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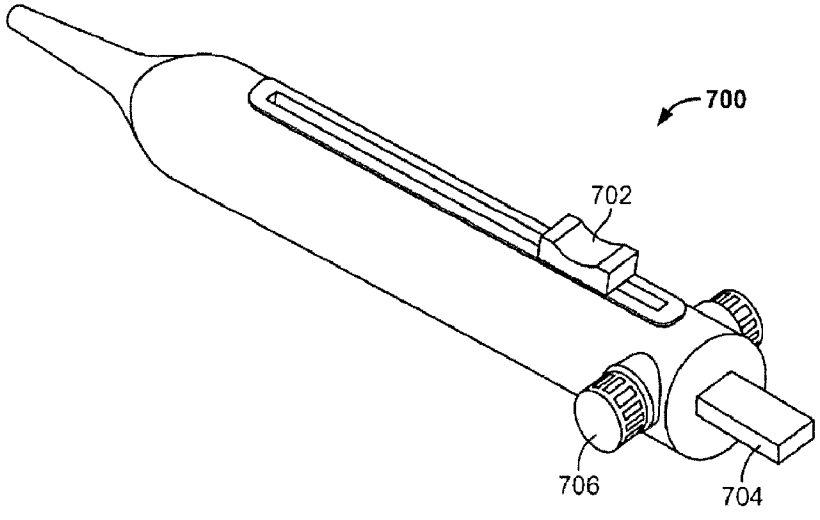

(57) Abrégé/Abstract:
Described here are devices for closing one or more tissues, and handles for controlling these devices. Generally, the devices described here comprise a snare loop assembly, wherein the snare loop assembly comprises a snare and a suture loop, and a

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(57) Abrégé(suite)/Abstract(continued):
handle for controlling the snare loop assembly. In some variations the snare loop assembly may comprise a retention member that may releasably connect the suture loop to the snare. In other variations the devices comprise one or more force-reducing suture locks to help prevent the suture loop from inadvertently disengaging from the snare loop assembly. In still other variations, the excess-suture management features. The handles described here may be configured to remove excess suture from a suture loop, and may also be configured to release the suture loop from the snare loop assembly.

ABSTRACT

Described here are devices for closing one or more tissues, and handles for controlling these devices. Generally, the devices described here comprise a snare loop assembly, wherein the snare loop assembly comprises a snare and a suture loop, and a handle for controlling the snare loop assembly. In some variations the snare loop assembly may comprise a retention member that may releasably connect the suture loop to the snare. In other variations the devices comprise one or more force-reducing suture locks to help prevent the suture loop from inadvertently disengaging from the snare loop assembly. In still other variations, the excess-suture management features. The handles described here may be configured to remove excess suture from a suture loop, and may also be configured to release the suture loop from the snare loop assembly.

TISSUE LIGATION DEVICES AND CONTROLS THEREFOR

This application is a divisional application of co-pending application Serial No. 2,757,497, filed April 1, 2010.

FIELD

[0002] This invention relates generally to devices and methods for ligating tissue, such as the left atrial appendage, using surgically, minimally invasive or intravascular approaches, and to handles for actuating such devices.

BACKGROUND

[0003] Atrial fibrillation is a common problem that afflicts millions of patients. Atrial fibrillation often results in the formation of a thrombus, or clot, in the appendage of the left atrium. This presents a problem, inasmuch as the thrombus can dislodge and embolize to distant organs, which may result in adverse events such as a stroke. For this reason, most patients with atrial fibrillation are treated with one or more blood thinners to help prevent the formation of a thrombus. Blood thinners, however, can present health risks of their own, especially in the elderly. These risks, such as bleeding, often require a user to make significant lifestyle changes.

[0004] Several methods have been developed to address the potential problem of thrombus formation in the left atrial appendage. One such method includes suturing the left atrial appendage along the base or ostial neck where it joins the atrial chamber. In this way, blood flow into the atrial appendage is cut off, eliminating the risk of thrombus formation therein. This is typically done through open-heart surgery, which limits the availability of the procedure to those who are at a particularly high risk, or who are otherwise undergoing an open-heart procedure. In addition, open-heart surgery requires general anesthesia and has a number of well-known risks, making it less desirable.

[0005] Other methods have also been investigated. These methods include methods of stapling the base of the appendage and methods of filling the appendage with a space occupying or occluding member. Stapling is not preferred given the fragility of the appendage and its

CA 2995931 2018-02-22

tendency to rupture, while occlusion devices may not effectively prevent all blood flow into the appendage.

[0006] Additional devices and methods for closing the left atrial appendage or other suitable tissues would therefore be desirable. In particular, devices and methods for closing the left atrial appendage using minimally invasive, intravascular, or a combination of these techniques, would be desirable in order to avoid the need for opening the chest. Of course, additional devices for use in open surgical procedures are desirable as well, especially when those devices offer additional advantages over standard devices.

BRIEF SUMMARY

[0007] Described here are devices for closing one or more tissues, and mechanisms for controlling these devices. Generally, the devices described here comprise a snare loop assembly, wherein the snare loop assembly comprises a snare and a suture loop, an elongate body, and a mechanism for controlling the snare loop assembly which may be mounted on a handle. In some variations the snare loop assembly may comprise a retention member that may releasably couple the suture loop and the snare. In other variations the devices comprise one or more force-reducing suture locks to help prevent the suture loop from inadvertently disengaging from the snare loop assembly.

[0008] Generally, the elongate body may be attached to the handle and may comprise one or more lumens. In some variations, the elongate body comprises one lumen. In another variation, the elongate body comprises two lumens. In still another variation, the elongate body comprises three or more lumens. In some variations, the elongate body may comprise one or more pieces of separation tubing, which may alter the size or shape of one or more lumens, or may divide one or more lumens into two or more sub-lumens. Additionally, in some variations the elongate body may comprise a tip portion. In some variations, the tip portion may be formed separately from the elongate body and may be attached thereto. In other variations, the tip portion may be formed integrally with the elongate body. The tip portion may have any suitable number of lumens or sub-lumens passing therethrough. In some variations, the tip portion may at least partially house one or more pieces of separation tubing. In some variations, the tip portion comprises a knot-receiving recess for at least temporarily housing a suture knot of a suture loop.

In some of these variations, the tip portion may comprise one or more elements that may eject a suture knot from a knot-receiving recess. In some of these variations, a balloon or other expandable structure may be expanded in knot-receiving recess to a eject suture knot therefrom. In other variations, a pusher may be used to eject a suture knot from the knot-receiving recess.

[0009] In some variations, the devices may comprise one or more suture management elements to hold a portion of the suture loop within the elongate body. In still other variations, the devices comprise one or more suture hooks. In some variations, the one or more suture hooks comprise one or more springs attached thereto. In some of these variations, the one or more springs may be disposed concentrically around a snare of the snare loop assembly. In other variations, separation tubing may be used to hold excess suture within the elongate body. In some of these variations, the closure device may further comprise a suture tube for releasably holding a length of suture. The suture tube may be configured such that suture held within suture tube may tear or otherwise break through a portion of the suture tube when the suture loop is tightened. In some variations, one end of the suture tube may be attached to separation tubing and the other end of the suture tube may be attached to one or more components of the snare loop assembly (e.g., a snare, a retention member, a suture lock, or the like). In some variations, the suture tube may comprise one or more grooves or cuts on a side thereof. In other variations, the suture tube may comprise one or more strengthening members disposed therein.

[0010] In other variations, the closure device may comprise a pulley suture. In some of these variations, the pulley suture may be looped around or doubled over a portion of a suture loop. In other variations, the pulley suture may be temporarily attached to a portion of a suture loop via one or more deformable elements. In some variations, one end of the pulley suture may be temporarily or permanently attached to a snare via a suture lock. Another end of the pulley suture may be attached to one or more components of the device handle. In some of these variations, an end of the pulley suture may be attached to a suture fob. In some of these variations, an end of a suture loop may be attached to the same suture fob.

[0011] The handles described here may have any suitable configuration of elements or combination of elements. In some variations, the handle comprises one or more device introducers. In some of these variations, the device introducer may be a guidewire introducer. In other variations, the handle may comprise a strain relief portion, which may help prevent the

handle from disengaging with the rest of the closure device. In still other variations, the handle may comprise one or more elements configured to tighten a suture loop. Tightening a suture loop may remove excess suture from the suture loop, release a suture loop from a snare loop assembly, or ligate a target tissue. For example, in some variations, this element is a snare control. In other variations, this element is a suture knob. In some variations, the devices may be actuated and controlled without an actual handle. In some of these variations, one or more devices or systems may be used to control the device, such as a surgical master-slave system utilizing a user-operated computer.

[0012] Also described here are methods for closing one or more tissues. In some variations, the methods comprise introducing a closure device into a body, where the closure device comprises a snare loop assembly having an opened configuration and a closed configuration and comprising a snare and a suture loop, where the suture loop has slack when the snare loop assembly is in its closed configuration. The snare loop assembly may be advanced in its closed configuration to a target tissue, opened to its open configuration, advanced over the target tissue, and closed around the target tissue. The slack from the suture loop may then be removed, and the suture tightened to disengage the suture loop from the snare loop assembly and ligate the target tissue. It should be appreciated that the closure device of these methods may be any suitable closure device as described hereinthroughout. In some variations, the method may comprise placing an expandable structure in the left atrial appendage to help position the snare loop assembly. In other variations, the method may comprise placing an expandable structure in or near an entrance to the left atrial appendage to help position the snare loop assembly. In some variations, one or more expandable structures may be released inside of and maintained in the left atrial appendage. In other variations, one or more embolic or haemostatic materials may be delivered to the left atrial appendage to help form a bolus or occlusive structure therein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] FIG. 1 is a view of a distal end of an illustrative device having a snare loop assembly.

[0014] FIG. 2 is a view of a distal end of a snare loop assembly, including a suture hook.

[0015] FIG. 3A is a perspective view of one variation of a handle suitable for use with the devices described here. FIG. 3B is a cross-sectional bottom view of the handle shown in FIG. 3A.

[0016] FIGS. 4-9 are perspective views of variations of handles suitable for use with the devices described here.

[0017] FIGS. 10 and 11 are cross-sectional side views of portions of two variations of the closure devices described here.

[0018] FIGS. 12 and 13A-13C illustrate two variations of snare loop assemblies suitable for use with the closure devices described here.

[0019] FIG. 14 shows a perspective view of an illustrative variation of the closure devices described here.

[0020] FIG. 15 shows a cross-sectional side view of a portion of one variation of the closure devices described here comprising a pulley suture.

[0021] FIGS. 16A-16B illustrate a variation of the closure devices described here in which a snare is releasably connected to an elongate body.

[0022] FIGS. 17A-17D illustrate different illustrative variations of snare configurations.

[0023] FIGS. 18A and 18B depict a perspective view and a side view, respectively, of a variation of a snare. FIGS. 18C and 18D depict a method by which the snare of FIGS. 18A and 18B may be used to ensnare tissue.

[0024] FIGS. 19A-19G illustrate several variations of knot shielding mechanisms suitable for use with the closure devices described here.

[0025] FIGS. 20A-20C depict illustrative retention members that may be used with the devices described here.

[0026] FIG. 21 depicts an illustrative variation of an elongate body suitable for use with the devices described here.

[0027] FIGS. 22A and 22B depict a perspective view and a top view, respectively, of one variation of separation tubing suitable for use with the devices described here. FIGS. 22C and 22D depict a perspective view and a top view, respectively, of another variation of separation tubing suitable for use with the devices described here.

[0028] FIG. 23A depicts a front view of one illustrative variation of a tip portion suitable for use with the devices described here. FIGS. 23B and 23C depict cross-sectional side views of the tip portion of FIG. 23A.

[0029] FIGS. 24A and 24B depict portions of two variations of tip portions suitable for use with the devices described here.

[0030] FIGS. 25A-25C depicts a perspective view, a front view, and a cross-sectional side view, respectively of an illustrative variation of a tip portion suitable for use with the devices described here. FIG. 25D illustrates a cross-sectional side view of one variation of a closure device incorporating the tip portion illustrated in FIGS. 25A-25C.

[0031] FIGS. 26A and 26B show an illustrative variation of a closure device comprising separation tubing.

[0032] FIG. 27 depicts an illustrative variation of a closure device comprising separation tubing and a suture tube.

[0033] FIGS. 28A and 28B depict a variation of a suture tube suitable for use with the devices described here.

[0034] FIG. 29 depicts a cross-sectional side view of a suture tube suitable for use with the devices described here.

[0035] FIGS. 30A-30D depict a variation of the closure devices described here comprising a pulley suture.

DETAILED DESCRIPTION

[0036] Described here are closure devices, handles for actuating closure devices, and methods for closing tissues using one or more closure devices. Generally, the closure devices comprise a

snare loop assembly comprising a snare and a suture loop, such as those described in U.S. Patent Application No. 12/055,213, entitled "Devices, Systems, and Methods for Closing the Left Atrial Appendage" and filed on March 5, 2008. The devices described here may be suitable for use with minimally invasive access to the left atrial appendage (e.g., through a small incision above, beneath or through the rib cage, through an incision in the costal cartilage or the xiphoid, through a port, through the vasculature, etc.).

[0037] Generally, the closure devices described here comprise an elongate body, and a snare loop assembly. In some variations the closure devices may further comprise a handle. A handle or other control mechanism (e.g., a surgical master-slave robotic system) may be used to control and actuate the snare loop assembly through the elongate body, as will be explained in more detail below. The snare loop assembly, in turn, may be used to temporarily or permanently close, tighten, ligate or other restrict tissue. To achieve this, the snare loop assembly may be changed between a delivery, or "closed," configuration and a deployed, or "open," configuration, and vice versa, as will be described in more detail below. Placing the snare loop assembly in a closed configuration may allow for low-profile advancement of the snare loop assembly to a target location, or may allow the snare loop assembly to close around a target tissue. Conversely, placing a snare loop assembly in an open configuration may allow the snare loop assembly to be placed around one or more target tissues, or may allow the snare loop assembly to release one or more target tissues previously closed by the snare loop assembly.

[0038] In use, a distal end of an elongate body may be advanced into the body toward a target tissue (e.g., the left atrial appendage). This advancement may be done in a minimally invasive manner. During advancement, the snare loop assembly may be in a closed configuration to help prevent the snare loop assembly from snagging or catching on tissue or other obstructions. Once the distal end of the elongate body has reached a location at or near the target tissue, the snare loop assembly may be opened to a deployed configuration. The snare loop assembly may then be advanced, moved, or otherwise manipulated to encircle at least a portion of the target tissue. The snare loop assembly may then be closed around the encircled tissue to close, ligate, or otherwise restrict the target tissue. The snare loop assembly may be re-opened, repositioned, and re-closed as necessary. In some instances, a suture loop (not shown) or other restricting

device may be tightened and released from the closure device to maintain the target tissue in a closed fashion. To remove the closure device from the body, the snare loop assembly may again be opened to release the target tissue (it should be appreciated that the suture loop or other closure device may remain in place) such that the snare loop assembly and elongate body may be withdrawn. Once the target tissue is released, the snare loop assembly may be closed to facilitate low-profile withdrawal.

[0039] The closure devices may contain one or more additional features, as will be described in more detail below. In some variations, the snare loop assembly comprises one or more force-reducing suture locks. These elements, as will be described in more detail below, may act to releasably or permanently connect various components of the snare loop assembly while reducing forces that are transmitted to one or more portions of the snare loop assembly. In other variations, the closure device may comprise one or more features that helps maintain at least a portion of the suture loop inside of the elongate body when the device is in an opened and/or closed configuration. In some of these variations, the closure device may comprise a suture hook that engages a portion of the snare loop assembly. In other variations, the elongate body may comprise one or more pieces of separation tubing. This separation tubing may further comprise a suture tube attached thereto for releasably holding at least a portion of the suture loop. In still other variations, the elongate body may comprise a pulley suture that engages one or more portions of the snare loop assembly. Each of these features will be described in more detail below, and it should be appreciated that the closure devices described here may comprise any combination of these features.

[0040] FIG. 14 depicts one illustrative variation of closure device (1400). Shown there is snare loop assembly (1402), elongate body (1404), and handle (1406). As noted above, handle (1406) may be used to control and actuate the snare loop assembly (1402) through the elongate body (1404) in order to move snare loop assembly (1402) between a closed configuration (as shown in FIG. 14) and a deployed configuration (not shown), and vice versa.

SNARE LOOP ASSEMBLY

[0041] As mentioned above, the snare loop assemblies of the closure devices described here may be used to temporarily close or restrict one or more target tissues. Generally the snare loop

assembly comprises a snare, a suture loop, and a retention member at least temporarily connecting the snare and the suture loop. The snare loop assembly may also comprise one or more force-reducing suture locks, as will be described in more detail below. FIG. 1 shows an illustrative variation of snare loop assembly (100) comprising snare (102), suture loop (104), and retention member (106). Snare loop assembly (100) may be at least partially disposed in elongate body (108) having tip (110). Snare loop assembly (100) is shown in FIG. 1 in an open configuration, and the portion of snare loop assembly (100) extending out of elongate body (104) may define a continuous aperture therethrough. This aperture may be defined by one or more components of the snare loop assembly (100) (e.g., the snare), and may be suitable for encircling tissue such as the left atrial appendage. Generally, the snare (102) may be used to open and close the snare loop assembly (100), as will be described in more detail below. In some instances, retention member (106) may be configured to releasably couple suture loop (104) and snare (102), and may be configured to release suture loop (104) from snare loop assembly (100) upon application of sufficient force to suture loop (104).

Snare

[0042] In variations of snare loop assemblies comprising a snare, the snare may be at least partially moveable to change a snare loop assembly between open and closed configurations. Generally, a portion of the snare may be housed in the elongate body, and another portion of the snare may extend outside of the distal end of the elongate body to at least partially define the aperture of the snare loop assembly. In some variations, one end of the snare is fixed relative to one or more portions of the closure device, while the other end may be advanced or retracted through the elongate body. Movement of the free end of snare may change the amount of the snare loop assembly that is disposed outside of elongate body, and thus change the size of the aperture defined thereby. Specifically, advancement of the snare through the elongate body may increase the size of the snare loop assembly aperture, while retraction of the snare may decrease the size of the snare loop assembly aperture to close the snare loop assembly. The free end of the snare may be manipulated in any suitable manner. In some variations, the snare may be attached directly to one or more portions of the handle, as will be described in more detail below. In other variations, a hypotube, rod, or other rigid structure may be attached to the free

end of the snare. This structure may in turn be moved by the handle, which may help facilitate advancement or withdrawal of the snare through the elongate body.

[0043] In variations where one end of the snare is fixed relative to the closure device, the snare may be fixed to any suitable portion of the device. For example, in some variations one end of the snare may be fixedly held in, on, or near a tip of the elongate body. In other variations, the fixed end of the snare may be affixed in one or more lumens of the elongate body. In still other variations, the fixed end of snare may be at least temporarily attached to the device's handle. Although one end of the snare may be temporarily fixed relative to the closure device, it should be appreciated that this fixed end may be configured to be releasable and/or moveable. Configuring the fixed end of the snare to be releasable and/or movable may serve a number of useful functions. In some instances, temporary or permanent device failure may result in the moveable portion of the snare becoming stuck or caught. In these instances, it may be necessary to release the fixed end in order to allow the closure device to release ensnared tissue. In other instances, it may be desirable to move the free end in order to provide for adjustment of the snare using both ends.

