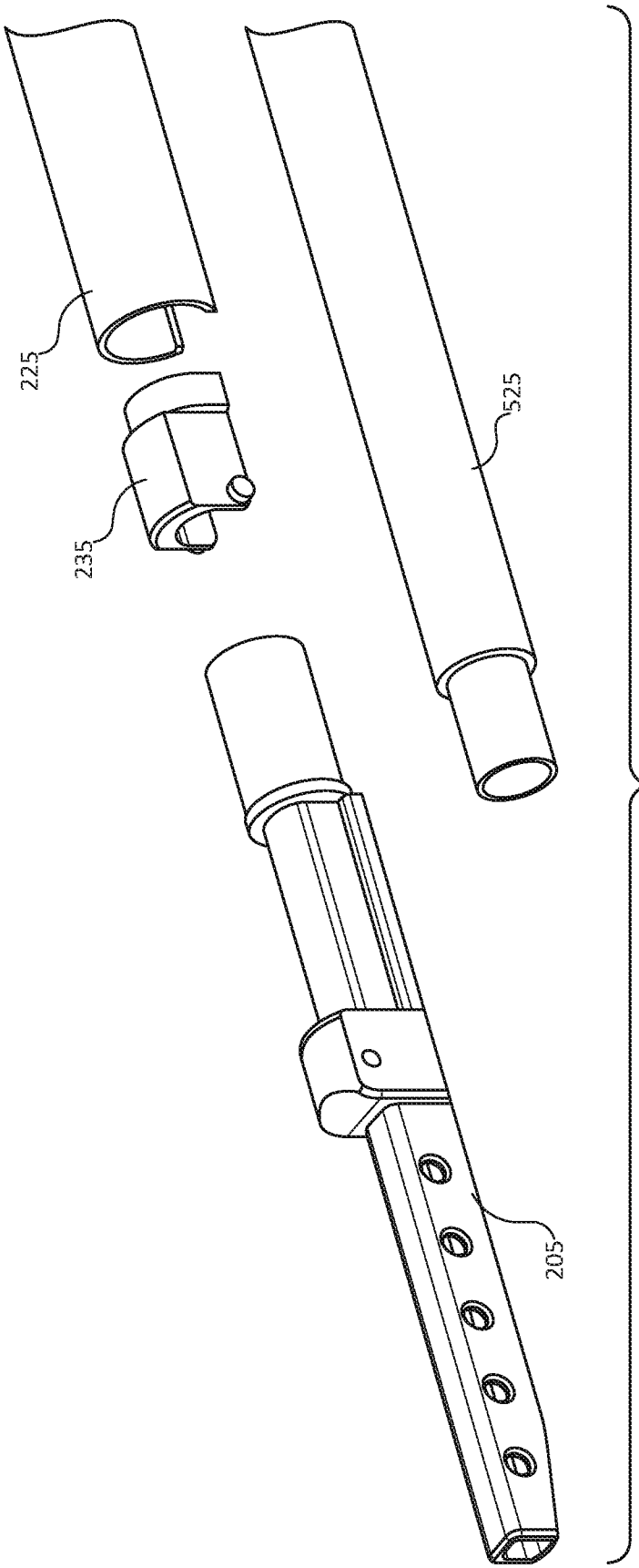



FIG. 8

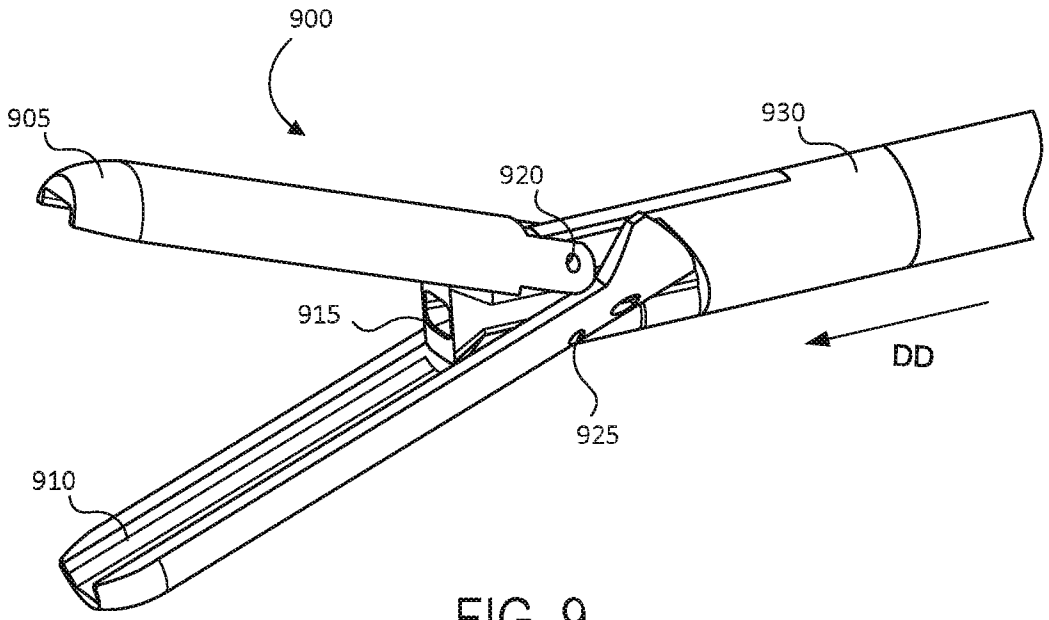



FIG. 9

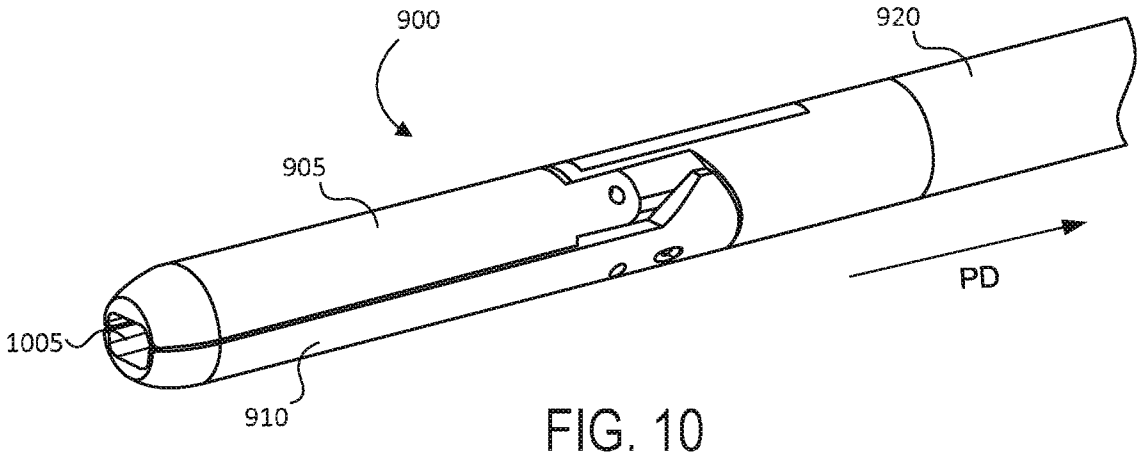



FIG. 10

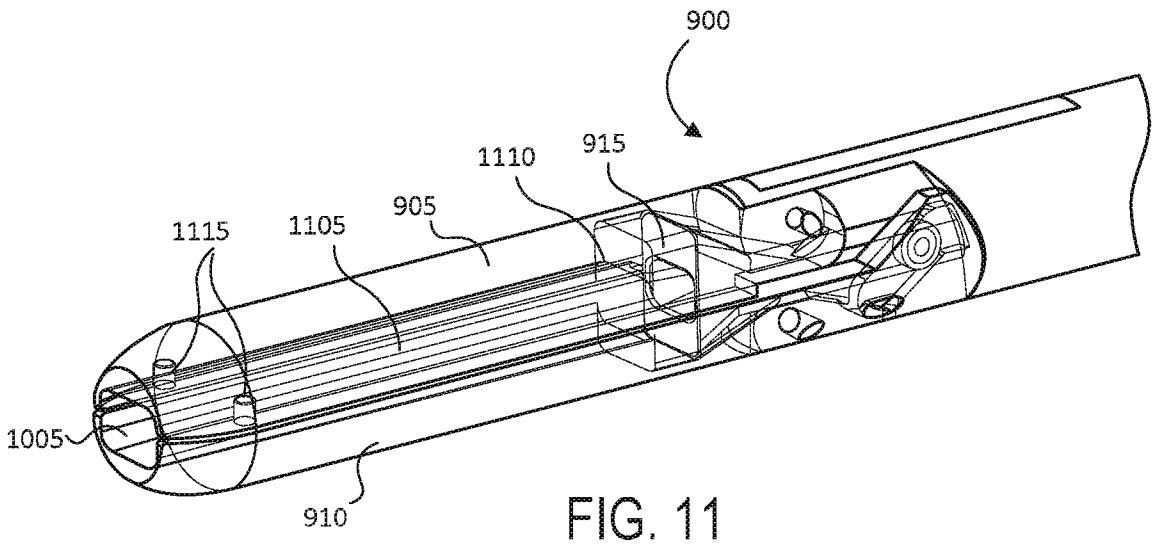



FIG. 11

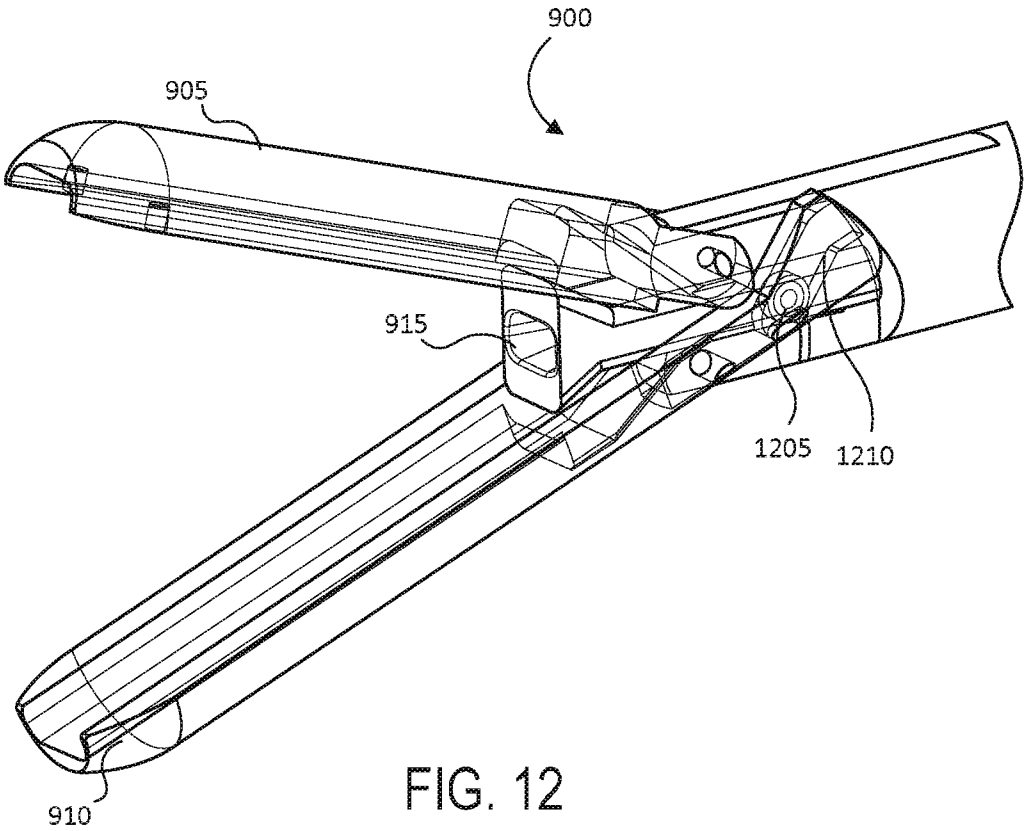



FIG. 12

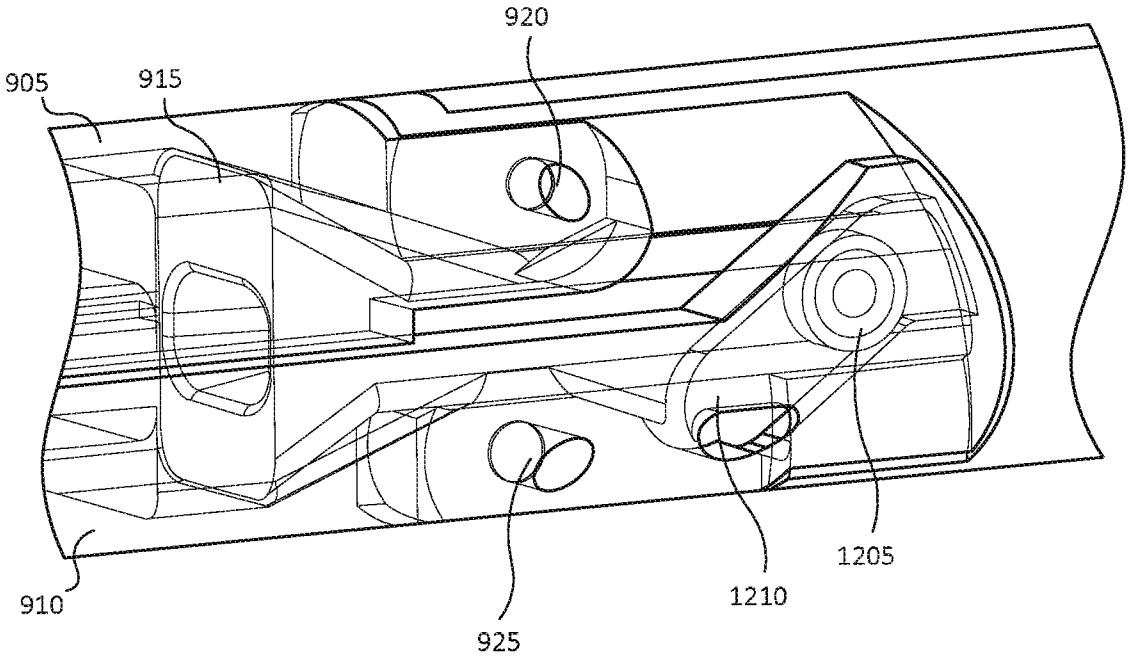



FIG. 13

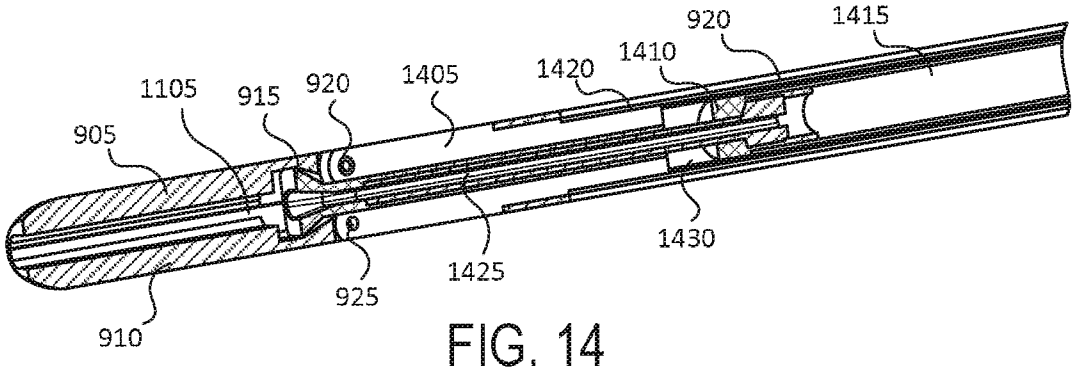



FIG. 14

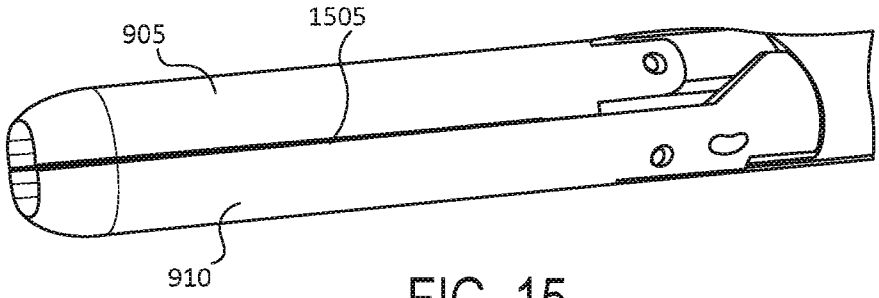



FIG. 15

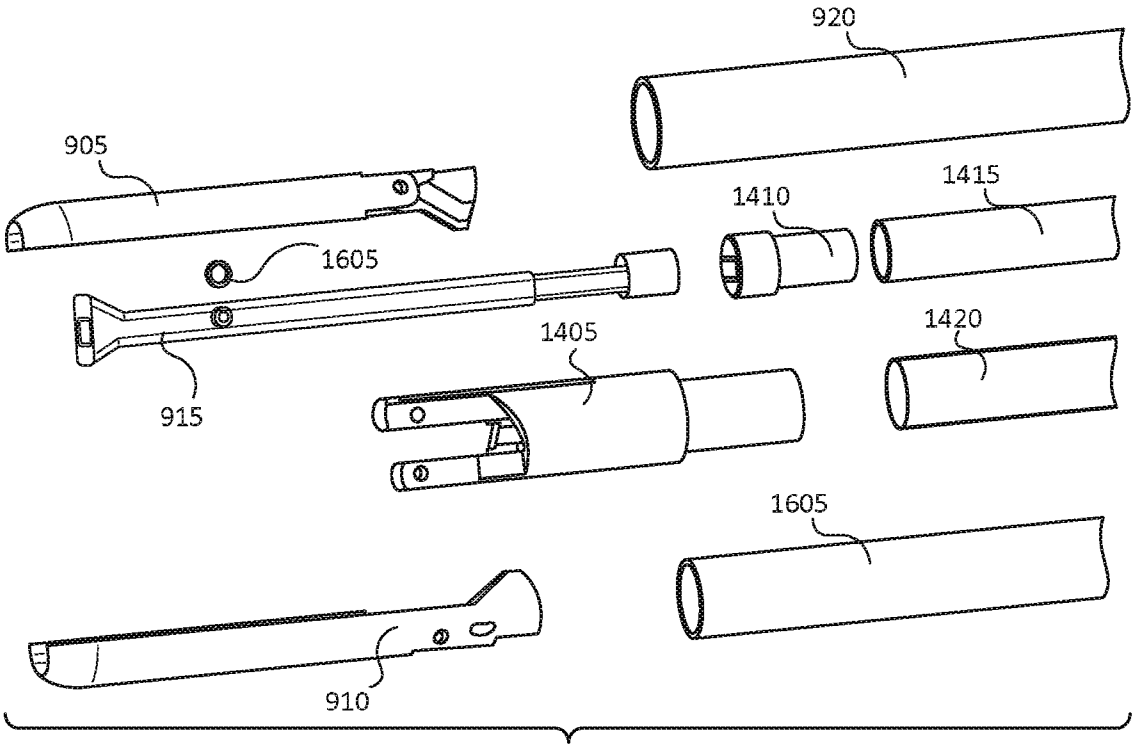



FIG. 16

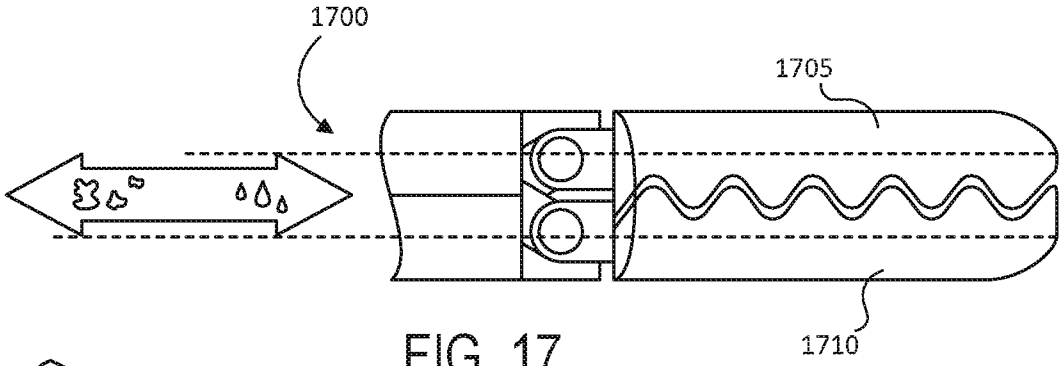