[0044] When one end of the snare is configured to be temporarily fixed relative to the elongate body, the end of snare may be released from its fixed relation in any suitable manner. For example, in some variations, an end of the snare may be temporarily held in a fixed manner by a frangible member. FIGS. 16A and 16B illustrate one variation by which an end of a snare (1600) may be releasably fixed to an elongate body (1602) by a frangible member (1604). Specifically, FIGS. 16A and 16B show a portion of elongate body (1602) having at least one lumen (1605). In this variation, a portion of lumen (1605) may be subdivided into at least first and second sub-lumens ((1606) and (1608) respectively). As shown in FIG. 16A, first sub-lumen (1606) has a first section (1610) with a first cross-sectional area, and a second section (1612) with a second cross-sectional area. The end of snare (1600) may be placed in first section (1610) of first sub-lumen (1606), and may be attached to the distal end of frangible member (1604), as shown in FIG. 16A. Frangible member (1604) may pass through second section (1612) of first sub-lumen (1606) and through lumen (1605).

[0045] The attachment of snare (1600) to frangible member (1604) may help temporarily lock the end of snare (1600) in place. The proximal end (not shown) of frangible member (1604)

may be temporarily attached in a fixed manner to one or more portions of the device handle (not shown). Because the proximal end of the frangible member (1604) is held in place, the frangible member (1604) may prevent the snare from being pulled distally out of the end of the elongate body (1602). Additionally, the cross-sectional area of first section (1610) may be different from the cross-sectional area of the second section (1612) such that the end of snare (1600) is unable to pass from first section (1610) into second section (1612). In this way, the snare (1600) is prevented from moving proximally into the elongate body (1602). Additionally, in some variations, at least a portion of snare (1600) and first section (1610) may have non-circular cross sections (e.g., oval, triangle, square, polygon, or shape with irregular geometry) such that the snare (1614) housed within first section (1610) may unable to rotate relative to first section (1610). Because the end of snare (1600) is prevented from moving proximally, distally, or rotating relative to first section (1610) of first sub-lumen (1606), the end of snare may be effectively immobilized relative to the elongate body (1602).

[0046] Frangible member (1604) may be configured such that application of a sufficient force to frangible member (1604) is sufficient to break the attachment between frangible member (1604) and snare (1600). To release snare (1600) from its fixed position, a user may pull on the proximal end of frangible member (1604) directly or indirectly (e.g., via one or more handle components). Because the snare (1600) is prevented from moving proximally into second section (1612), sufficient proximal force applied to the frangible member (1604) may act to break the engagement between frangible member (1604) and snare (1600), thereby releasing the snare (1600) as shown in FIG. 16B.

[0047] The snares described here may be made of any suitable material or combination of materials. For example, in some variations the snare may be made from a shape-memory material, such as a shape-memory alloy (e.g., a nickel titanium alloy, etc.), or may be made from stainless steel, polyester, nylon, polyethylene, polypropylene, combinations thereof, and the like. In variations where the snare is made from the shape-memory material, the snare may be configured to take on a particular shape or configuration when the snare loop assembly is placed in an open configuration, but may still be at least partially withdrawn into the elongate body to place the snare loop assembly in a closed configuration. For example, as shown in FIG. 1 above, snare (102) may form a generally circular loop when snare loop assembly (100) is placed in an

open configuration. While shown in FIG. 1 as being generally circular, snare (102) may form a loop of any given shape. FIGS. 17A-17D illustrate several additional snare configurations. In the variation shown in FIG. 17A, snare (1700) may form a teardrop-shaped loop (1702) when in a deployed configuration. In the variation shown in FIG. 17B, snare (1704) may form an oval or ellipsoid loop (1706) when in a deployed configuration. In the variation shown in FIG. 17C, snare (1708) may take on a substantially triangular loop (1709) when in a deployed configuration. Furthermore, in some variation, the snare loop may be angled relative to the elongate body. For example, FIG. 17D shows a side view of closure device (1710), in which snare (1712) exits elongate body (1714) that is at an angle (θ) relative to the elongate body's longitudinal axis (1716). This angle (θ) may be any suitable angle. For example, angle (θ) may be about 5°, about 15°, about 30°, about 45°, about 60°, about 75°, about 90°, between about 40° and about 50°, between about 35° and about 55°, between about 30° and about 60°, or the like. Angling snare (1712) relative to elongate body (1714) may aid the snare (1712) in capturing tissue, as angling may better position the snare (1712) relative to tissue as the closure device is moved in the body.

[0048] FIGS. 18A-18D illustrate yet another variation of snare (1800). In this variation, snare (1800) may form a hook-shaped loop (1802) when snare (1800) extends from elongate body (1804) in an open configuration. FIG. 18A shows a perspective view of snare (1800), while 18B shows a side view of snare (1800). Because the loop (1802) bends back over itself to form a hook shape (as highlighted in a side view in FIG. 18B), the snare (1800) may help create space between body tissues when in an open configuration. For example, when opened in the pericardial space, as shown in FIG. 18C, the snare (1800) may lift the pericardial sac (1806) away from the heart (1808). Creating additional space within the pericardial sac may make it easier for snare (1800) to capture tissue, such as the left atrial appendage (1810), as shown in FIG. 18D.

Suture Loop

[0049] The snare loop assemblies described here may also comprise a suture loop for maintaining tissue in a closed manner. Generally, the suture loop may be releasably attached to the snare, for example, via a retention member, as will be described in more detail below. Furthermore, the suture loop may comprise a suture knot, but need not. This suture knot may be

any suitable knot, including, but not limited to, a slip knot (e.g., a one-way slip knot). In some variations, as will be described in more detail below, at least a portion of the knot may be held within the tip of elongate body. In other variations, the suture knot may be temporarily held in fixed relation to the elongate body, as will be described in more detail below.

[0050] In variations where the suture loop comprises a slip knot, suture may be advanced or withdrawn through the slip knot to change the size of suture loop. In some instances where the suture knot is held within or against a tip of elongate body, the suture knot may not move while the size of suture loop is changed. This may help prevent the closure device from damaging tissue, as will be described in more detail below.

[0051] In some variations, the suture loop further comprises a unidirectional locking structure. In these variations, the unidirectional locking structure may be any structure capable of being advanced along the suture in one direction, but resisting movement in a second direction. In these variations, the locking structure may be advanced over a portion of the suture loop to help lock a suture knot in place. For example, in some variations the unidirectional locking structure may comprise a bead which is placed at least partially around the suture. In these variations, the bead may comprise one or more teeth or projections that allow for the bead to be advanced along the suture in one direction, but prevents or resists movement in the opposite direction. The locking structure may be advanced via one of the closure devices described here, or may be advanced by a separate device after the suture loop has been released from the closure device.

[0052] Suture loop may be made from any suitable material useful in exclusion or closure. For example, it may be made of a biodegradable material (e.g., polylactic acid, polyglycolic acid, polylactic-co-glycolic acid, etc.), or may be made of a non-biodegradable material (e.g., metal, steel, polyester, nylon, propylene, silk, combinations thereof and the like).

[0053] When the suture loop is tightened to close tissue, it may be possible for tissue to be pulled into the suture knot of the suture loop. If too much tissue is pulled into suture knot, the suture knot may clog or jam in a way that prevents the suture loop from being further tightened. In some variations the suture loop may comprise one or more pledgets or tube sections to help shield a portion of the suture knot. FIGS. 19A-19G illustrate several variations of suture loops comprising knot-shielding elements. In FIG. 19A, two legs of suture loop (1900) are threaded

through a pledget (1902). Pledget may be made from any suitable material, such as, for example, polyurethane foam, felt, Teflon fabric, Dacron, collagen, or the like. FIG. 19B shows another variation of suture loop (1904) in which pledget (1905) is doubled over and two legs of suture loop (1904) are threaded therethrough. By increasing the thickness of pledget (1905) disposed between suture knot (1906) and tissue (not shown), the pledget (1905) may further reduce the amount of tissue that is pulled into suture knot (1906). FIG. 19C shows yet another variation of suture loop (1908) comprising pledget (1910), in which only a portion of pledget (1910) is doubled over. In this variation, one leg (1912) of suture loop (1908) may be threaded through the doubled-back portion of pledget (1910) while the other leg is threaded through the single-layered portion of pledget (1910).

[0054] FIG. 19D shows still another variation of suture loop (1914), in which one leg (1916) of suture loop (1914) and free end (1918) of suture loop (1914) are threaded through pledget (1920). FIG. 19E shows a variation of suture loop (1922) in which both legs and a free end (1924) of suture loop (1922) are all threaded through a pledget (1926). It should be appreciated that in some of these variations, one or more portions of pledget (1926) may be sized or otherwise configured to fit in one or more portions, lumens or recesses of the elongate body. FIG. 19F shows a variation of suture loop (1928) in which suture knot (1930) is at least partially shielded by tubing (1932). In this variation, the legs of suture loop (1928) may pass through the ends of tubing (1932), while suture knot (1930) may exit out of an aperture (1934) in the side of the tubing (1932). FIG. 19G shows another variation of suture loop (1936) in which the suture knot (not shown) is shielded by tubing (1938). In this variation, legs of suture loop (1936) may exit out of slots (1940) in the sides of tubing (1938), while the free end of suture loop (1936) may exit out of one end of the tubing (1938).

Retention Member

[0055] FIGS. 20A-20C depict illustrative retention members that may be used with the devices described herein. FIG. 20A shows an end view of a retention member (2014) having first and second lumens (2016, 2018) for retaining a closure element and a suture loop therein. In this variation, the second lumen (2018) has a slit or other opening (2020) along its length, for allowing the suture to pass therethrough when it is ready to be deployed. Of course, it should be understood that the first and second lumens may be positioned or oriented in any suitable way

with respect to each other, and similarly, the slit or other opening on the second lumen may be positioned or oriented in any suitable fashion with respect to the first lumen (e.g., it may be approximately 180°, approximately 150°, approximately 120°, approximately 90°, approximately 60°, approximately 30°, or the like, from the first lumen (2016)). FIG. 20B provides an illustration of a retention member having a first lumen (2022), a second lumen (2024), and a slit (2026). In this variation, the slit (2026) is positioned closer to the first lumen (2022) than the slit of FIG. 20A. The width or spacing of the slit opening may be selected as desired or appropriate. Similarly, the slit need not extend or be continuous along the entire length of the retention member. In some variations, the slits may have prongs or arms along its length to help capture and retain the suture therein. In other variations, the slits may be covered at spaced apart locations therealong with a biodegradable polymer, temporarily used to tack or hold down the suture. Of course, in still other variations, the retention member does not comprise a slit, and instead comprises some other type of retention mechanism, such as the prongs or tacks described just above. In yet other variations, there are no slits or openings in the retention member and the suture loop is released upon removing or withdrawing the retention member and closing the device.

[0056] FIG. 20C provides another variation of a retention member. In this variation, the retention member has a first lumen (2028), second lumen (2030), and a separation region (2032). The separation region may be constructed in any suitable fashion. For example, the separation region may comprise a perforated region adapted to perforate and release the suture with the application of force. Alternatively, the separation region may be a thin-walled or other type of weakened region that may be configured to break and release the suture. It should be understood that the retention member may have any suitable geometry or shape, and may be made from any suitable material. Similarly, the lumens need not be full circles or have a circular cross-sectional geometry. When these or other types of retention members are used, the suture loop may be torn out, pulled through, or otherwise released from the retention member after it has been properly positioned and tightened as desirable.

ELONGATE BODY

[0057] As mentioned briefly above, the elongate body of the closure devices described here may connect the distal end of the snare loop assembly and the handle or actuating mechanism

while still allowing for control of the snare loop assembly through the elongate body. Specifically, at least a portion of some of the snare loop assembly components may be housed within elongate body, and may be connected to the handle through the elongate body. In some variations, at least a portion of the elongate body may be flexible, which may help facilitate navigation of the elongate body in and through tissue.

[0058] FIG. 21 shows one illustrative variation of an elongate body suitable for use with the closure devices described here. Shown there is elongate body (2100) attached to handle portion (2102). Elongate body (2100) may comprise tip portion (2103), curve (2104), first lumen (2106), second lumen (2108), and third lumen (2110). While shown in FIG. 21 as having a single curve (2104), elongate body (2100) may have no curves or may have multiple curves in different portions of the elongate body (2100). Furthermore, in some variations the closure device may comprise one or more mechanisms that may act or function to change the shape of the elongate body (2100). In instances where the elongate body (2100) comprises one or more curves (2104), a tube, mandrel or other straightening mechanism (not shown) may be used to temporarily straighten the elongate body. For example, a rigid tube or mandrel may be placed in one or more lumens of elongate body (2100), which may temporarily straighten any curved sections. Straightening may occur during delivery (e.g., when used in conjunction with a left atrial appendage ligation procedure, before the pericardial space is reached), and the straightening mechanism may be withdrawn at any point to allow elongate body (2100) to return to its original configuration. The straightening mechanism may be made of any suitable material (e.g., a rigid plastic, stainless steel, a combination thereof, etc.).

[0059] In other variations, one or more pre-curved tubes or mandrels may be inserted into elongate body (2100) to create one or more curved sections. In still other variations, one or more pull wires may be disposed in, on, or around elongate body (2100) and may cause elongate body (2100) to flex or bend when one or more of the pull wires is pulled, pushed or otherwise manipulated. It should be further understood that any of the devices described here may be configured for steerability, or may be configured for robotic use (e.g., configured for use with one or more robotic or otherwise automated devices).

Lumens

[0060] The elongate bodies described here may have any suitable number of lumens. It should be appreciated that when the term "lumen" is used herein, it may be used to describe any bore or passageway extending through a length of the elongate body or other portion of the closure device. It should be appreciated that a lumen need not be entirely enclosed (i.e., the lumen may comprise one or more slots, slits, gaps or other openings along some or all of the length of the lumen). Elongate body may comprise one, two, three, four, or five or more lumens. Some or all of the lumens may extend entirely through the elongate body (i.e., from the proximal end of the elongate body to the distal end of the elongate body). Other lumens may pass through only a portion of the elongate body (e.g., from one end to an intermediate point along the elongate body, or between two intermediate points along the elongate body). For example, in the variation shown in FIG. 21, third lumen (2110) passes from the proximal end of the elongate body (2100) to an intermediate point along the length of the elongate body (2100). In this variation, one or more guidewires, visualization devices, or working devices (not shown) may be passed through third lumen (2110).

[0061] The various components of the snare loop assembly may be housed within any lumen or lumens of the elongate body. For example, in some variations, all components of the snare loop assembly may be housed in a single lumen. In other variations, different portions of the snare loop assembly may be at least partially housed in different lumens. For example, in some variations, the elongate body may comprise at least two lumens. In these variations, the free end of suture loop may pass to the handle portion through a first lumen, while the free end of the snare may pass to the handle portion through a second lumen. In variations where the suture loop has excess suture housed within the elongate body, as described in more detail below, this excess suture may be housed in any suitable lumen. For example, in some variations, the excess suture may be held in the same lumen as the free end of the suture loop, in the same lumen as the free end of the snare, or in an altogether different lumen.

[0062] In some instances, one or more of the lumens of the elongate body may be at least partially divided into one or more sub-lumens. Specifically, a lumen may be split into two or more sub-lumens along a portion of the length of that lumen. In some of these variations, a piece of separation tubing may be used to divide a lumen into two or more sub-lumens. FIGS.

22A-22D illustrate several variations of separation tubing suitable for use with the closure devices described here. Specifically, FIGS. 22A and 22B show a perspective view and a top view, respectively, of one variation of separation tubing (2200). In this variation, separation tubing (2200) may comprise first (2202) and second (2204) lumens extending therethrough. When placed inside of a lumen of the elongate body (not shown), the first (2202) and second (2204) lumens of separation tubing (2200) may act as sub-lumens within the lumen of the elongate body. In this way, the separation tubing (2200) may allow for a lumen to be a single passageway along one length of the elongate body and two or more separate passageways along another length of the elongate body.

[0063] It should be appreciated that although shown in FIGS. 22A and 22B as having two lumens ((2202) and (2204)), separation tubing (2200) may include any suitable number of lumens (e.g., one, two, three, or four or more). In this way, a lumen of the elongate body may be subdivided into any suitable number of sub-lumens along the length of the separation tubing. It should be noted that in some variations, the separation tubing may only have a single lumen passing therethrough. In these variations, the separation tubing may not divide a lumen into multiple sub-lumens, but instead may alter the size and/or shape of the lumen along a portion thereof. It should also be appreciated that some or all of the lumens of the separation tubing (2200) may only pass through a portion of the separation tubing.

[0064] In other variations, a piece of separation tubing may include one or more grooves or channels. These grooves or channels may form a fully-enclosed sub-lumen when placed inside of a lumen of an elongate body. For example, FIGS. 22C and 22D illustrate one such variation of separation tubing (2206). Specifically, FIG. 22C shows a perspective view of separation tubing (2206), which comprises lumen (2208) and channel (2210) along an outer surface of separation tubing (2206). When separation tubing (2206) is placed inside of a lumen (2211) of an elongate body (2212), as shown in a top view in FIG. 22D, channel (2210) may form an enclosed lumen which may defined in part by the separation tubing (2206) and in part by the lumen wall. It should be appreciated that the separation tubing described here may comprise any suitable number and combination of channels and/or lumens.

[0065] In some variations it may desirable to configure the separation tubing to allow one or more components of the snare loop assembly to be released therethrough. For example, in some

instances a portion of the suture loop may be threaded through two or more lumens/channels of a section of separation tubing, as will be described in more detail below. In order to release the suture loop from the device, it may be necessary to remove any excess suture from separation tubing without undoing or breaking the suture loop. Thus, in some variations, the separation tubing may comprise one or more separation regions (not shown) between two or more lumens, channels, or combinations thereof. The separation regions may be constructed in any suitable manner, such as those described above with respect to the retention members. For example, in some variations the separation region may comprise a perforated region adapted to perforate and allow suture to pull therethrough as the suture loop is tightened. Alternatively, in some variations the separation region may be a thin-walled or other type of weakened region that may be configured to tear or otherwise break upon the application of force from a suture or other device component.

Tips

[0066] The elongate body generally comprises a tip portion at the distal end thereof. In some variations, the tip of the elongate body may be formed separately from the elongate body, and may be attached to the body during assembly of the device. In other variations the tip portion may be formed integrally with the elongate body as a unitary device. The tip portion may serve a number of useful functions for closure device. In some instances, the tip may be configured to be atraumatic, which may act to reduce the risk of damaging tissue as the proximal end of the elongate body is moved within the body. In other instances, the tip may allow certain portions of the snare to pass through elongate body while holding other portions in place relative to elongate body, as will be described in more detail below.

[0067] The tip portion may have the same number of lumens as the elongate body, but need not. Indeed, in some variations, the tip portion may divide one or more lumens of the elongate body into two or more sub-lumens. In some of these variations, the tip portion may house at least one portion of a piece of separation tubing. In other variations, the tip portion may alter the size or shape of one or more lumens of the elongate body.

[0068] FIGS. 23A-23C show the distal end of one illustrative variation of closure device (2300). Specifically, FIG. 23A shows a front view of tip (2302) of elongate body (2304). As

can be seen there, tip (2302) may comprise first sub-lumen (2305), second sub-lumen (2306), and third sub-lumen (2308). FIG. 23B shows a cross-sectional side view of elongate body (2304) and tip (2302). As shown there, first (2305) and second (2306) sub-lumens may exit into a first lumen (2310) of elongate body, while third sub-lumen may exit into a second lumen (2312).

[0069] In some variations, one sub-lumen may be configured to at least partially house a suture knot of the suture loop. For example, second sub-lumen (2306) shown in FIG. 23B may comprise a knot-receiving recess (2316) with a first cross-sectional area, and a second section (2318) with a second cross-sectional area. A suture knot (2320) of a suture loop (2330) may be placed in knot-receiving recess (2316) of second sub-lumen (2306), as shown in FIG. 23C. A free end of suture loop (2330) may pass through second section (2318) into first lumen (2310) of elongate body (2304). Additionally, the cross-sectional area of knot-receiving recess section (2316) may be different (e.g., smaller and/or differently shaped) from the cross-sectional area of the second section (2318) such that the suture knot (2320) is unable to pass from knot-receiving recess section (2316) into second section (2318). In this way, the suture knot (2320) may be prevented from moving proximally into the elongate body (2304). Additionally, because suture knot (2320) may be housed at least partially in the knot-receiving recess (2316) of second sub-lumen (2306), suture knot may be prevented from pulling into third sub-lumen (2308) when excess suture is pulled into elongate body (2304), as will be described in more detail below.

[0070] FIG. 23C also illustrates how other components of a snare loop assembly (2324) may be disposed relative to tip (2302). As shown there, snare loop assembly (2324) may comprise snare (2326), suture loop (2330), and retention member (2328). Retention member (2328) may releasably connect a portion of snare (2326) and suture loop (2330). A free end of suture loop (2330) may pass through second sub-lumen (2306) and first lumen (2310) to a handle portion (not shown), while an amount of excess suture (2330) may be housed within third-sub lumen (2308) of tip and second lumen (2312) of elongate body. At least a portion of this excess suture (2330) may be held within the elongate body by one or more suture management features (not shown) described below. Additionally, one end of snare may be fixed, temporarily or permanently, at least partially within first sub-lumen (2305), while a free end of snare (2326)

may be moved at least partially through third sub-lumen (2308) of tip and second lumen (2312) of elongate to open and close the snare loop assembly (2324).

[0071] In variations where the tip of an elongate body comprises a knot-receiving recess, it may be desirable to eject or move the suture knot from the recess during or prior to tightening of the suture loop. Moving a suture knot out of the recess may improve the ability of the suture loop to tighten around tissue by improving knot placement relative to tissue. A suture knot may be displaced from the recess in any suitable manner. For example, FIGS. 24A and 24B illustrate two suitable variations by which a suture knot may be advanced from a knot-receiving recess. In a first variation, closure device (2400) may comprise a balloon (2402) or other expandable structure disposed in a knot-receiving recess (2406), as illustrated in FIG. 24A. Suture knot (2408) of suture loop (2410) may be at least partially housed in knot-receiving recess (2406) when balloon is collapsed. When balloon (2402) is expanded, it may displace at least a portion of suture knot (2408) from the knot-receiving recess (2406). In another variation, closure device (2412) may comprise a pusher (2414) at least partially disposed in a knot-receiving recess (2416), as shown in FIG. 24B. In this variation, pusher (2414) may be advanced within knot-receiving recess (2416) to push at least a portion of suture knot (2418), and in some instances the entire suture knot (2418), from the knot-receiving recess (2416).

[0072] In other variations of the closure devices described here, the tip portion may comprise a distal recess. FIGS. 25A-25D illustrate one such variation of tip (2500). FIG. 25A-25C show a perspective view, a front view, and a cross-sectional side view of tip (2500). Shown there is proximal recess (2502) for receiving a distal end of the elongate body (not shown), distal recess (2504), first sub-lumen (2506), second sub-lumen (2508), and third sub-lumen (2510). While shown in FIGS. 25A-25C as being formed separately from the elongate body, it should be appreciated that the tip may be formed integrally with the elongate body.

[0073] FIG. 25D illustrates a cross-sectional side view of one instance of how tip (2500) may be incorporated into a closure device (2512). Shown there is tip (2500) attached to elongate body (2514). As shown there, elongate body (2514) may comprise a first lumen (2516) and a second lumen (2518), and may be placed within the proximal recess (2502) of tip (2500). First (2506) and second (2508) sub-lumens may exit into first lumen (2516), while third sub-lumen may exit into second lumen (2518).

[0074] Closure device (2512) may further comprise separation tubing (2520) that may be disposed partially in third sub-lumen (2510) of tip (2500) and second lumen (2518) of elongate body (2514), and may divide the lumen into sub-lumens (2522) and (2524). Also shown in FIG. 25D is snare loop assembly (2526) comprising snare (2528), suture loop (2530), and retention member (2532). One end (2534) of snare (2528) may be fixedly attached to tip (2500) via first sub-lumen (2506) or may be attached in lumen (2516) through sub-lumen (2506), while a free end of the snare may be advanced or withdrawn through sub-lumen (2524) of separation tubing (2520). Similarly, a free end (2536) of suture loop (2530) may pass through second sub-lumen (2508) of tip (2500), while a portion of excess suture of suture loop (2530) may be housed in sub-lumens (2522) and (2524) of separation tubing (2520).

[0075] Suture knot (2538) may be housed in distal recess (2504). Additionally, second sub-lumen (2508) of tip (2500) and sub-lumen (2522) of separation tubing (2520) may be sized such that suture knot (2538) is unable to pass into either sub-lumen, thereby preventing suture knot (2538) from being pulled or pushed into the elongate body (2514). Additionally, by placing the ends of the suture knots against the entrances to these sub-lumens, the suture loop (2530) may be tightened around tissue while minimizing the amount of tissue that may be pulled into suture knot (2538) as the suture loop (2530) is tightened.

EXCESS-SUTURE MANAGEMENT

[0076] In operation of the closure devices, it may be desirable to be able to open and close a snare loop assembly without prematurely releasing the suture loop from the snare assembly. Because the size of the continuous aperture defined by the snare loop assembly changes as the snare loop assembly is opened and closed, it may be necessary for the size of the suture loop to change in order to accommodate this change in aperture size and to prevent the suture from being prematurely released from the snare loop assembly. In some variations, opening the snare loop assembly may pull suture through a slip knot to increase the size of the suture loop. This may, however, provide sufficient force to the suture loop to cause the suture to break or sever. To help prevent this undesirable outcome, the suture loop may be sized such that the suture loop is as large as or larger than the size of the aperture defined by the snare loop assembly when the snare loop assembly is in an open configuration. Thus, when the snare loop assembly is opened to a deployed configuration, the suture loop can assume a similar size without needing to advance additional suture through the suture knot. Pre-sizing the suture loop to such a size, however, may result in extra slack in the suture loop when the snare loop assembly is in a closed configuration. To help prevent the excess suture from getting entangled with or caught on anatomical structures, instruments, or other obstructions, some or all of the slack in the suture loop may be held inside of the elongate body when the snare loop assembly is opened and/or closed.

[0077] As such, the closure devices described here may comprise one or more excess-suture management features, which may be used in any suitable manner. In some instances, the feature may be configured to apply a force to the excess suture when the device is an open and/or a closed configuration. This force may act to pull the excess suture into the elongate body or may temporarily prevent excess suture from exiting the elongate body. Additionally, this force may act to prevent the excess suture from knotting or bunching up, which may potentially affect device performance. The following is a discussion of a number of different potential suture management features suitable for use for the closure devices described here. It should be appreciated that the closure devices described here may comprise any combination of these suture management features.

Suture Hooks

[0078] In some variations, a suture hook may be used to hold the excess suture within the elongate body. FIG. 2 shows one such variation of a snare loop assembly (200) having suture hook (202). Also shown there is snare (204), suture loop (206) having suture knot (208), and retention member (210). As illustrated in FIG. 2, suture hook (202) may hold excess suture from suture loop (206) within an elongate body (not shown). In variations in which the elongate body has multiple lumens, suture hook (202) may hold excess suture in any suitable lumen.

[0079] In some variations the proximal end of the suture hook may be able to move relative to the elongate body when snare is advanced from or withdrawn through or within the elongate body. FIG. 10 shows a cross-sectional side view of a portion of closure device (1000) comprising elongate body (1002) with lumen (1004) disposed therethrough, and connected to interconnect (1006) of a handle (not shown). It should be appreciated that, although shown in FIG. 10 as having only one lumen (1004) disposed therethrough, elongate body (1002) may have any number and configuration of lumens as described above. Also shown in FIG. 10 is a portion of snare (1008) attached to hypotube (1009) and suture hook (1010) engaging a portion of suture loop (1012). As described above, snare (1008) may be advanced or withdrawn through or within elongate body (1002) to open or close a snare loop assembly (not shown).

[0080] When snare (1008) is advanced and snare loop assembly is opened, suture loop (1012) may pull suture hook (1010) toward the distal end of the elongate body (1002) to release some of the excess suture from the elongate body (1002) or to allow some of the excess suture to advance within the elongate body (1002). In some variations, suture hook (1010) comprises a spring (1014). Spring (1014) may stretch when suture hook (1010) moves toward the distal end of the elongate body (1002). Conversely, closing the snare loop assembly may reduce the force applied to suture hook (1010) by suture loop (1012), which may allow the return force of the spring (1014) to pull suture hook (1010) proximally. This, in turn, may pull any excess suture back into or through a portion of elongate body (1002). Because excess suture is released from elongate body (1002) when the snare loop assembly is opened and withdrawn into elongate body (1002) when snare loop assembly is closed, the suture loop (1012) may be maintained at the same size as the snare loop assembly. Additionally, because the excess suture is doubled back into the elongate body when held by suture hook (1010), suture hook (1010) need only to be

configured to move half as much as snare (1008) in order to maintain the suture loop (1012) at the same size as snare loop assembly.

[0081] It should be appreciated that although shown in FIG. 10 as having one end attached to suture hook (1010) and the other end attached to interconnect (1006) (which will be described in more detail below), spring (1014) may be attached to any suitable portion or portions of the closure device (1000). In some variations, the spring may be attached to one or more elements of the handle, as will be described in more detail below. In other variations, the spring may be attached to one or more portion of the elongate body (1002). In still other variations, suture hook (1010) does not comprise a spring at all. In some of these variations, at least a portion of the suture hook (1010) may be capable of stretching or otherwise deforming to allow excess suture to be pulled out of elongate body (1002). For example, suture hook (1010) may comprise an elastic material or combination of materials that are capable of both stretching and returning to an unstretched state. In these instances, as snare loop assembly opens, the elastic material or materials may stretch to allow excess suture to be pulled out of or through a portion of elongate body (1002). When snare loop assembly is closed, the suture hook (1010) may return to its unstretched state, and may thereby pull the excess suture back into or through a portion of the elongate body (1002).

[0082] In variations where excess suture from suture loop (1012) is held within the elongate body by suture hook (1010), an additional step may be required to release suture loop (1012) from snare loop assembly. Once snare loop assembly is advanced over a target tissue and closed over the tissue, there may be excess suture from suture loop (1012) held in the elongate body by suture hook (1010). Before suture loop (1012) can be released from the snare loop assembly, this slack may first need to be removed. To achieve this, the excess suture may be pulled through a suture knot (not shown) to reduce the size of suture loop (1012). In some variations, suture hook (1010) may be configured to deform once sufficient force is applied thereto. Furthermore, in some variations suture hook (1010) comprises a stop (1016) that prevents suture hook (1010) from moving distally beyond a certain point. Thus, as suture is withdrawn through suture knot and the size of suture loop (1012) decreases, suture loop (1012) places an increasing force on suture hook (1010). Suture hook (1010) may move toward the distal end the elongate body (1002) until stop (1016) engages interconnect (1006). It should be noted that stop (1016)

may engage any suitable structure in closure device (1000). When stop (1016) engages interconnect (1006), suture hook (1010) is held in place and eventually the force applied by suture loop (1012) may cause the end of suture hook (1010) to deform and release the remaining excess suture.

[0083] After suture loop (1012) has been released from suture hook (1010) and the excess suture has been removed from suture loop (1012), any additional suture that is pulled through suture knot may begin to release suture loop (1012) from the snare loop assembly. If the snare loop assembly is closed around tissue before releasing suture loop (1012), any excess suture may be held within the elongate body (1002). Thus, any excess suture removed from the suture loop (1012) is housed within the elongate body (1002). Because this suture is housed within the elongate body (1002), it will not rub against or otherwise make contact with tissue disposed outside of the elongate body (1002). Additionally, as the suture loop (1012) is released from the snare loop assembly, the suture is released directly into contact with the tissue. Thus, a user may both remove excess suture from the suture loop (1012) and release the suture loop (1012) from the snare loop assembly without rubbing or sliding against the tissue. Because tissue may be damaged when suture slides or rubs against tissue, the closure devices described here may help minimize damage caused to tissue in this way. Once the suture loop (1012) is completely separated from the snare loop assembly, it may be tightened to ligate the target tissue.

[0084] As shown in FIG. 10, snare (1008) and suture hook (1010) may be disposed in the same lumen (1004) of elongate body (1002), but need not be. In variations where the snare (1008) is disposed in the same lumen (1004) as suture hook (1010), there may be a risk of the snare (1008) becoming entangled with the suture hook (1010). Additionally, because the suture hook (1010) need only move half as much as snare (1008) when opening and closing the snare loop assembly, the snare (1008) may rub against spring (1014), which may in turn cause spring (1014) to rub against the inner wall of lumen (1004). This friction may impede the actuation of the closure device (1000), and thus increase the force a user must provide to actuate the device.

[0085] In some variations, the closure device may be configured to help prevent the suture hook from tangling with snare. FIG. 11 shows one such variation of a middle portion of closure device (1100). Shown there is elongate body (1102) attached to interconnect (1104), hypotube (1106), snare (1108), spring (1110), suture hook (1112), sleeve (1114), and suture loop (1116).

The free end of snare (1108) may be attached to hypotube (1106), as described above. Additionally, suture hook (1112) may be attached to hypotube (1106) via spring (1110). Spring (1110) may additionally be disposed around snare (1108), which may help prevent spring (1110) from tangling with snare (1108). Additionally, this may reduce the amount of space taken up by snare (1108) and spring (1110), which may, in turn, allow snare and spring to be placed within a smaller lumen without adding to the amount of rubbing that occurs between the spring and the inner wall of lumen.

[0086] Sleeve (1114) may also act to help prevent tangling between suture hook (1112) and snare (1108). Sleeve (1114) may have two or more lumens. Suture hook (1112) may pass through one lumen, while snare (1108) may pass through a separate lumen. In some variations, sleeve (1114) may be attached to snare (1108). Sleeve (1114) may be attached in any suitable manner (e.g., bonding, welding, mechanical attachment, etc.). In these variations, sleeve (1114) may act as a stop to help release suture loop (1116) from suture hook (1112). As excess suture is removed from suture loop (1116), as described above, spring (1110) may stretch until it comes into contact with sleeve (1114). Once in contact with sleeve, spring (1110) may be held in place while the force exerted on suture hook (1112) by suture loop (1116) may cause suture hook (1112) to deform, and may thereby release suture loop (1116) from suture hook (1112).

Separation Tubing

[0087] In some instances it may be desirable to maintain excess suture within the elongate body without the need for a suture hook. Under certain circumstances, as a portion of the elongate body is advanced into or through the body, one or more portions of the elongate body may bend or flex to allow the snare loop assembly to reach a target location. Bending or flexing the elongate body, however, may impede movement of the suture hook or spring, which may potentially impede the snare hook's ability to maintain excess suture loop within the elongate body. Thus, it may be desirable to have a suture maintenance feature that is located in a distal portion of the elongate body.

[0088] As such, in some variations of the closure devices described here, one or more pieces of separation tubing may be used to help maintain excess suture within the elongate body, and may thereby limit the exposure or release of excess suture out of the elongate body. FIGS. 26A

and 26B show cross-sectional side views one such variation of a closure device (2600). Shown there is lumen (2602) with separation tubing (2604) disposed therein. Separation tubing (2604) may divide lumen (2602) into a first sub-lumen (2606) and a second sub-lumen (2608). Closure device (2600) may comprise a snare loop assembly (2610), which may comprise snare (2612), suture loop (2614), and retention member (2616). As shown in FIGS. 26A and 26B, suture from suture loop (2614) may pass through first sub-lumen (2606) into lumen (2602), where it may be connected to snare (2612) via retention member (2616). Snare (2612) may be advanced or withdrawn through second sub-lumen (2608) to open or close the snare loop assembly, respectively. When snare loop assembly (2610) is in a closed configuration, as shown in FIG. 26A, excess suture from suture loop (2614) may be held in snare lumen (2602) and first sub-lumen (2606). When snare is advanced to open the snare loop assembly, some of the suture held within the snare lumen may be advanced into the second sub-lumen (2608) to allow the snare loop assembly to open, as shown in FIG. 26B. The presence of separation tubing, however, may prevent the excess suture from being pushed or pulled out of the tip of the closure device.

[0089] When separation tubing is employed to maintain excess suture within elongate body, it may be necessary for the separation tubing to comprise one or more separation regions to release the excess suture from the elongate body. These separation regions, as described in more detail above, may allow suture to pass therethrough during release of the suture loop. Specifically, as excess suture is removed from the suture loop (i.e., as suture is pulled through the suture knot to tighten the suture loop), the suture may be pulled through the separation regions, allowing the excess suture to span the space between the sub-lumens of the separation tubing.

[0090] It should be appreciated that any suitable piece of separation tubing as described in more detail above may be used to maintain excess suture within the elongate body. It should also be appreciated that separation tubing may be used in conjunction with a suture hook, as described above, or one or more additional excess-suture management features. For example, in some instances separation tubing may be used in conjunction with one or more suture tubes. Generally, a suture tube has a first end that may be connected to the separation tubing, a second end that may be connected to a portion of the snare loop assembly, and may temporarily hold excess suture therein. The suture tube may be made from any suitable material (e.g., pebax,

tecothane, nylon, or the like), and may be comprise one or more separation regions which may allow the excess suture to be removed from the suture tube.

[0091] FIG. 27 shows a partial cutaway view of one such variation of a closure device (2702) comprising elongate body (2701), separation tubing (2704) and a suture tube (2705). Shown there is separation tubing (2704), which divides lumen (2700) into first sub-lumen (2706) and second sub-lumen (2708). Also shown there is snare loop assembly comprising snare (2712), suture loop (2714), and retention member (2716) at least temporarily connecting snare (2712) and suture loop (2714). As shown in FIG. 27, suture tube (2705) may releasably house a portion of suture loop (2714). One end of suture tube (2705) may be attached to the separation tubing (2704), and the other end may be attached to a portion of the snare loop assembly (e.g., attached to snare (2712) or retention member (2716)). By virtue of this attachment, one end of the suture tube (2705) may be fixed relative to the closure device (2702) while the other end may move with snare (2712) and closure element (2716) as the snare loop assembly is moved between a closed configuration and an open configuration.