FIG. 17

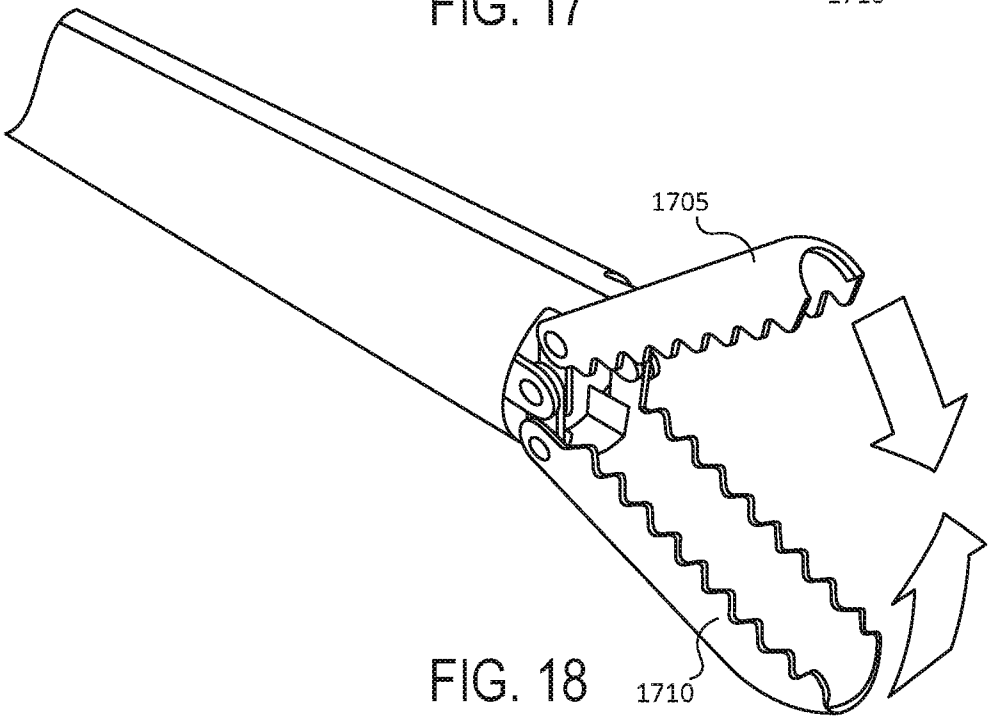



FIG. 18

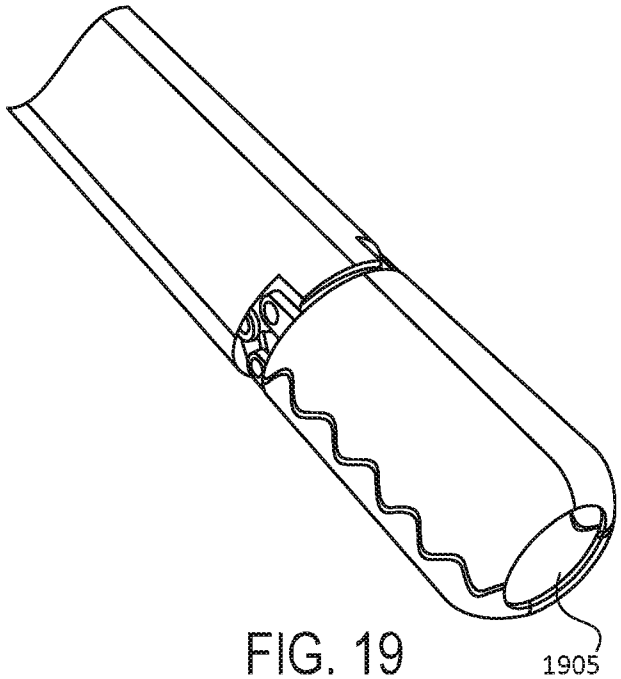



FIG. 19

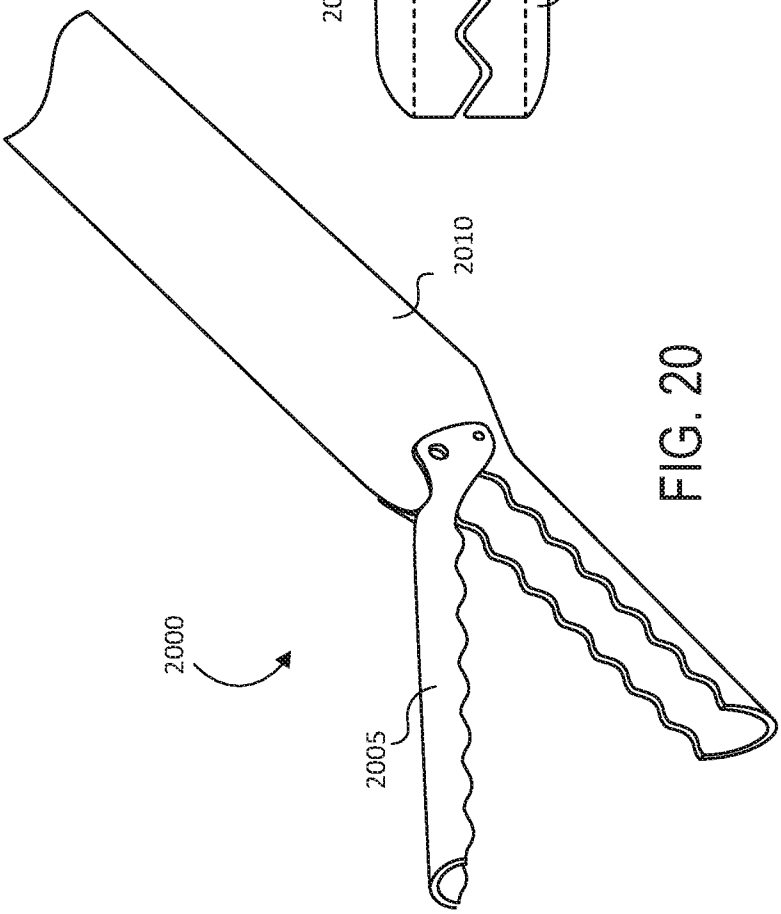



FIG. 20

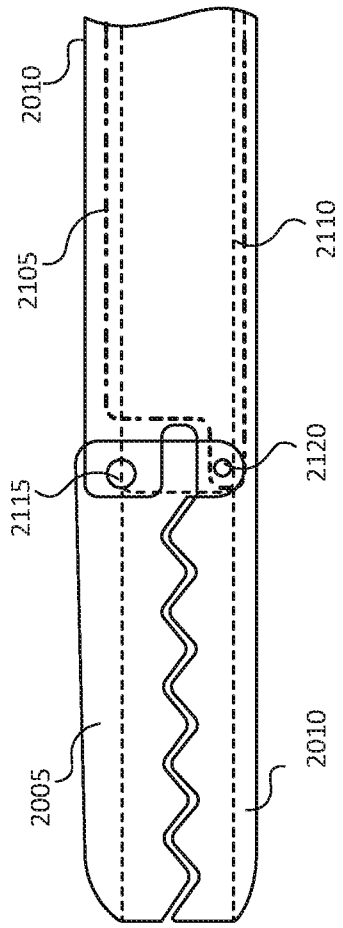



FIG. 21

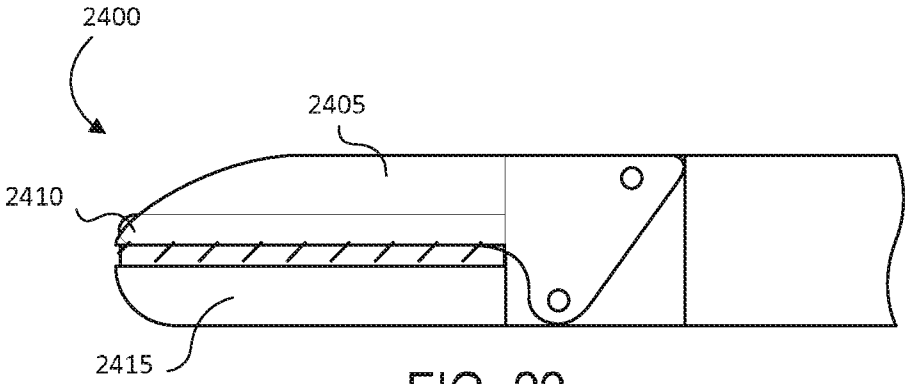



FIG. 22

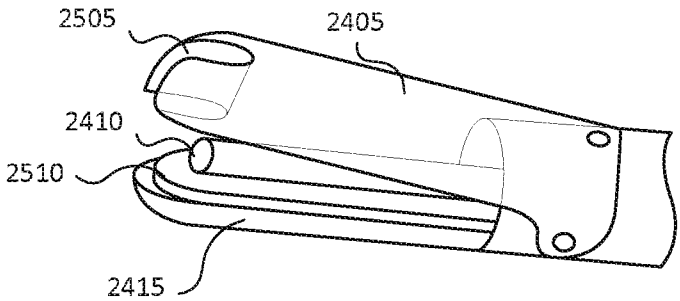



FIG. 23

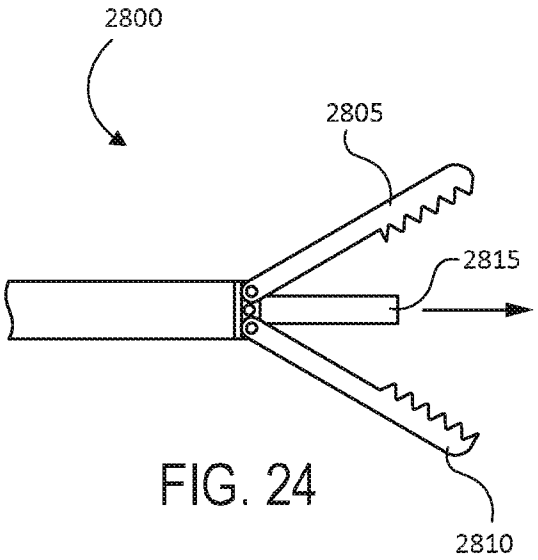



FIG. 24

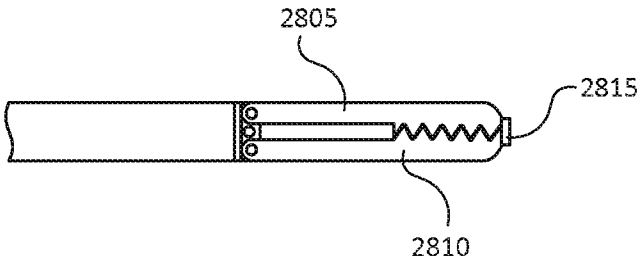



FIG. 25

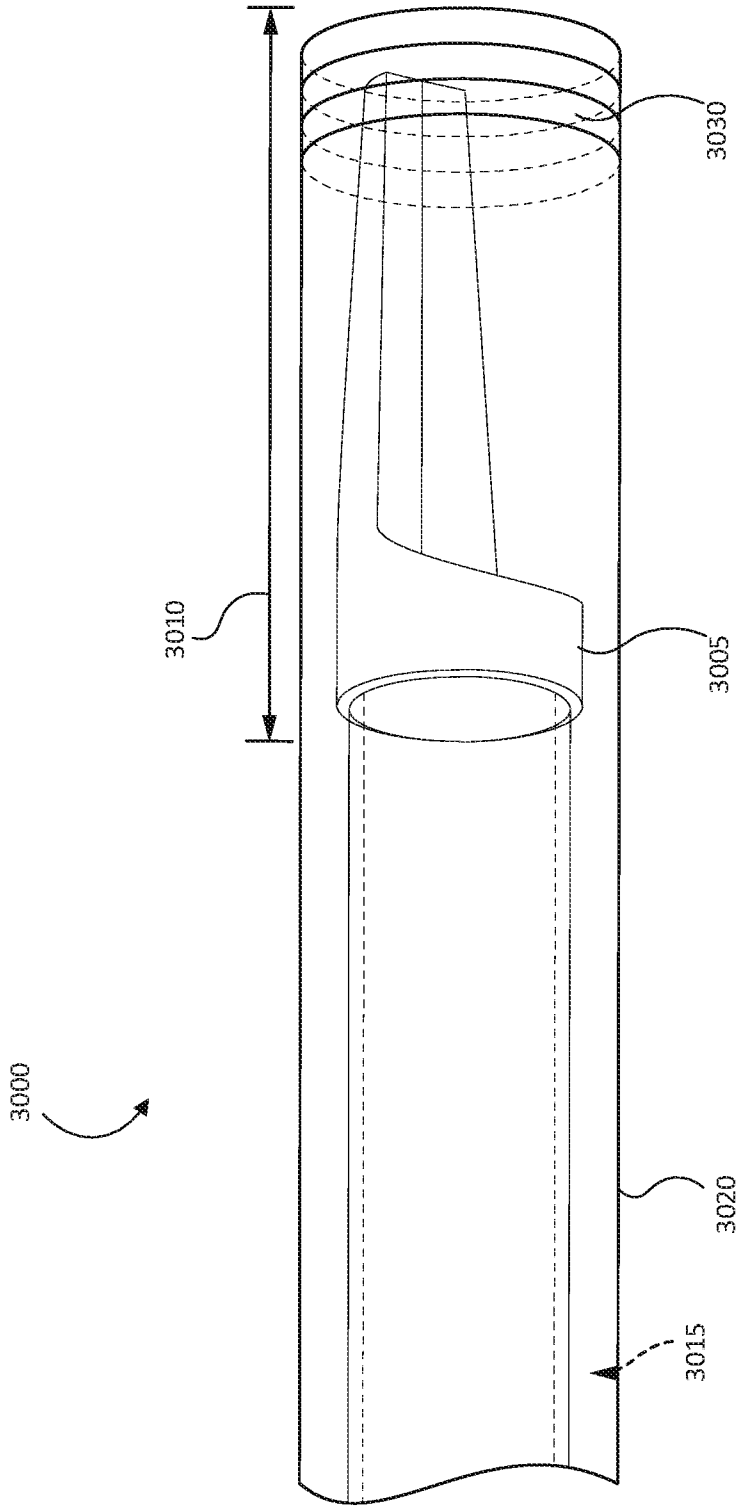



FIG. 26