[0092] When placed in lumen (2700), suture tube (2705) may double back upon itself at bend (2718). In this way, the portion of suture loop (2714) temporarily housed in suture tube (2705) may be held in the doubled-back suture tube (2705), which may help prevent the excess suture held within lumen (2700) from bunching. The position of bend (2718) may move as the snare loop assembly is changed between opened and closed configurations. Additionally, in some instances the suture tube (2705) may have a tendency to return to an unbent shape, which may also give the suture tube (2705) tendency to twist and kink at points other than bend (2718). As such, suture tube may comprise one or more features that may help reduce twisting or kinking. For example, in some variations, tube comprises a plurality of cut or slits that may act as relief areas. FIGS. 28A and 28B show one such variation of suture tube (2800). FIG. 28A shows suture tube (2800) comprising v-shaped cuts (2802) along one side thereof. Each v-grooved cut (2802) reduces the rigidity of suture tube (2800) along that side, and may make the suture tube (2800) more likely to bend or flex at that cut (2802). Thus, when suture tube (2800) is placed within a lumen (2804), as shown in FIG. 28B, and doubles back at bend (2806), some of the v-shaped cuts (2802) may be essentially closed. As such, the v-shaped cuts (2802) may reduce the straightening force of the suture tube (2800), and may thereby alter the tendency of the

suture tube (2800) to kink or twist. While shown in FIGS. 28A and 28B as being v-shaped, the cuts may be any suitable shape (e.g. semi-circular, semi-oval, etc.).

[0093] In other variations, the suture tube may comprise one or more strengthening members that may affect the rigidity of one or more portions of the suture tube. FIG. 29 illustrates a cross-sectional view of one such variation of suture tube (2900). Shown there is suture tube (2900), comprising suture lumen (2902), two strengthening members (2904), and separation region (2906). The strengthening members (2904) provide extra rigidity to a portion of the suture tube (2900). As such, when suture tube (2900) is doubled-over for placement in a snare lumen, the side of suture tube (2900) containing the strengthening member (2904) will have more resistance to bending, which may allow suture tube (2900) to better resist twisting and kinking. Additionally, strengthening members (2904) may increase the column strength of the suture tube (2900), such that the tube may be more easily moved as the snare is advanced or retracted. Strengthening members may be any suitable structures, such as, for example a wire made from a nickel titanium alloy, steel, a polymer, or the like. While shown in FIG. 29 as having two strengthening members (2904), it should be appreciated that the suture tube may comprise any suitable number of strengthening members (e.g., one, two, or three or more)

Pulley Suture

[0094] In still other variations, the snare loop assembly may comprise a second suture, a pulley suture, that may engage a portion of the suture loop to help hold excess suture. Generally, one end of the pulley suture may be fixedly attached to a portion of the closure device (e.g., the handle or the elongate body) while the other end may be temporarily or permanently attached to the snare loop assembly. In some variations, the body of the pulley suture may be looped around or doubled back over a portion of suture loop to help hold a portion of the suture loop in the elongate body. FIGS. 30A-30D depict one variation of closure device (3000) comprising a pulley suture (3002) that may be used to hold a portion of a suture loop (3010) within a lumen (3004) of an elongate body (3006). Shown in FIG. 30A is snare loop assembly (3008) comprising suture loop (3010), snare (3012), retention member (3014), first suture lock (3016), second suture lock (3018), first separation tubing (3020), and second separation tubing (3022). While shown in FIG. 30A as having first (3020) and second (3022) separation tubing segments, closure device (3000) may comprise any number of separation tubing segments (e.g., zero, one, two, or three or more). Additionally, for clarity's sake first (3020) and second (3022) separation tubing segments are not shown in FIGS. 30B and 30C.

[0095] As mentioned above, one end (not shown) of pulley suture (3002) may be fixedly attached to a portion of the handle (e.g., a suture fob, as will be described in more detail below) while the other end may be temporarily attached to snare (3012) via second suture lock (3018) (suture locks will be described in more detail below). Pulley suture (3002) may also be doubled-back over a portion of suture loop (3010) between knot (3024) and second suture lock (3018), as shown in FIGS. 30A-30C. This engagement may allow excess suture to be advanced through elongate body (3006) when snare (3008) is advanced (as shown in FIG. 30B), while pulling excess suture distally into elongate body when snare (3008) is retracted (as shown in FIG. 30C). Because both suture loop (3010) and pulley suture (3002) are each temporarily attached to snare (3008) (by virtue of first (3016) and second (3018) suture locks, respectively), the sutures may be moved the same distance when snare (3008) is moved. This movement may also advance or retract the point of overlap between the two sutures when the snare is advanced or retracted, respectively.

[0096] In order to release the suture loop (3010) from the closure device (3000), it may be necessary to terminate the engagement between the pulley suture (3002) and suture loop (3010). This engagement may be terminated in any manner. In some variations the pulley suture may be released from suture lock and removed from the elongate body by pulling on one end of the pulley suture (3002). Indeed, pulley suture (3002) may be configured to pull out of or otherwise separate from the second suture lock (3018) upon application of a certain force to the pulley suture. As shown in FIGS. 30A-30C, pulley suture (3002) may double back as it enters second suture lock (3018). This may help release pulley suture (3002) from second suture lock (3018) as the change in direction may increase the shear force applied by the pulley suture (3002) to the second suture lock (3018). Additionally, first suture lock (3016) may be configured to release suture loop (3010) when a certain force is applied to the suture loop. To help prevent premature release of the suture loop (3010) from retention member (3014), the closure device (3000) may be configured such that the release force for the second suture lock (3018) is less than the release force for the first suture lock (3016), but need not be.

[0097] In order to release pulley suture (3002) from snare (3008), one end of pulley suture (3002) may be attached to one or more portions of the device's handle. For example, FIG. 30D shows one variation of a portion of handle (3024) of closure device (3000). As shown there, an end of pulley suture (3002) and an end of suture loop (3010) may be attached to suture fob (3026). While shown in FIG. 30D as attached to the same suture fob, it should be appreciated that pulley suture (3002) and suture loop (3010) need not be attached to the same handle component. In variations where the pulley suture (3002) and the suture loop (3010) are attached to the same handle component, such as the variation shown in FIG. 30D, the suture loop (3010) may comprise slack/excess suture inside of the handle (3024). Thus, when suture fob (3026) is pulled away from handle (3024), the pulley suture (3002) may be placed under tension before the suture loop (3010) is placed under tension. In this way, as the suture fob (3026) is pulled, the closure device (3000) may be configured to release the pulley suture (3002) from second snare lock (3018) prior to tightening and releasing the suture loop (3010).

[0098] FIG. 15 shows another variation of closure device (1502) comprising a pulley suture (1504). In this variation, pulley suture (1504) may be releasably connected to suture loop (1506) via deformable link (1508). One end of pulley suture (1504) may be attached to snare (1510) via

first suture lock (1512), while the other end of the pulley suture (1504) may be fixedly attached to any suitable portion of the device (e.g., one or more portions of the handle or the elongate body). As in the other variations described above, pulley suture (1504) may be advanced or withdrawn with snare (1510) to help hold a portion of the suture loop (1506) inside of elongate body (1514).

[0099] To release the engagement between pulley suture (1504) and the suture loop (1506), the suture loop (1506) may be pulled away from the pulley suture (1504). This may be done in any suitable manner, such as, for example, tightening the suture loop (1506) or pulling one end of pulley suture (1504) relative to the suture loop (1506). As the suture loop (1506) and pulley suture (1504) are pulled away from each other, the two sutures may apply one or more forces to the deformable link (1508). These forces may cause the deformable link (1508) to deform, which may release the engagement between the suture loop (1506) and pulley suture (1504).

FORCE REDUCTION

[0100] In some instances, when a suture hook or other suture maintenance feature pulls and holds excess suture in an elongate body, it may exert one or more forces on the suture loop. This force applied to the suture loop may, in some instances, cause the suture loop to prematurely disengage from the snare loop assembly. This is illustrated in FIG. 12. Shown there is the distal end of closure device (1200) comprising snare loop assembly (1202) and suture hook (1204). Snare loop assembly comprises suture loop (1206) with suture knot (1208) and releasably coupled to snare (1210) via retention member (1212). When suture loop (1206) is pulled into an elongate body (not shown) by suture hook (1204), suture hook (1204) may place one or more tensile forces (1214) on the suture of suture loop (1206). These tensile forces may be translated into inwardly directed forces (1216) in the portion of suture loop (1206) disposed within snare loop assembly (1202). These inwardly directed forces (1216) may cause suture loop (1206) to disengage the suture loop (1206) from the retention member (1212), thereby releasing suture loop (1206) from snare loop assembly (1202) prematurely.

[0101] In order to prevent this problem, the snare loop assembly may comprise one or more suture locks. FIGS. 13A-13C illustrate one such variation of a closure device (1300). FIG. 13A shows a cross-sectional side view of closure device (1300) comprising snare loop assembly

(1302), suture hook (1304), and suture lock (1306). Snare loop assembly (1302) may comprise suture loop (1308) with suture knot (1310) and coupled to snare (1312) via retention member (1314). FIG. 13B shows a front view of suture lock (1306). Shown there is suture lock (1306) comprising first lumen (1316), second lumen (1318), and slit (1320). Generally, at least a portion of snare (1312) may pass through first lumen (1316), while at least a portion of suture loop (1308) may pass through second lumen (1318). In some variations, force-reducing element (1306) may be attached to snare (1312) via first lumen (1316).

[0102] Generally, second lumen (1318) of force-reducing element (1306) may be configured to compress at least a portion of suture loop (1308). Because suture generally comprises a braided material disposed around a strength member, portions of a suture may be compressed without significantly affecting its strength. Second lumen (1318) may have a cross-sectional area that is smaller than the cross-sectional area of the suture. Thus, a portion of suture loop (1308) may be advanced through or otherwise placed in the second lumen (1318), and the narrow cross-sectional area of second lumen (1318) may act to compress the portion of suture loop (1308) disposed within second lumen, as shown in FIG. 13C. The compressed portion of suture loop (1308) may cause the suture loop (1308) to resist being pulled or pushed through force-reducing element (1306). More specifically, the uncompressed portions of suture loop (1308) may abut against the outer surface of the force-reducing element, and this abutment may resist movement of suture through the second lumen (1318).

[0103] Compression of a portion of suture loop (1308) may help prevent suture loop (1308) from prematurely releasing from snare loop assembly (1302). As described above with respect to FIG. 12, tensile forces placed on a suture loop may be translated into one or more forces that may cause a suture loop to disengage from a snare loop assembly. A force-reducing suture lock (1306) may help reduce or eliminate the forces applied to the portion of suture loop held by snare loop assembly (1302). More specifically, the compression of the portion of suture loop (1308) disposed within second lumen (1318) may prevent or reduce the transmission of the tensile force through force-reducing element (1306). As noted above, the compression of suture loop (1308) may cause the suture loop (1308) to resist movement through force-reducing element (1306). Thus, when suture hook (1304) applies a tensile force to suture loop (1308), as described above, this tensile force may attempt to pull suture through force-reducing suture lock

(1306), but any such movement is resisted by the compression caused by force-reducing element (1306). As a result, some or all of the tensile force is, in effect, dissipated by trying to pull suture through force-reducing suture lock. This, in turn, may reduce or completely remove any force experienced by the suture on the other side of force-reducing element. Thus, force-reducing suture lock (1306) may reduce or remove the forces that may cause the suture loop (1308) to prematurely release form the snare loop assembly (1302).

[0104] Force-reducing suture lock (1306) may comprise one or more slits (1320) or other openings. These slits may allow suture loop (1308) to pass therethrough when it is ready to be deployed. These slits may have any suitable configuration, such as those described in U.S. Patent Application No. 12/055,213. Generally, once suture loop (1308) is tightened to remove excess suture from suture loop (1308), the suture loop (1308) may be tightened further, which may cause a portion of the suture loop (1308) to pass through the slit or other opening. As suture passes through the slit, suture loop (1308) may be released from force-reducing suture lock (1306).

[0105] In some variations, a force-reducing suture lock may be made from one or more pieces of shrink tubing. In these variations, a portion of the snare and the suture loop may be threaded through one or more lumens of the shrink tubing. One or more stimuli (e.g., heat) may be applied to the shrink tubing, which may cause the shrink tubing to get smaller. This reduction in size may act to hold and connect suture loop and snare.

HANDLES

[0106] Handles or proximal controls that are capable of facilitating removal of excess suture from a suture loop and releases of suture loop from snare loop assembly are provided. Handles having one or more ergonomic features or configurations to help facilitate and improve the use thereof are also described herein. FIGS. 3A and 3B show one suitable variation of handle (300). FIG. 3A shows a perspective view of handle (300) attached to elongate body (302). Also shown there is strain relief portion (304), snare lock (306), snare control (308), suture fob (310), and guidewire introducer (312). FIG. 3B shows a cross-sectional bottom view of handle (300). Also shown there is interconnect (314), locking collar (316), suture (318) and snare (320). Generally, suture (318) may be attached to suture fob (310), which may be pulled away from the handle. Pulling suture fob (310) may tighten the suture loop (not shown), and this tightening may pull excess slack from the suture loop. Once any excess slack has been removed from the suture loop, a user may continue to tighten the suture loop to release the suture loop from the snare loop assembly (not shown). Similarly, snare (320) may be attached to snare control (308), which may in turn be used to control a snare and/or a snare loop assembly. As snare control (308) is moved proximally or distally relative to handle (300), a portion of snare (320) may be moved proximally or distally through elongate body (302). This, in turn, may cause a snare loop assembly to move between an open and a closed configuration, as described in more detail above.

[0107] While shown in FIG. 3B as having a locking collar (316), handle (300) need not. In variations that include a locking collar (316), locking collar (316) may be attached to elongate body (302) and held by handle (300) to help prevent elongate body (304) from being disengaged from handle (300). Similarly, while shown in FIGS. 3A and 3B as having a strain relief portion (304), handle (300) need not. In variations that include a strain relief portion (304), the strain relief portion (304) may stretch, compress, or otherwise deform to help reduce the strain placed on elongate body (304) by handle (300). This deformation may or may not be reversible. Generally, the strain relief portion (304) may be attached to both handle (300) and elongate body (304). When a force pushes, pulls, or twists elongate body (304) relative to handle (300), the strain relief portion (304) may resist this movement and thus a portion of the force may cause the strain relief portion to stretch, compress, or otherwise deform as mentioned above. The

deformation of the strain relief portion (304) may act to reduce the relative movement between elongate body (304) and handle (300), which may help minimize the likelihood of the elongate body (304) disengaging from handle (300). Strain relief portion (304) may have any suitable size, shape, or configuration.

[0108] Additionally, while shown in FIG. 3A as having an interconnect (314), handle (300) need not. In variations that include an interconnect (314), interconnect (314) may be attached to elongate body (304), and may align the various lumens of elongate body (304) within handle (300). For example, in variations where handle (300) comprises a guidewire introducer (312), interconnect (314) may align guidewire introducer (312) with a working lumen (not shown) in elongate body (304). Interconnect (314) may align any number of device components with any number of lumens in elongate body (304).

[0109] While handle (300) is shown in FIGS. 3A and 3B to have a guidewire introducer (312), it may have any number of introducers or guides for introducing devices, fluids, or other components into elongate body (304). Indeed, handle (300) may have a guide to introduce one or more working devices such as a tissue grasper, a tissue ablator, cutting tool, visualization device, a combination thereof, or the like, into a lumen in elongate body (304). In other variations, handle (300) may include an introducer to provide flushing, drug delivery, vacuum, or the like through a lumen in elongate body (304).

[0110] Furthermore, while shown in FIG. 3A as having a snare lock (306), handle (300) need not. In variations that include a snare lock (306), snare lock (306) may be used to prevent snare control (308) from being moved relative to handle (300). Thus, in order to manipulate a snare loop assembly (not shown) a user must first depress snare lock (306) to release snare control (308). Once snare control (308) is released, a user may push snare control distally or pull snare control proximally to open or close the snare loop assembly. When a user stops depressing snare lock (306), snare control (308), and with it the snare loop assembly, may again be locked in place. In other variations, handle (300) may have one or more features to prevent snare control (308) from being accidentally actuated. In some of these variations, snare control (308) may be configured such that it cannot slide relative to the handle unless a user first depresses the snare control itself. In other variations, the snare control (308) comprises a button or other control that must first be manipulated before the snare control (308) may be actuated. In still other

variations, the snare control (308) may be freely actuated, but may be locked into place by depressing either a button, other control, or the snare control (308) itself.

[0111] Once the snare loop assembly is properly closed, suture fob (310) may be detached from the handle to tighten the suture loop (not shown). As suture fob (310) is pulled away from handle (300), suture fob (310) may pull suture through a suture knot (knot shown) to tighten the suture loop. As the suture loop is tightened, any excess suture held in the elongate body may be removed from the suture loop. Once this slack has been removed, the user may continue to pull suture fob (310) to disengage the suture loop from the snare loop assembly. Once disengaged from the snare loop assembly, the suture loop may be further tightened to ligate the enclosed tissue. The direct connection of suture fob (310) to suture (318) may provide tactile feedback to the operator to indicate the various stages of a closing procedure. More specifically, a user may experience different resistances when pulling suture fob (310) that may correspond to different stages of suture loop tightening. For example, a user may experience a given resistance when removing excess suture (318) from the suture loop. In variations where the closure device comprises a suture hook (not shown), the resistance may change when the suture (318) is released from the suture hook. Additionally, the resistance may change once all of the excess suture has been removed from the suture loop, once the suture loop starts being released from the snare loop assembly, and once the suture loop is completely released from the snare loop assembly.

[0112] Additionally, in some variations it may be desirable to ensure that a user may only apply a given force to the suture loop. If a suture loop is tightened too much, it may damage the ensnared tissue. As such, in some variations a suture fob (310) may be configured to break away from suture (318) upon application of a predetermined force (for example, between about 8 lbs and about 10 lbs) to suture fob (310). In this way, the device may be configured such that a user may tighten a suture loop using a suture fob (310) without damaging the ensnared tissue, as the suture fob (310) may be configured to separate from the suture prior to damaging tissue.

[0113] Suture (318) may additionally include one or more visual markers (e.g., a colored coating) to indicate when the excess suture (318) has been removed from the suture loop. For example, a portion of suture (318) may have a colored marker located a certain distance from suture fob (310). The distance between the colored marker and the suture fob (310) may

correspond to the amount of excess suture in the suture loop when the snare loop assembly is closed. A user may then pull suture (318) out of handle (300) using suture fob (310). When the colored marker becomes visible outside of handle (300) (or through a window in handle (300)), a user may know that the excess suture has been removed. Because the amount of excess suture may be dependent on the size of the loop formed by snare loop assembly, and because the size of the loop formed by snare loop assembly may be changed by snare control (308), in some instances the one or more visual markers on the suture (318) may correspond to one or more visual markers on snare control (308).

[0114] Additionally, suture (318) may be connected to suture fob (310) in any suitable manner. In some variations, such as that shown in FIG. 3B, one end of suture (318) may be connected directly to suture fob (310). In some of these variations, suture (318) may pass through a channel in suture fob (310), and may be knotted such that the resulting knot engages suture fob (310). In others of these variations, suture (318) may be clipped, grasped, or otherwise attached to suture fob (310). In other variations, suture fob (310) may comprise a pulley (not shown) that engages suture (318). In these variations, the end of suture (318) may be attached to another structure in handle (300), such as interconnect (314), and the pulley may slidably engage the suture (318). Because the suture is doubled-back over the pulley, a user may need to pull a suture fob (310) a shorter distance to achieve the same amount of tightening. For example, when a user withdraws a suture fob one inch, the pulley may also be withdrawn one inch. During this withdrawal, the pulley may pull more suture (318) into handle (300). For each inch that pulley moves, about two inches of suture are pulled into handle (one inch for each portion of suture (318) on either side of the pulley), and thus a user need only move suture fob (310) half the distance to achieve the same level of tightening.

[0115] In some instances, it may be desirable to remove at least a portion of the excess suture without having to first disengage the suture fob. For example, FIG. 4 shows a perspective view of one variation of handle (400) attached to elongate body (402). Shown there is strain relief portion (404), suture fob (406), guidewire introducer (408), snare control (410), and suture fob control (412). Generally, snare control (410) may attach to a snare (not shown) to control a snare loop assembly (not shown), as described above. In some variations, snare control (410) may be configured to lock in place when not being actuated. In these instances, the snare control

(410) may be unlocked in any number of ways, such as by depressing snare control (410) or by depressing a snare lock (not shown). In some of these variations, when snare control (410) or snare lock is no longer being depressed, snare control (410) is again locked into place.

[0116] In the variation shown in FIG. 4, suture fob (406) may be moved into and out of handle (400) by suture fob control (412). Suture fob (406) may be attached to a suture (not shown) in any manner as described above. Generally, the closure device is initially configured such that the suture fob control (412) is positioned near the distal end of handle (400), and suture fob (406) is entirely contained within handle (400). Suture fob control (412) may have one or more locking features like those described with respect to the snare control (410) above. Once the snare loop assembly has been closed around a target tissue using snare control (410), suture fob control (412) may be pulled proximally to the position shown in FIG. 4, to remove excess suture from the suture loop. Because movement of suture loop handle (412) is limited by the length of the track in which it sits, the length of this track may determine the amount of suture that may removed from the suture loop. In other variations, the handle (400) may comprise one or more features (e.g., stops) that limit the amount that suture fob control (412) may move. Thus the amount of suture pulled by suture fob control (412) may be dependent on the track in which suture fob control (412) is disposed, as well as the manner in which the suture is attached to the suture fob (406). As such, handle (400) may be configured to remove a predetermined amount of excess suture from the suture loop (not shown) when suture fob control (412) is actuated. Once suture fob control (412) has been moved to the position shown in FIG. 4, suture fob (406) may project out of the end of handle (400) and may be disengaged from handle (400). Once disengaged, the suture fob (406) may be pulled to remove any remaining excess suture from the suture loop, and then may pulled to remove the suture loop from the snare loop assembly. Once the suture loop has been released from the snare loop assembly, the suture fob (406) may be used to further tighten the suture loop and ligate tissue.

[0117] In some variations, a suture fob control has one or more features to help facilitate actuation of the suture fob control. FIG. 5 shows one such variation of a handle (500). Shown there is handle (500) with snare control (502), suture fob (504), and suture fob controls (506) with extensions (508). Snare control (502) and suture fob controls (506) may work in any suitable manner as described above. Extensions (508) may be any suitable structure or

protrusion attached to, formed in, or formed upon one or more suture fob controls (502) that provide a surface that can be grasped, gripped, or otherwise contacted by a user to facilitate actuation of the suture fob controls (506). Extensions may have any suitable size, shape, configuration, and orientation. For example, in the variation shown in FIG. 5, extensions (508) are configured to allow a user to hold and actuate the handle (500) in a "syringe-like" fashion.

[0118] In other variations, a handle may have one or more alternative mechanisms to help remove excess suture from a suture loop. FIG. 6 shows one such variation of handle (600) comprising snare control (602), suture fob (604), and squeeze grip (606). To remove excess suture from a suture loop, a user may repeatedly compress squeeze grip (606). When a user compresses squeeze grip (606), squeeze grip (606) may pull suture from suture loop into handle (600). In some of these variations, compressing squeeze grip (606) may rotate a suture reel (not shown), which may collect suture as it rotates. Once a sufficient amount of suture has been removed from the suture loop, suture fob (604) may be disengaged to release suture loop from the snare loop assembly, as described above.

[0119] FIG. 7 illustrates another variation of handle (700). Shown there is handle (700) comprising snare control (702), suture fob (704), and suture knob (706). In these variations, suture knob (706) may be rotated to remove excess suture from a suture loop. In some of these variations, suture knob (706) may rotate a suture reel, which collects suture as it rotates. In other variations, rotating suture knob (706) may move suture fob (704) into and out of handle (700), as described above in relation to FIG. 4. Suture knob (706) may have one or more visual indicators to indicate how much suture has been removed from suture loop. For example, specific distance markings may be placed on one or more surfaces of suture knob (706). Handle (700) may have one or more reference markers (not shown). The distance markings on suture knob (706) may be configured such that each distance marking on suture knob (706), when aligned with the reference marker on handle (700), may correspond to the amount of suture that has been removed from the suture loop. For example, before the suture knob has been turned, a distance marking of "0" on suture knob (706) may be aligned with the reference marker, and may indicate that no suture has been removed from the suture loop. When the suture knob has been rotated a half-rotation, a distance marking of "3" on the suture knob (706) may be aligned with the reference marker on handle (700), and may indicate that 3 centimeters of suture has been

removed from the suture loop. The specific distance markings on the suture knob (706) may depend on how much suture is removed from a suture loop as the suture knob (706) is rotated.

[0120] In other variations, a user may not be able to rotate suture knob (706) beyond a certain point. This feature may prevent a user from over-tightening the suture loop or unintentionally releasing the suture loop from the snare loop assembly. In some of these variations, the amount that suture knob (706) is able to rotate may correspond to the amount of excess suture in the suture loop. Generally, by only allowing a user to rotate a suture knob (706) a given distance, a user may know that they have removed a predetermined amount of suture from the suture loop. Depending on the configuration of handle (700), a user knows that all excess suture has removed from the suture loop, and the suture loop is ready to be released from the snare loop assembly. The suture fob (704) may then be released from the handle, and used to release suture loop from the snare loop assembly. Suture fob (704) may be released from handle (700) in any suitable way. In some variations, one or more buttons, knobs, or other controls may be actuated to release suture knob (704) from handle (700). By only allowing a user to rotate a suture knob (706) a given amount, the steps of tightening the suture loop and releasing the suture loop may be divided into two discrete steps, and thus a user does not to release the suture loop immediately after removing excess suture therefrom. This gives a user the ability to remove excess suture from the suture loop, and then to release the suture loop at his or her leisure. This in turn may provide an additional level of freedom to the user, who may want to attend to other matters between tightening the suture and releasing it from the snare loop assembly.

[0121] In some variations, a suture knob may be disengaged from the handle to act as a suture fob. FIG. 8 depicts one such variation of handle (800) comprising snare control (802) and suture knob (804). Suture knob (804) may have any suitable configuration, as described in U.S. Patent Application No. 12/055,213. Generally, suture knob (804) may be rotated to remove excess suture from a suture loop. In some variations, suture knob may only be rotated a certain amount, as described above. This may correspond to the amount of excess suture that is disposed in the suture loop. In some variations, one or more visual indicators, such as those described above, may inform a user how much suture has been removed from the suture loop. In some variations, the suture knob (804) may be configured to only require a certain amount of force by a user in order to rotate suture knob (804). In other variations, the force required to rotate the suture knob

(804) may be determined by the resistance provided by the suture loop, and thus may provide a user with tactile feedback while rotating the knob.

[0122] Once the suture knob (804) has been rotated to remove excess suture from the suture loop, the suture knob may be disengaged from handle (800) to act as a suture fob, as described above. In some variations, suture knob (804) may automatically disengage from handle (800) once suture knob (804) has been rotated a certain amount. In some of these variations, suture knob (804) may comprise threading (not shown) that may engage handle (800). When suture knob (804) is rotated a certain amount, it may become "unscrewed" and release suture knob (804) from handle (800). In other variations, suture knob (804) may automatically disengage from handle (800) when the suture loop is subjected to a pre-determined force. In some of these variations, as the suture loop is tightened, it may pull one or more switches, levers, or other controls that disengages suture knob (804) from handle (800). In still other variations, the handle (800) may comprise one or more buttons, knobs, or levers that may be activated to release the suture knob (804) from the handle (800). Additionally, while shown in FIG. 8 to have a square suture knob (804), suture knob (804) may be of any suitable size or shape (e.g., square, rectangle, circle, oval, triangle, etc.).

[0123] Also provided here are ergonomically-improved handles. In some variations, the handle bodies may be shaped to contour to one or more portions of a user's hand. In other variations, the handles described here may have widths greater than their heights. These variations may have any suitable height to width rations, including, but not limited to about 1:1.5, about 1:2, about 1:2.5, about 1:3, or the like. When a user places one of these handles down on a surface, he or she may be more likely to place it on the wider base as opposed to one of the narrower sides. This may be beneficial in preventing device complications, such as rotation of the snare loop assembly, elongate body, or handle during a procedure, which may either damage the target tissue or interfere with the functioning of the closure device. If a user is less likely to place a handle on one of its narrower sides when setting the handle on a tray or another surface, then he or she may be less likely to overly rotate the handle during a procedure.

[0124] In other variations, the handle may comprise one or more protrusions that may help ensure the device is laid down with a particular orientation. FIG. 9 shows one such variation of handle (900) comprising snare control (902), suture knob (904), suture knob release (906), and

protrusions (908). Protrusions (908) may act to help ensure that handle (900) is only placed with a particular side down. While shown as having four separate protrusions (908), handle (900) may have any suitable number of protrusions (908), and each protrusion may have any suitable size and shape.

[0125] Although the foregoing invention has, for the purposes of clarity and understanding been described in some detail by way of illustration and example, it will be apparent that certain changes and modifications may be practiced, and are intended to fall within the scope of the appended claims. Additionally, it should be appreciated that the closure devices described here may comprise any combination of device components and features described above.

METHODS

[0126] Methods for closing the left atrial appendage are also described here. It should be appreciated that any of the devices described above may be used in conjunction with one or more of the methods described here or those described in U.S. Patent Application No. 12/055,213. Generally, methods described here comprise accessing the left atrial appendage. Once access has been achieved, a closure device (such as those described above) may be advanced to the left atrial appendage. In some variations, the closure devices may be advanced and positioned with the help of one or more guide devices and/or one or more stabilizing/positioning devices (e.g., an expandable member or the like). The closure device may be used to ensnare and close the left atrial appendage. A suture loop or other closure element may be tightened and released from the closure device to hold the left atrial appendage in closed configuration. The closure device may be withdrawn, and a portion of the suture may be severed. These steps will be described in more detail below.

[0127] As mentioned above, some variations of the methods described here may comprise gaining access to the left atrial appendage. In some variations, the methods for closing the left atrial appendage include accessing the left atrial appendage from both the inside of the heart and the outside of the heart. To access the inside of the heart, the vasculature is typically used. For example, access may be obtained via one or several of the various veins or arteries (jugular, femoral, carotid, etc.). In some variations, the heart is accessed on the inside via the common femoral vein (e.g., the left common femoral vein) using a standard Seldinger technique with a

needle. An introducer wire may then be advanced through the needle, followed by an introducer sheath. The introducer wire may then be removed. In some variations, a guiding catheter sheath may be placed as an alternative to an introducer sheath or the initial sheath may be replaced with a guiding catheter sheath.

[0128] Using fluoroscopy, an angiogram performed through the sheath, a catheter placed through the sheath, a guiding catheter sheath, or any combination thereof, may be performed to observe anatomical characteristics and considerations of the access route for the purpose of transseptal access into the left atrium (e.g., tortuosity, clots, devices, such as vena cava filters, etc.). Fluoroscopy, ultrasound, intracardiac echocardiography, extracardiac echocardiography, transesophageal echocardiography, or combinations thereof, may be used to help visualize transseptal access to the left atrium, and access to the left atrium may be obtained using standard transseptal access techniques.

[0129] For access to the heart from the outside, a subthoracic access point may be used. The access point is typically identified based on patient anatomical characteristics. In some variations, the access point may be any suitable location (e.g., intercostal access via a sternotomy, thoracostomy, or thoracotomy, right of the xiphoid process and pointed towards the patient's left shoulder, or in the costal cartilage or xiphoid process itself). Once the access point has been determined, a needle (e.g., a 17G Tuohy needle) may be advanced using standard pericardiocentsesis techniques under fluoroscopic guidance. After access to the pericardium has been obtained, a guidewire may be advanced through the needle under fluoroscopic visualization within the pericardiac sac. The needle may then be removed. Access to the pericardial space has thus been obtained.

[0130] In other variations, the left atrial appendage may be closed off using the systems and devices described here without performing both access procedures as described above. For example, in some variations the methods comprise advancing a first guide having a proximal end and a distal end into the left atrial appendage, through the left atrial appendage, and out of the left atrial appendage, such that one of the proximal or distal ends is within the vasculature, and one of the proximal or distal ends is within the subthoracic space.

[0131] By virtue of gaining access to the left atrial appendage, one or more guides having alignment members may be advanced to the left atrial appendage. These guides may be any suitable guide, such as those described in U.S. Patent Application No. 12/055,213. For example, first and second guides having alignment members may be used to guide the procedure. The alignment member may be any suitable alignment member (e.g., interconnecting elements, one or more vacuum members, radiopaque or echogenic markers, members that are configured to produce an audible response, magnets, etc.). In some variations, the alignment members are magnets located at the distal ends of the guides. The magnets may be made from or comprise any suitable magnetic material, e.g., a rare earth magnet, such as neodymium-iron-boron, cobalt-samarium, or other powerful fixed magnet elements. These guides may be used for guiding additional tools and/or devices to the left atrial appendage.

[0132] For example, in some variations, a first guide may be advanced into the left atrial appendage, while the second guide may be advanced into the pericardial space adjacent to the left atrial appendage. Either of these guides may be advanced under any of a variety of visualization techniques, e.g., fluoroscopic visualization, ultrasound visualization, some combination thereof, etc. Once the first and second guide members have been advanced to the left atrial appendage, one or more positioning and/or stabilizing elements (e.g., balloons or other expandable structures) may be advanced over or in conjunction with the first guide (e.g., it may be coupled to or be part of the first guide) and into the left atrial appendage. Similarly, a closure device may be advanced over the second guide to the exterior of the left atrial appendage. It should be appreciated that the closure device may be any of the closure devices described above.

[0133] When placed in the left atrial appendage, the positioning element may be used to help position the snare loop assembly of a closure device. In some variations, an expandable structure may be inflated or otherwise expanded in or near the opening of the left atrial appendage and the snare loop assembly of the closure device may be closed around the left atrial appendage distally of the expandable structure. In these variations, the expandable structure may help position the closure device away from the Coumadin ridge. In other variations, the expandable member may be expanded inside of the left atrial appendage. In some of these variations, when the expandable member is expanded, the left atrial appendage may become distended and its shape changed from roughly conical to roughly spherical, thus better defining

the junction between the left atrial appendage and left atrium. In addition, the expandable member in its expanded state may be at a pressure much greater than that of the left atrium proper, resulting in a significant differential in tension between the left atrial appendage and the left atrium. In these variations, the expandable member may help position the closure device near the base of the left atrial appendage. In still other variations, one expandable structure may be expanded in or near the opening of the left atrial appendage while a second expandable structure may be expanded inside of the left atrial appendage. In these variations, the snare loop assembly of the closure device may be closed around the left atrial appendage between the two expandable structures, which may help ensure correct device positioning.

[0134] It should be appreciated that the expandable structure may be any suitable expandable structure. In some variations, one or more the expandable structures may be a balloon or another inflatable structure. In some of these variations, the balloon or balloons may be attached to a catheter. In some variations, the balloon or inflatable structure may be configured to be detached in an expanded state inside of the left atrial appendage. In other variations, the expandable structure may comprise an expandable mesh or cage structure. This mesh may be self-expanding or mechanically expandable, and may be made from any suitable material (e.g., platinum, nitinol, stainless steel, Dacron wool, PTFE, combinations thereof, or the like). Again, the expandable mesh or cage structure may be configured to be detached in an expanded state in the left atrial appendage, but need not be.

[0135] While the expandable member is in an expanded state, the snare loop assembly may be moved to an open configuration and may be placed around a portion of the left atrial appendage. Once placed around the left atrial appendage, the snare loop assembly may be closed around the left atrial appendage. In some variations, the snare loop assembly is placed around the left atrial appendage while the balloon is in its deflated or unexpanded stated, and then the balloon is expanded after the snare loop assembly is closed. In some instances it may be desirable to confirm proper closure of the appendage prior to tightening of the suture. If closure is not adequate or otherwise not desirable, the snare loop assembly may be opened, repositioned, closed, and then confirmed once again.

[0136] Once proper closure has been affected, the suture loop may be tightened to release the suture loop from the snare loop assembly. In some variations, the snare loop assembly may then

be returned to an open configuration and the suture loop may be tightened again. This may act to help ensure that the suture loop is sufficiently tightened around the left atrial appendage. In some variations, a user may re-tighten the suture loop after waiting for a period of time. This waiting period may allow tissue to readjust and settle within suture loop, which may allow for a tighter closure of tissue. This period of time may be any suitable period of time, such as, for example, greater than about 30 seconds, greater than about a minute, or greater than about 2 minutes. After releasing the suture loop from the snare loop assembly, the closure device may be withdrawn. In some variations, it may be desirable to further tighten the suture loop after the closure device has been withdrawn. This may be accomplished with one or more additional devices (e.g., a knot pusher).

[0137] It should be appreciated that some or all of the guide member or positioning elements may be removed from the left atrial appendage at any suitable point or points during the methods. For example, in some variations, some or all of these structures may be removed from the left atrial appendage after closing the snare loop assembly but prior to releasing the suture loop from the snare loop assembly. In other variations, some or all of these structures may be removed after releasing the suture loop from the snare loop assembly. The suture loop may be further tightened after some or all of these elements are removed. In still other variations, one or more expandable members may be detached and may remain in the left atrial appendage. In these variations, the expanded member may act to displace blood from the left atrial appendage and to help keep additional blood from entering the left atrial appendage. When the expandable member comprises a balloon or inflatable structure, the balloon may be filled with any suitable substance, such as, for example, saline or one or more hydrophilic polymers (e.g., hydroxyethyl methacrylate).

[0138] In yet other variations, one of the guide members or other elements placed inside of the left atrial appendage may be configured to release one or more materials to the closed left atrial appendage prior to removal. This material may act to create haemostasis or embolization of the closed left atrial appendage, which may prevent the ingress and egress of blood from the closed left atrial appendage. Examples of suitable materials include, but are not limited to gelatins (e.g., gel foam), liquid embolic agents (e.g. n-butyle-2-cyanoacrylate, ethidol), gelatin

microspheres (e.g., polyvinyl alcohol acrylic microspheres), or pieces of thrombotic materials (e.g., platinum, stainless steel, Dacron wool, combinations thereof or the like).