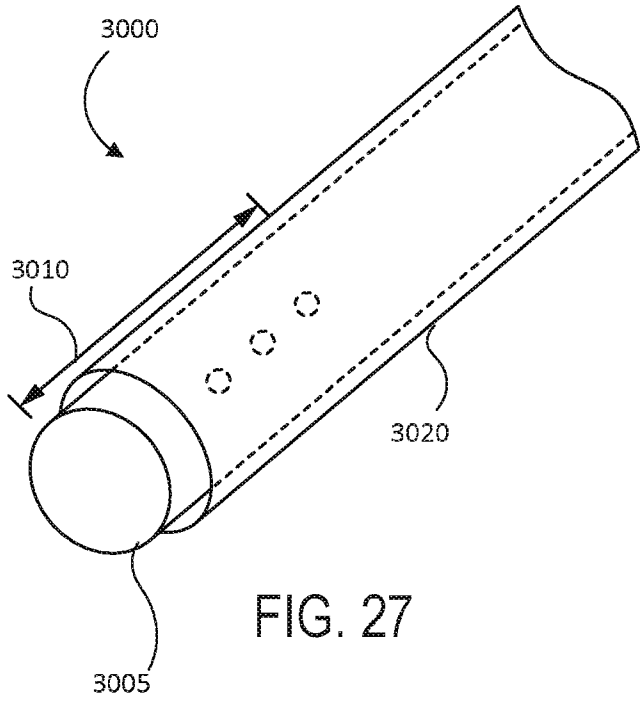



FIG. 27

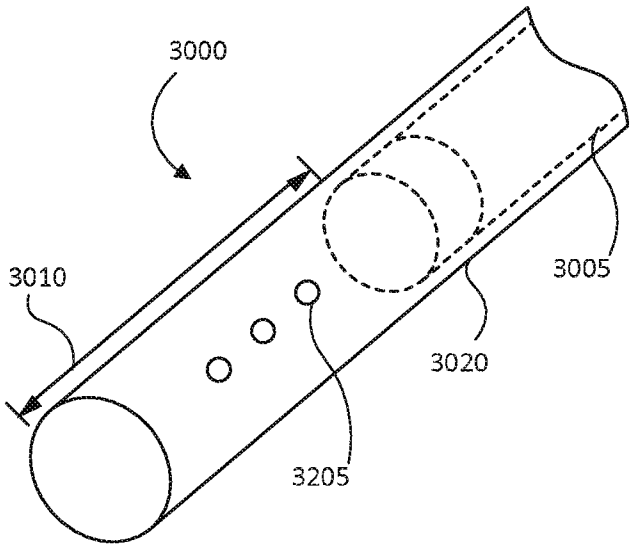



FIG. 28

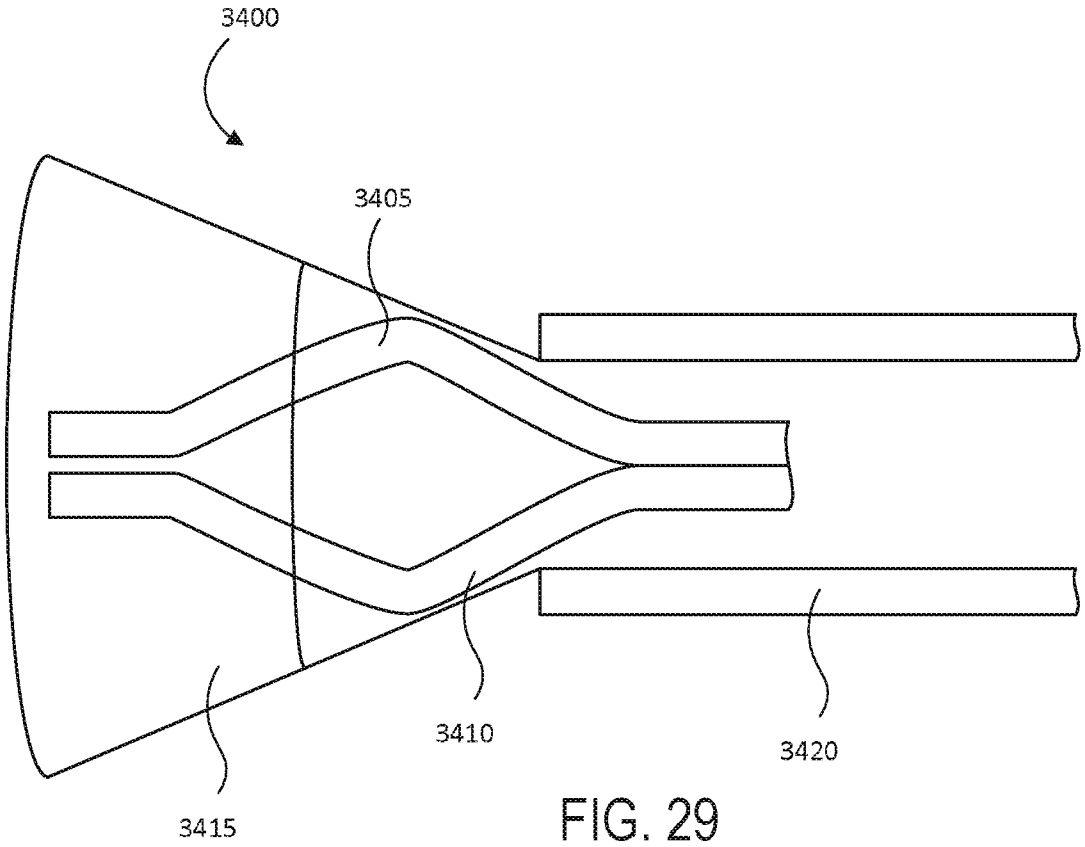



FIG. 29

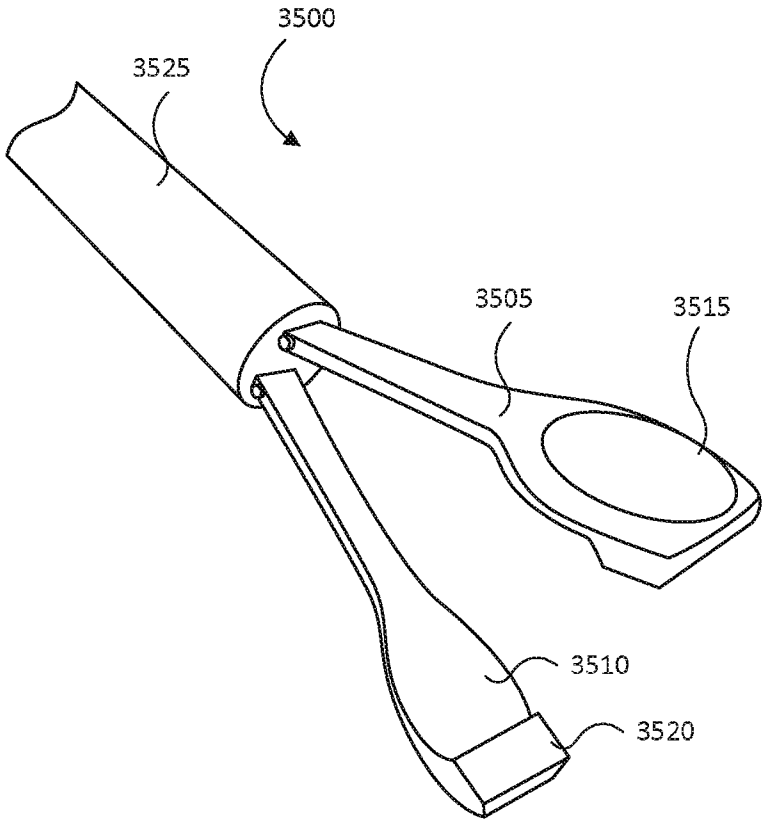



FIG. 30

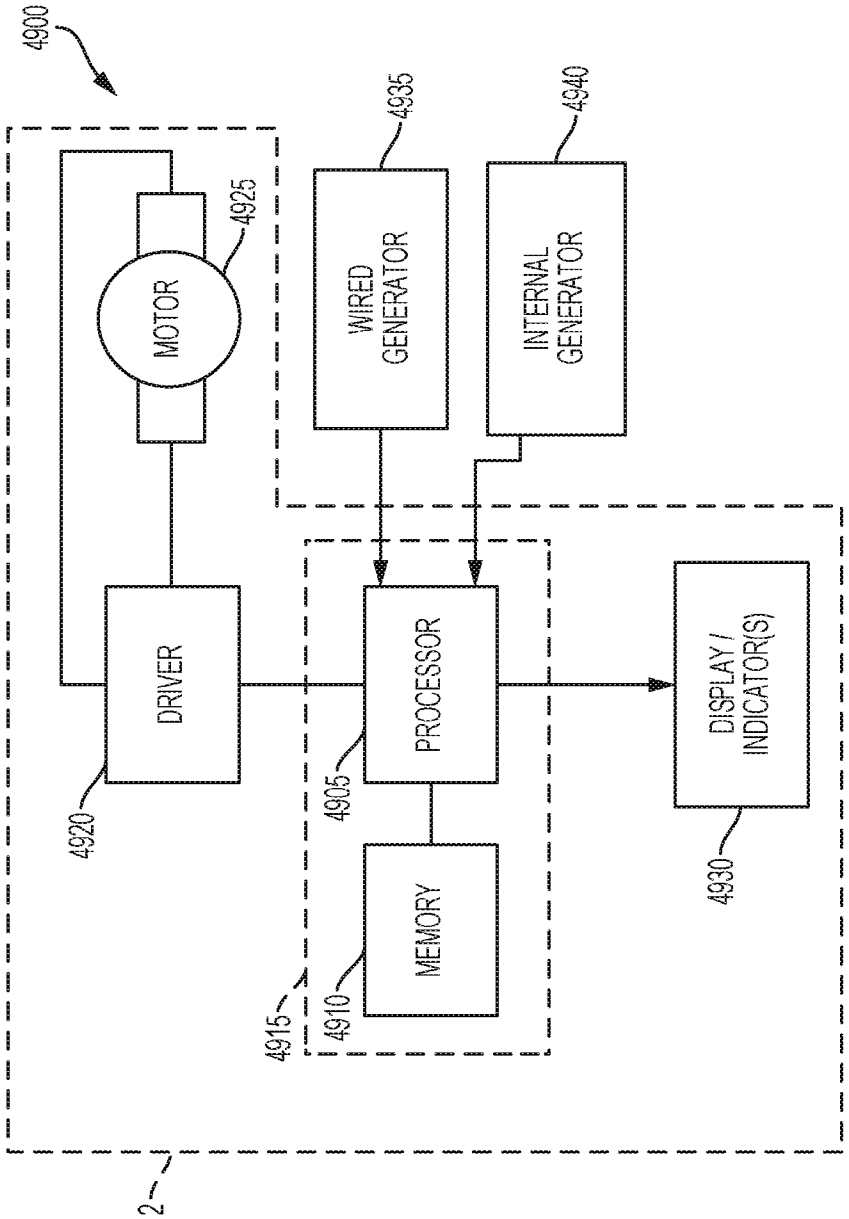

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MOTOR
WIRED GENERATOR
INTERNAL GENERATOR
DRIVER
PROCESSOR
DISPLAY / INDICATOR(S)
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MEMORY
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FIG. 31

# INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/056715

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B18/14
ADD.

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

B. FIELDS SEARCHED

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

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| X | US 5 417 709 A (SLATER CHARLES R [US]) | 1-5, |
| | 23 May 1995 (1995-05-23) | 13-15,19 |
| Y | abstract; figures 1-3 | 6 |
| A | column 3, line 48 - column 6, line 7 | 7-12 |
| | ----- | |
| X | US 2014/350540 A1 (KITAGAWA YUKO [JP] ET | 1-5, |
| | AL) 27 November 2014 (2014-11-27) | 7-10, |
| | | 13-15 |
| Y | abstract; figures 1-19 | 6 |
| A | paragraphs [0039] - [0125] | 11,12,19 |
| | ----- | |
| X | WO 2015/038346 A1 (ETHICON ENDO SURGERY | 1-5, |
| | INC [US]) 19 March 2015 (2015-03-19) | 13-18 |
| Y | abstract; figures 1-19 | 6 |
| A | paragraphs [0039] - [0125] | 7-12,19 |
| | ----- | |
| | -/-- | |

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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

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

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

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

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

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

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 22 December 2016 | 11/01/2017 |

| Name and mailing address of the ISA/ | Authorized officer |
|---|---|
| European Patent Office, P.B. 5818 Patentlaan 2<br>NL - 2280 HV Rijswijk<br>Tel. (+31-70) 340-2040,<br>Fax: (+31-70) 340-3016 | Mendelevitch, L |

1

Form PCT/ISA/210 (second sheet) (April 2005)

# INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/056715

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| Y | US 6 228 084 B1 (KIRWAN JR LAWRENCE T [US]) 8 May 2001 (2001-05-08) | 6 |
| A | abstract; figures 1-4<br>column 2, line 29 - column 3, line 42<br>----- | 1-5,7-19 |

1

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2016/056715

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
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| US 2014350540 A1 | 27-11-2014 | CN 104144654 A | 12-11-2014 |
| | | EP 2944280 A1 | 18-11-2015 |
| | | JP 5677633 B2 | 25-02-2015 |
| | | US 2014350540 A1 | 27-11-2014 |
| | | WO 2014109181 A1 | 17-07-2014 |
| WO 2015038346 A1 | 19-03-2015 | US 2015080879 A1 | 19-03-2015 |
| | | WO 2015038346 A1 | 19-03-2015 |
| US 6228084 B1 | 08-05-2001 | NONE | |