[0139] In some variations, it may be desirable to lock the suture knot in place once the suture loop has been tightened around the left atrial appendage. In some variations, the suture knot may be locked using one or more unidirectional locking structures, as described in more detail above. In other variations, the knot may be locked in place with one or more bioglues or other biocompatible adhesives (e.g., cyanoacrylate). In still other variations, energy (e.g., RF energy, thermal energy, light energy, or the like) may be used to fuse the knot in place. In yet other variations, one or more portions of the suture knot may be configured to expand upon application of or exposure to one or more stimuli. For example, in some variations the suture may comprise collagen filaments that may be exposed to moisture when the suture is severed. Once the collagen is exposed to moisture, it may expand to lock the suture knot in place.

[0140] Once the suture loop has been properly placed, the suture may be severed in any suitable fashion, and at any suitable location along its length (i.e., from immediately adjacent to the knot at the left atrial appendage to just proximal to, or just distal to, the skin surface). In some instances it may be desirable to sever the suture at the knot itself (e.g., in instances where it is desirable to release tension on the suture entirely). The suture may be severed in any suitable manner, such as for example by mechanically cutting, or by the application of energy. For example, the suture may be severed with the application of light energy, thermal energy, RF energy, electrical energy, magnetic energy, electromagnetic energy, kinetic energy, chemical energy, and combinations of any of the above.

CLAIMS:

1. A tissue closure device comprising:

an elongate body; and

a snare loop assembly at least partially slidably disposed within the elongate body, the snare loop assembly comprising a retention member, a snare, a suture loop, and a force-reducing suture lock, wherein each of the retention member and the force-reducing suture lock comprise a first lumen and a second lumen, wherein the first lumen of each retains at least a portion of the snare therein and the second lumen of each retains at least a portion of a loop of the suture loop therein, and wherein the retention member releasably couples the snare to the suture loop.

2. The device of claim 1 wherein the elongate body comprises a first lumen and a second lumen.

3. The device of claim 2 wherein the device further comprises separation tubing disposed in the first lumen, and wherein the separation tubing comprises a first sub-lumen and a second sub-lumen.

4. The device of claim 3 wherein at least a portion of suture loop is housed within the first and second sub-lumens of the separation tubing.

5. The device of claim 4 further comprising a suture tube, wherein a first end of the suture tube is attached to the separation tubing and a second end of the suture tube is attached to the snare loop assembly, and wherein the suture tube releasably houses at least a portion of the suture loop.

6. The device of claim 5 wherein the suture tube comprises a plurality of cuts or grooves.

7. The device of claim 6 wherein the suture tube comprises one or more strengthening members.

8. The device of claim 1 wherein the elongate body comprises a tip portion.

9. The device of claim 8 wherein a first end of the snare is releasably held in the tip portion.

Date Reçue/Date Received 2020-05-04

10. The device of claim 9 wherein the first end of the snare is connected to a frangible member, and wherein breaking the connection between the snare and the frangible member releases the snare from the tip portion.

11. The device of claim 8 wherein the suture loop comprises a suture knot, and wherein the tip portion comprises a recess for housing the suture knot.

12. The device of claim 11 wherein the tip portion is configured to eject the suture knot from the recess.

13. The device of claim 12 wherein the tip is configured to eject the suture knot from the recess using a balloon.

14. The device of claim 13 wherein the tip is configured to eject the suture knot from the recess using a pusher.

15. The device of claim 1 further comprising a handle.

16. The device of claim 15 wherein the handle comprises a device introducer.

17. The device of claim 16 wherein the device introducer is a guidewire introducer.

18. The device of claim 15 wherein the handle comprises a suture tightening element for tightening the suture loop.

19. The device of claim 18 wherein the suture-tightening element may be disengaged from the handle.

20. The device of claim 15 wherein the handle comprises an interconnect for connecting the handle to an elongate body.

21. The device of claim 15 wherein the handle comprises a snare lock.

Date Reçue/Date Received 2020-05-04

22. The device of claim 15 wherein the handle comprises a strain relief portion.

23. The device of claim 1 wherein the force-reducing suture lock further comprises a slit.

24. The device of claim 23 wherein the force-reducing suture lock is configured to release the suture loop via the slit.

25. The device of claim 1 wherein the force-reducing suture lock is configured to compress at least a portion of the loop of the suture loop.

26. The device of claim 1 wherein the force-reducing suture lock is configured to reduce the transmission of tensile force to the suture loop.

27. The device of claim 1 wherein the force-reducing suture lock is configured to prevent the suture loop from releasing from the retention member prematurely.

28. The device of claim 1 wherein the force-reducing suture lock comprises shrink tubing.

29. Use of the tissue closure device defined in any one of claims 1 to 28 for ligating tissue.

30. A tissue closure device comprising:

an elongate body;

a snare loop assembly extending from a distal end of the elongate body, wherein the snare loop assembly comprises a snare and a suture loop releasably coupled to the snare; and

a suture management feature configured to temporarily prevent excess suture from exiting the elongate body, wherein the excess suture forms a portion of the suture loop, and

wherein at least a portion of the suture management feature is moveable relative to the elongate body and a portion of the suture management feature is configured to deform to release the suture loop.

31. The tissue closure device of claim 30 wherein the suture management feature is configured to release the suture loop when a threshold force is applied to the suture loop.

Date Reçue/Date Received 2020-05-04

32. The tissue closure device of claim 30 wherein the suture management feature comprises a deformable suture hook.

33. The tissue closure device of claim 32 wherein the suture management feature further comprises a stop configured to prevent the deformable suture hook from moving distally beyond a certain point.

34. The tissue closure device of claim 32 wherein the deformable suture hook comprises a spring configured to pull excess suture into the elongate body when the snare loop assembly is closed.

35. The tissue closure device of claim 34 wherein the spring is disposed around the snare.

36. The tissue closure device of claim 32 wherein the deformable suture hook is configured to move half as much as the snare to maintain the suture loop at the same size as the snare loop assembly.

37. The tissue closure device of claim 32 wherein the deformable suture hook is configured to stretch to allow excess suture to be pulled out of the elongate body.

38. The tissue closure device of claim 37 wherein the deformable suture hook comprises an elastic material.

39. The tissue closure device of claim 30 wherein the entire suture management feature is moveable relative to the elongate body.

40. The tissue closure device of claim 30 wherein the elongate body comprises a lumen therethrough, and wherein the suture management feature and at least a portion of the snare are housed in the lumen.

41. The tissue closure device of claim 30 further comprising a sleeve configured to help prevent tangling between the suture management feature and the snare.

Date Reçue/Date Received 2020-05-04

42. The tissue closure device of claim 41 wherein the sleeve comprises a first lumen and a second lumen, and wherein the suture management feature passes through the first lumen and the snare passes through the second lumen.

43. The tissue closure device of claim 41 wherein the excess suture forms a portion of the suture loop and the sleeve acts as a stop for the suture management feature to help release the suture loop.

44. The tissue closure device of claim 41 wherein the sleeve is attached to the snare.

45. The tissue closure device of claim 30 wherein the snare loop assembly further comprises a retention member releasably coupling the suture loop to the snare.

46. The tissue closure device of claim 30 wherein the suture management feature comprises a hook having a spring and wherein the tissue closure device further comprises a first member, wherein a free end of the snare and the spring are coupled to the first member.

47. A tissue closure device comprising:

an elongate body;

a snare loop assembly extending from a distal end of the elongate body, wherein the snare loop assembly comprises a snare and a suture loop releasably coupled to the snare; and

a suture management feature configured to temporarily prevent excess suture from exiting the elongate body, wherein at least a portion of the suture management feature is moveable relative to the elongate body, and wherein the suture management feature comprises a pulley suture.

48. The device of claim 1 wherein the portion of the loop of the suture loop is released from the force-reducing suture lock by application of a force to the suture loop.

49. The device of claim 1 further comprising an excess-suture management feature proximal to the force-reducing suture lock.

Date Reçue/Date Received 2020-05-04

50. The device of claim 49 wherein the force-reducing suture lock is configured to reduce the transmission of force from the excess-suture management feature to a portion of the suture loop distal to the force-reducing suture lock.

51. The device of claim 50 wherein the excess-suture management feature comprises one of the following: a suture hook comprising a spring, separation tubing, and a pulley suture.

Date Reçue/Date Received 2020-05-04

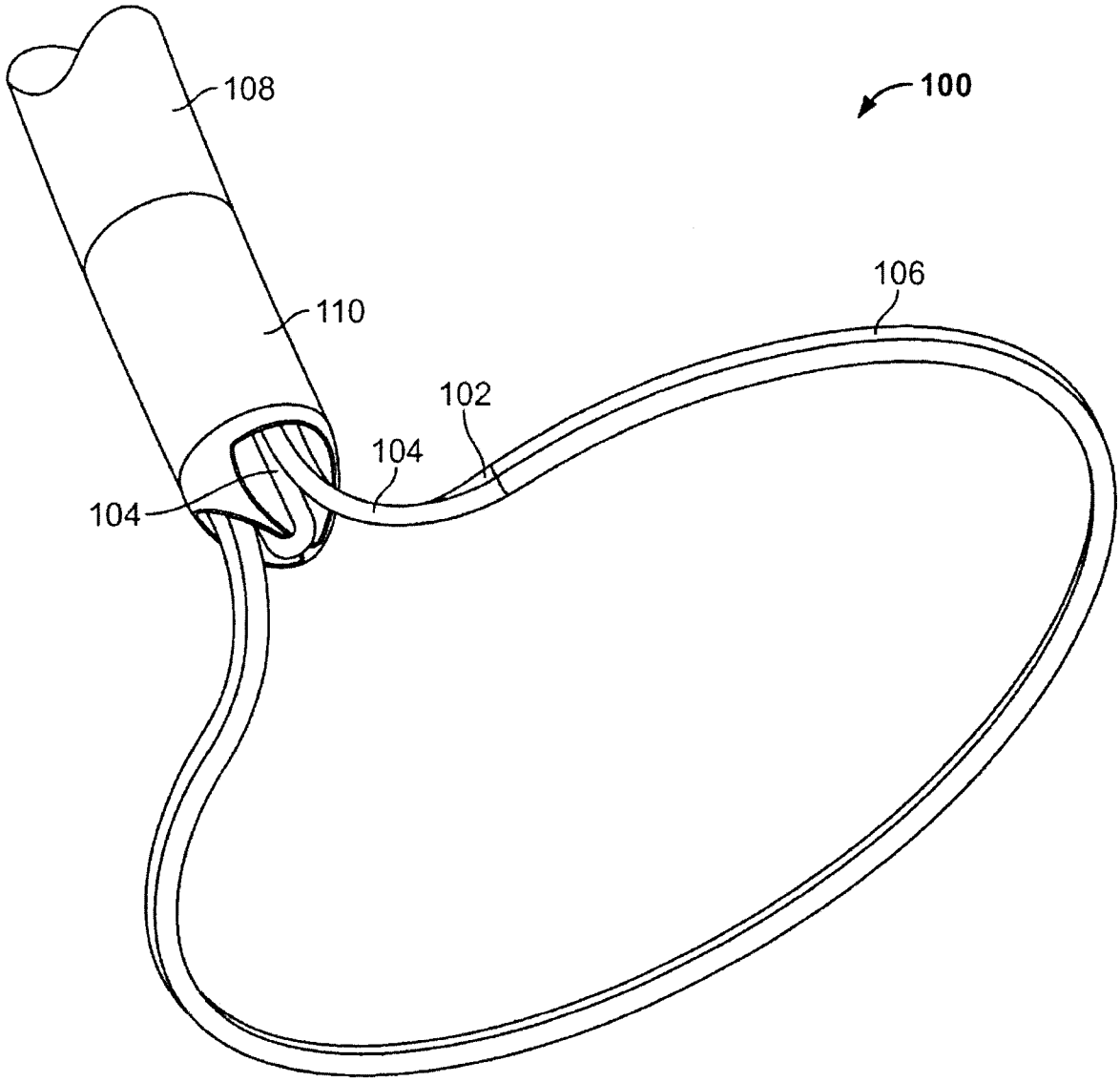

FIG. 1

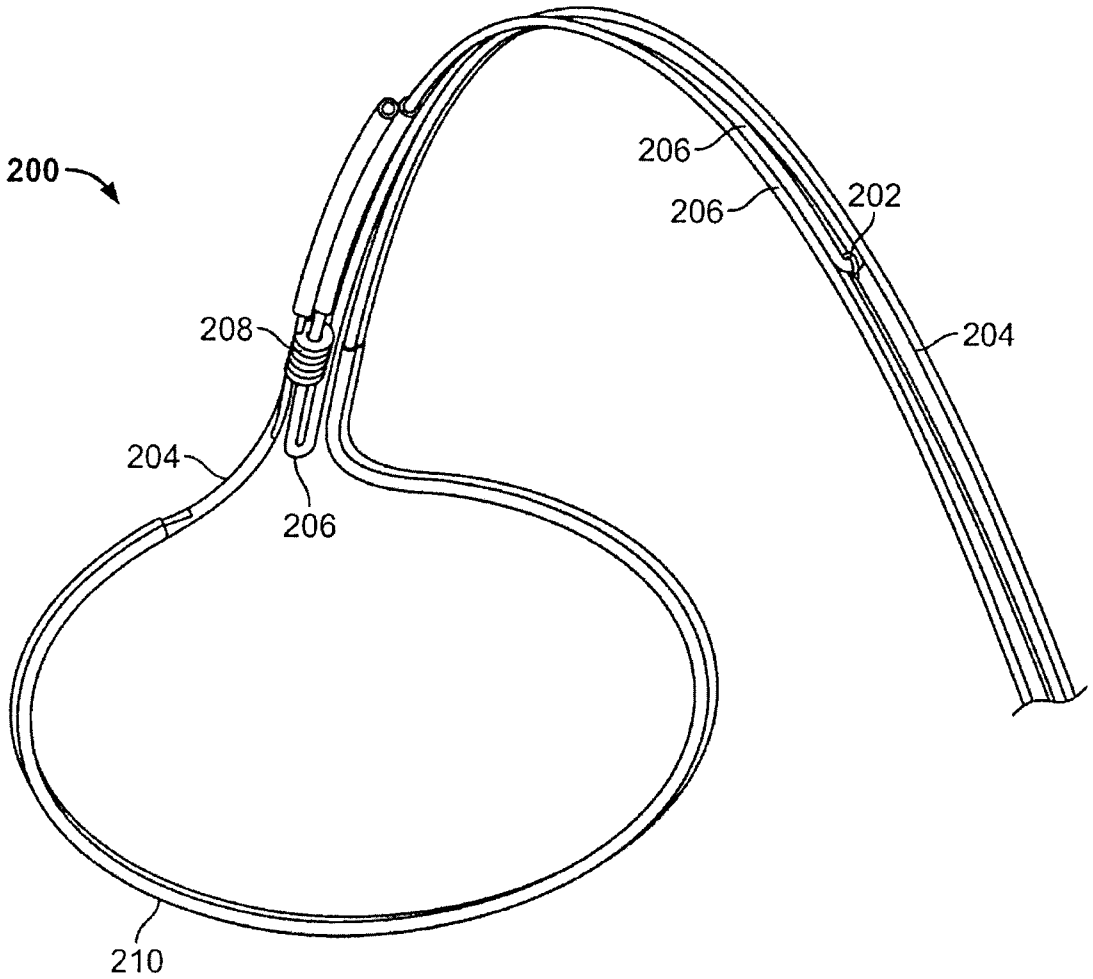

FIG. 2

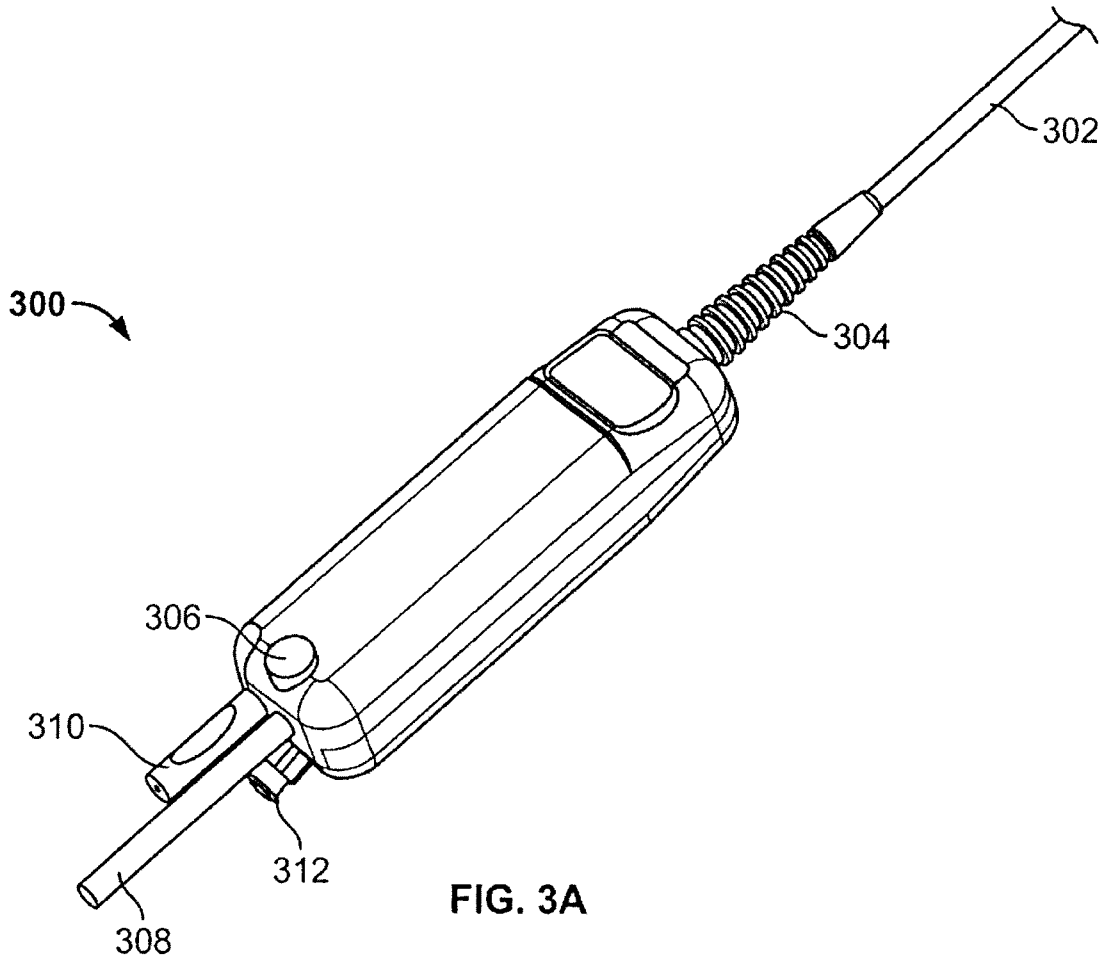

FIG. 3A

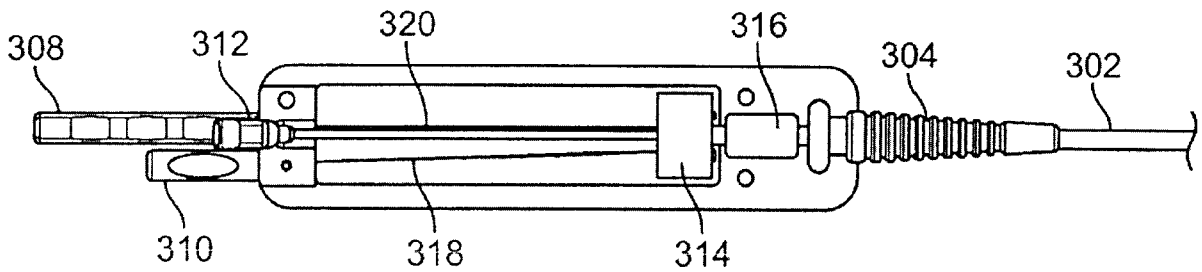

FIG. 3B

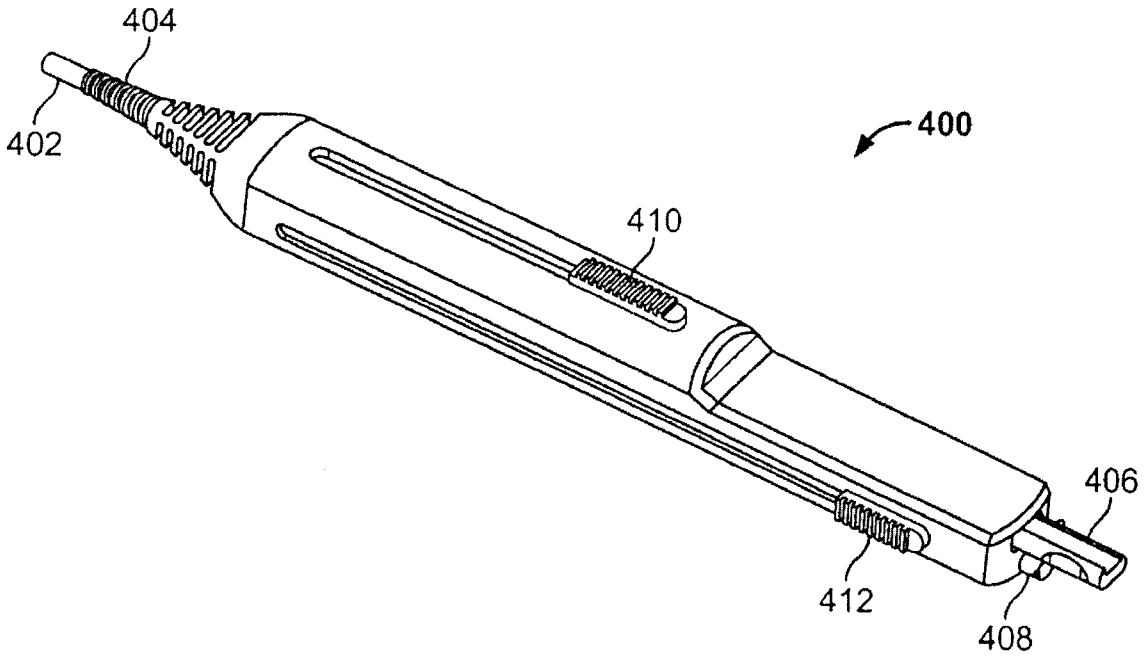

FIG. 4

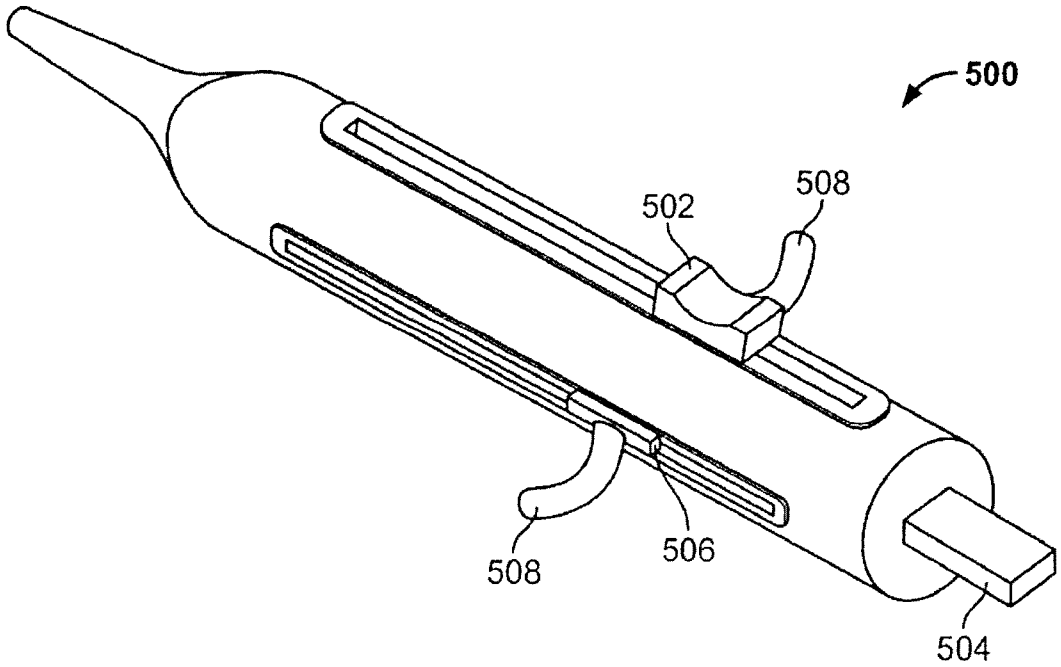

FIG. 5

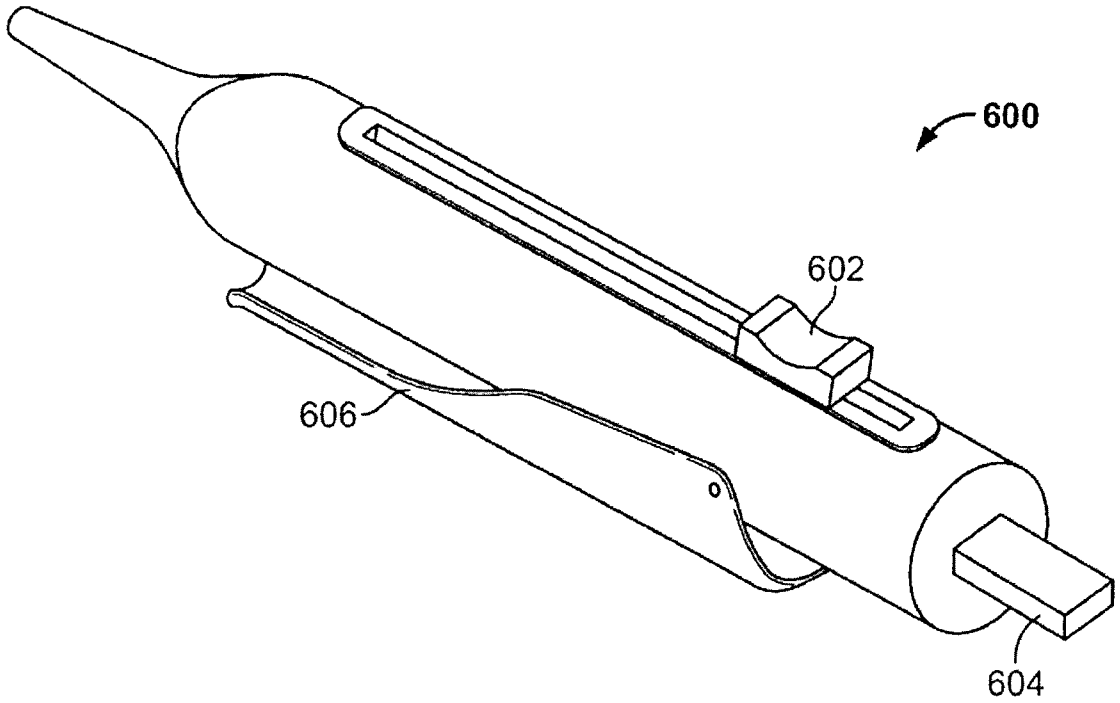

FIG. 6

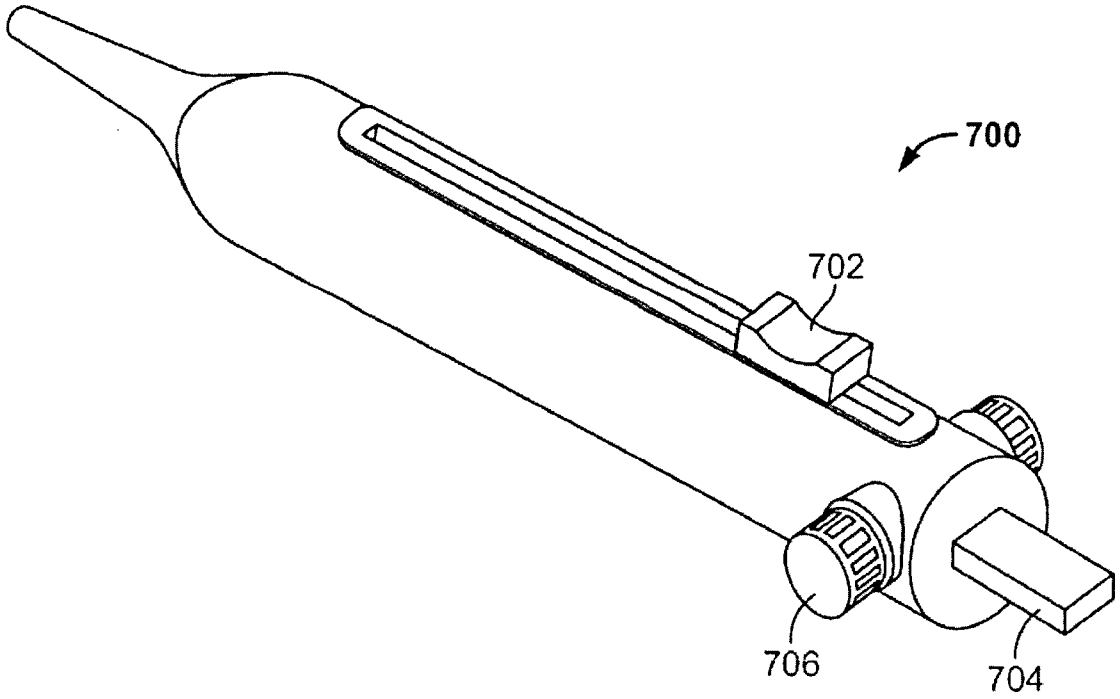

FIG. 7

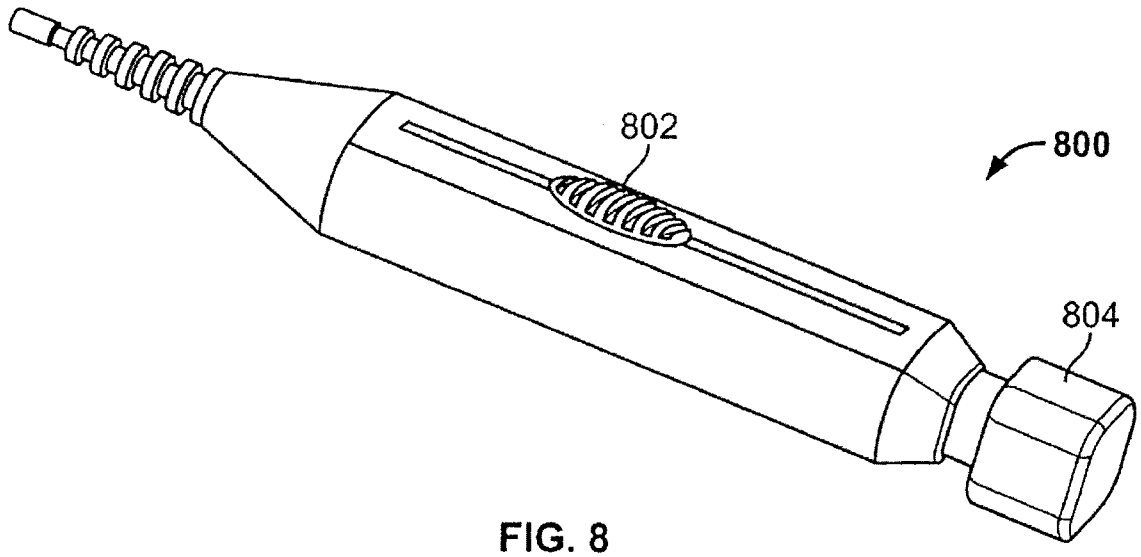

FIG. 8

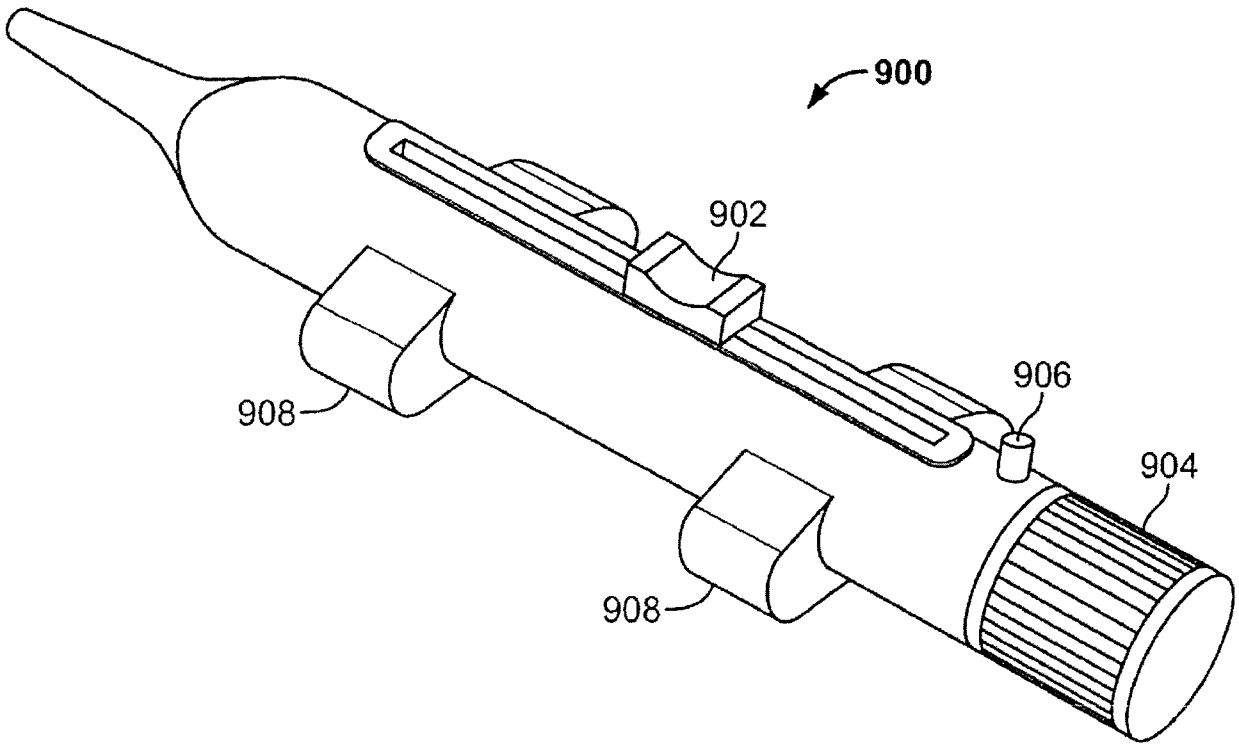

FIG. 9

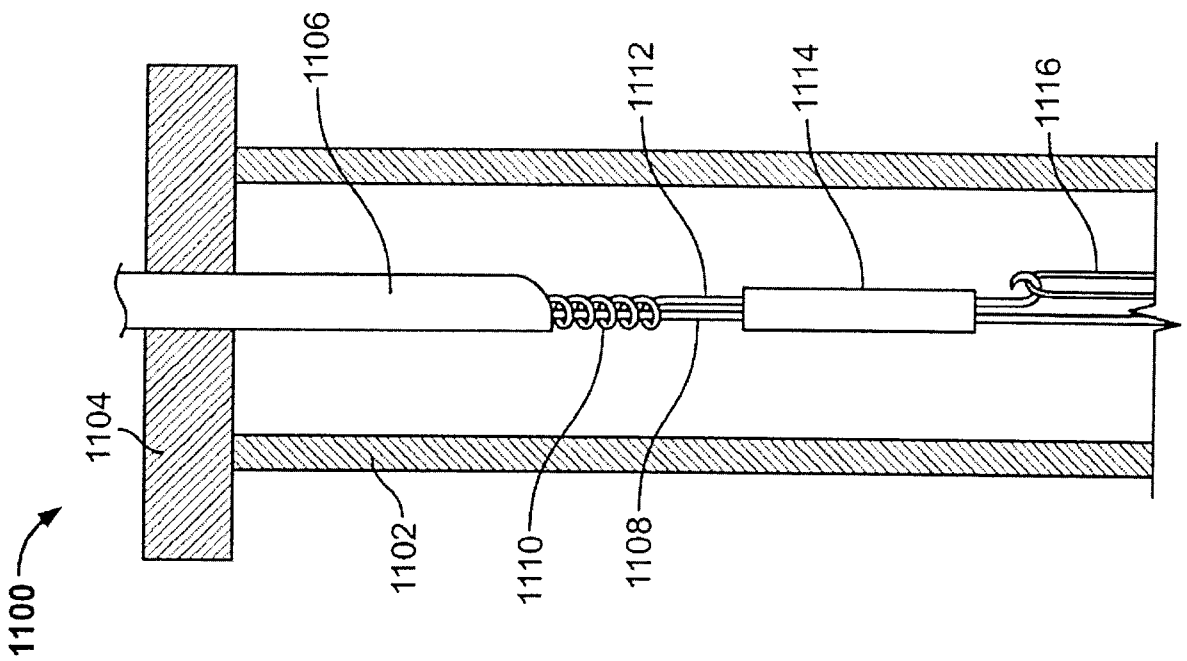
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FIG. 11

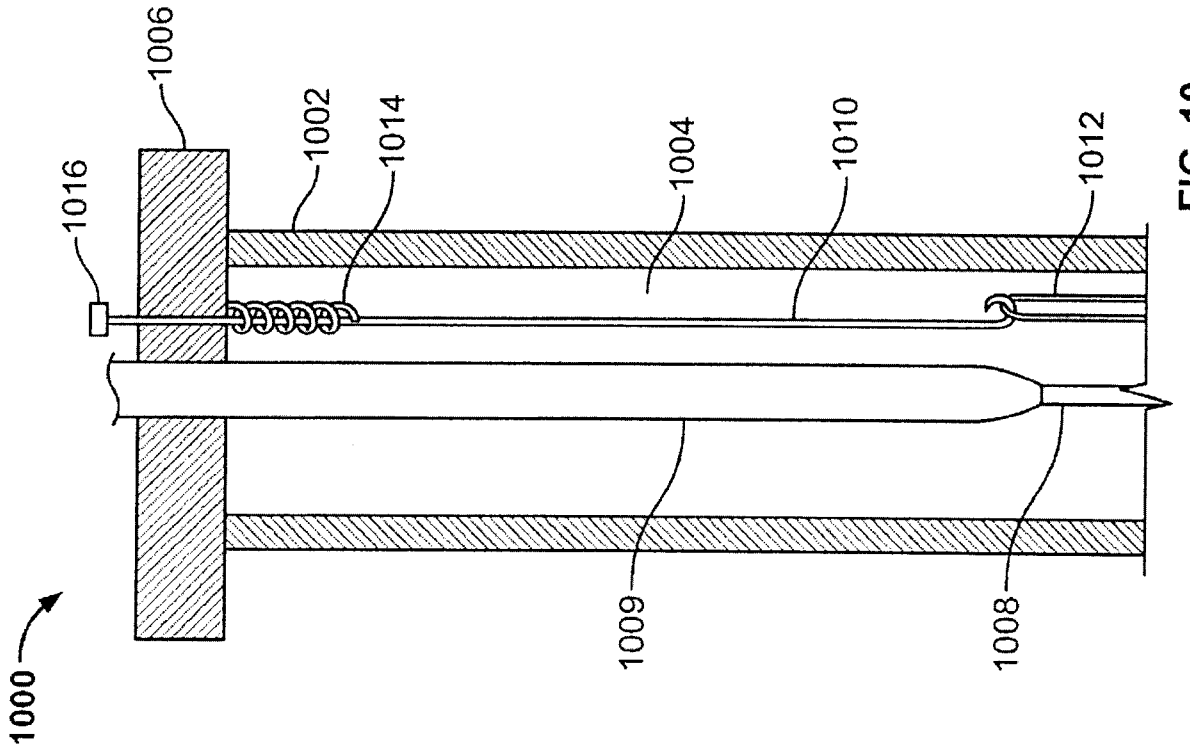
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FIG. 10

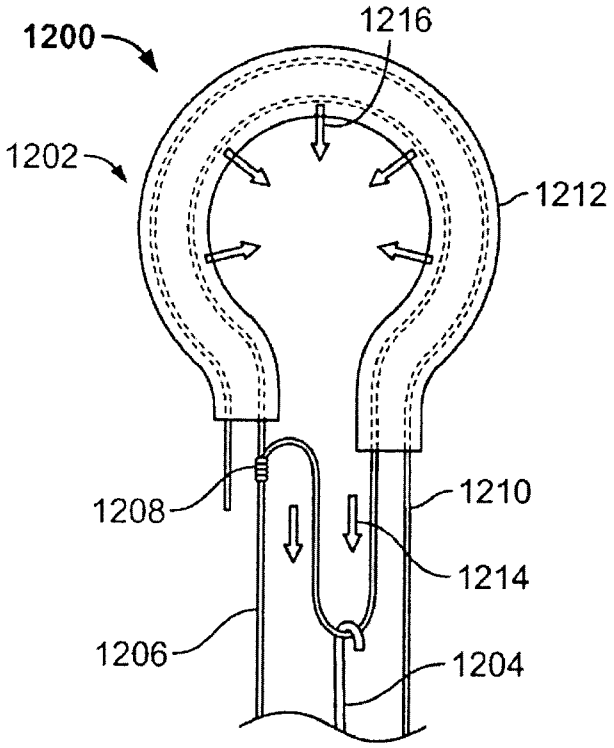

FIG. 12

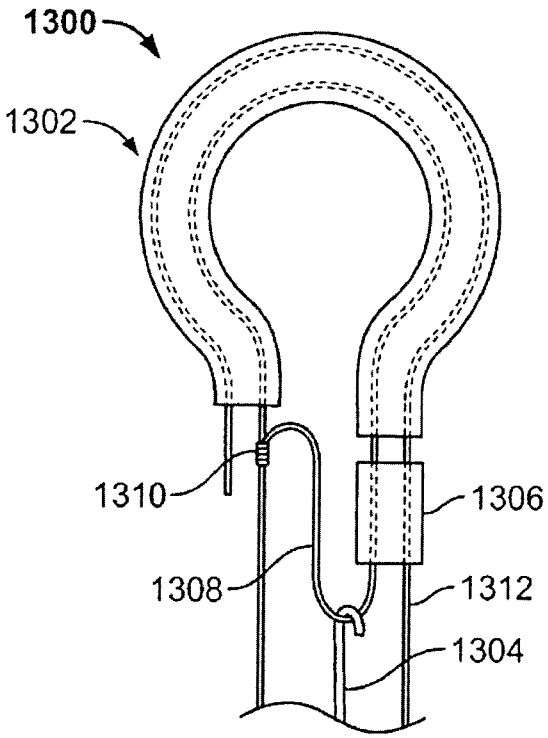

FIG. 13A

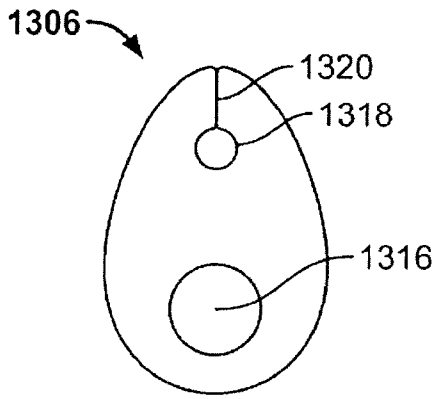

FIG. 13B

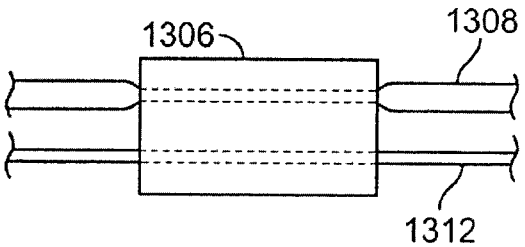

FIG. 13C

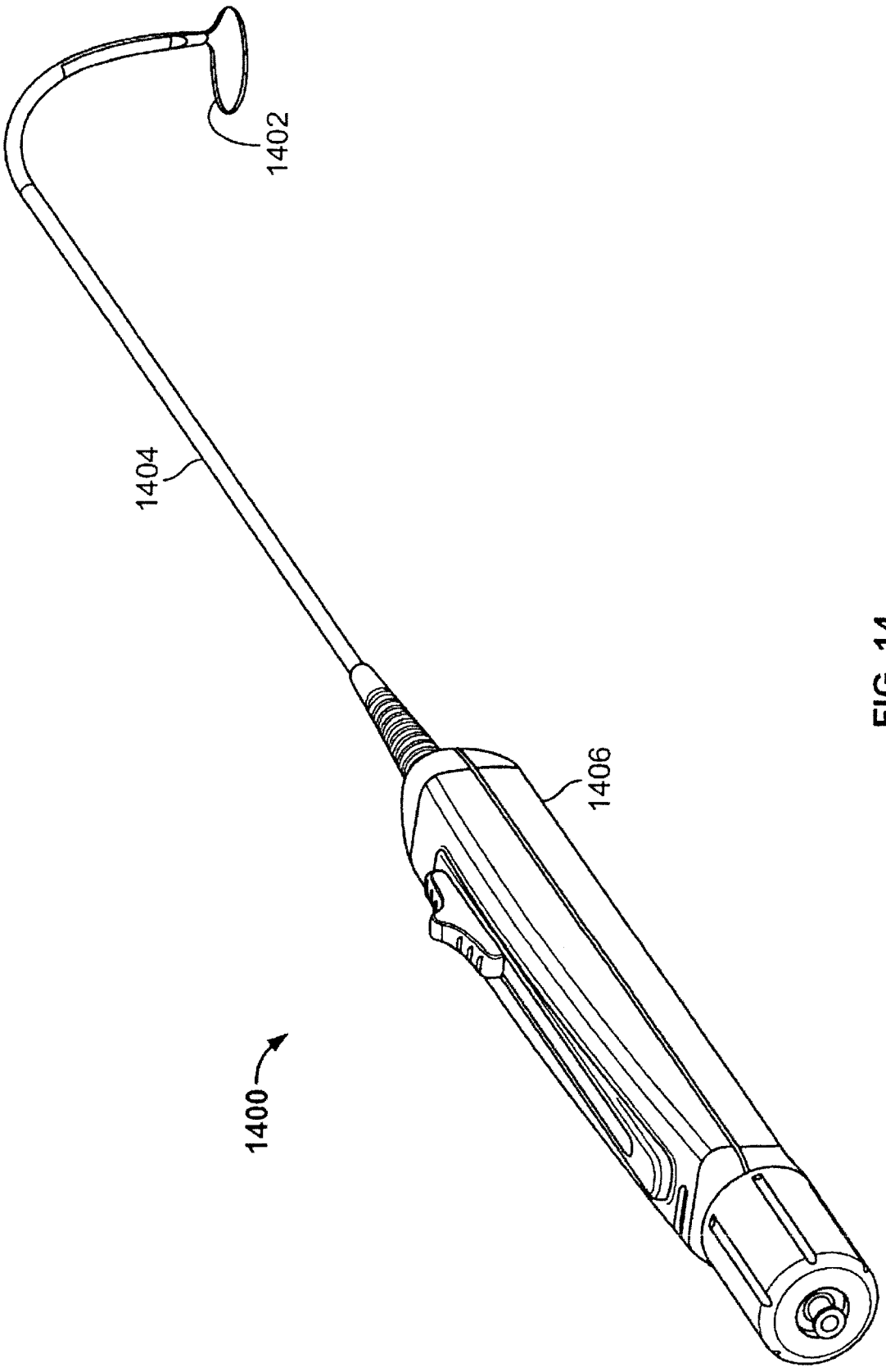

FIG. 14

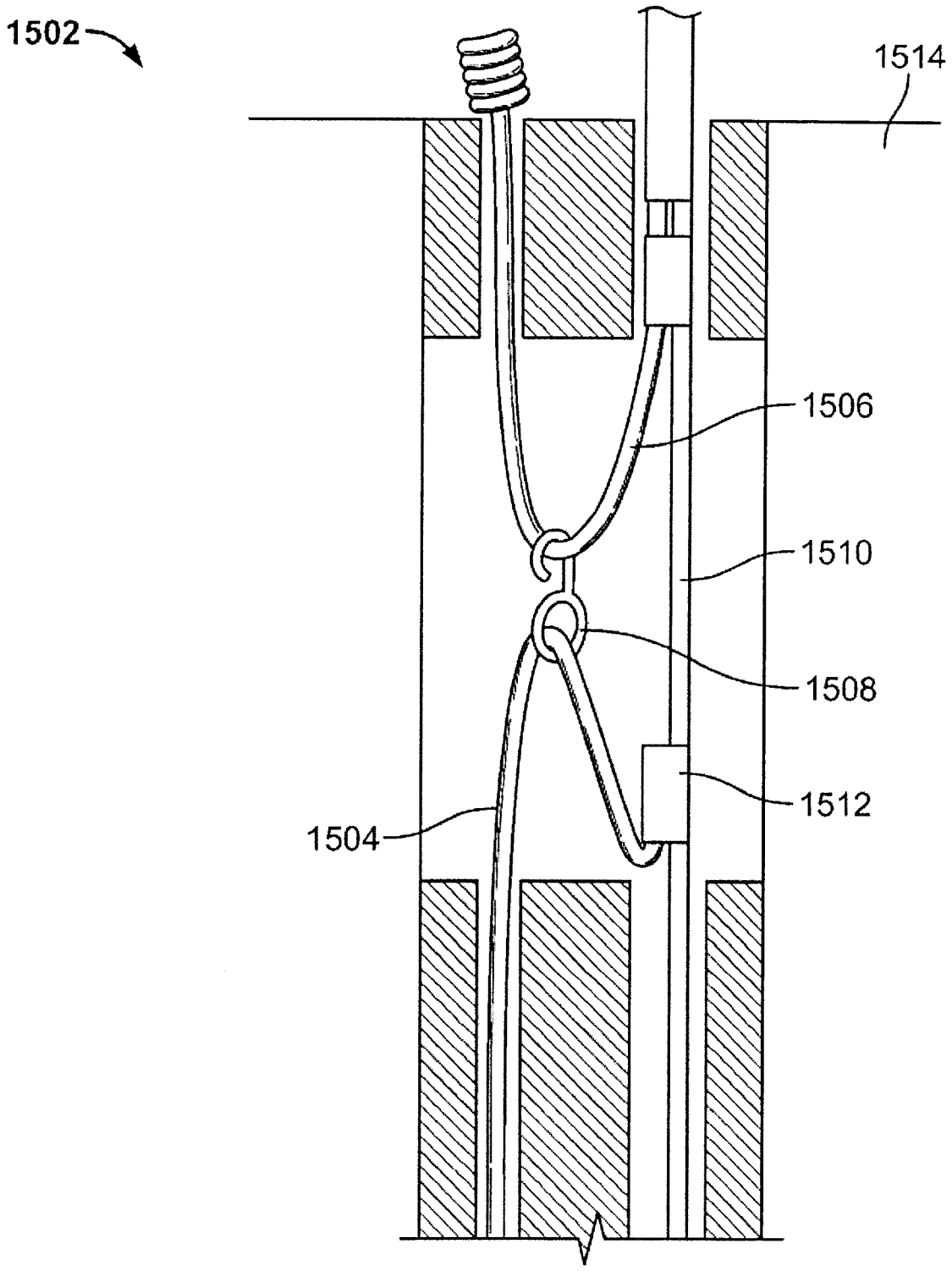

FIG. 15

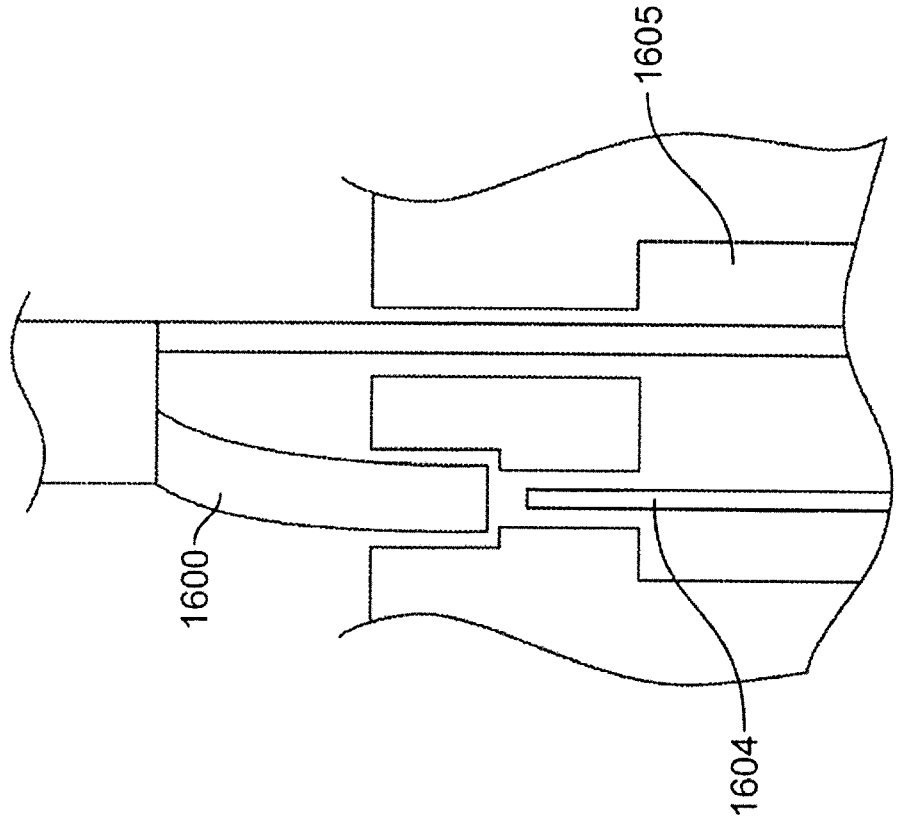

FIG.16B

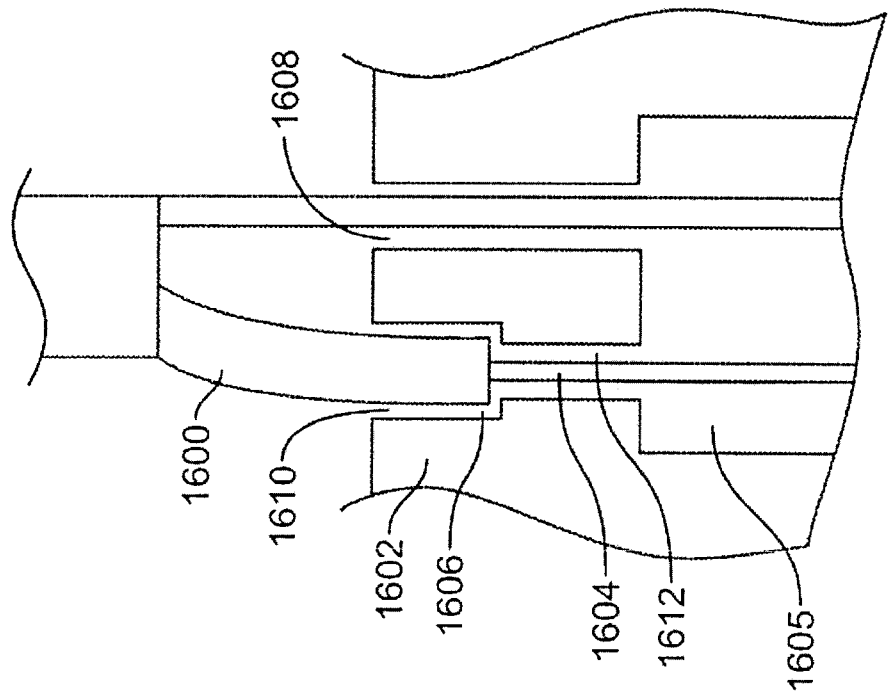

FIG.16A

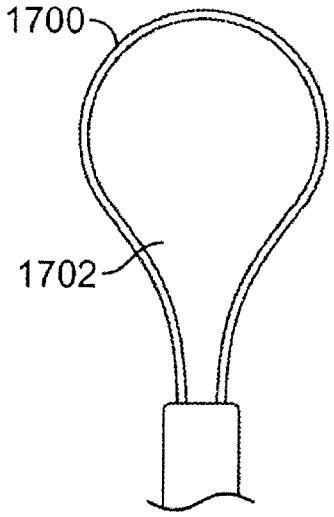

FIG. 17A

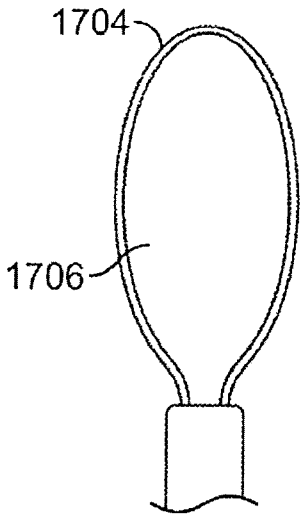

FIG. 17B

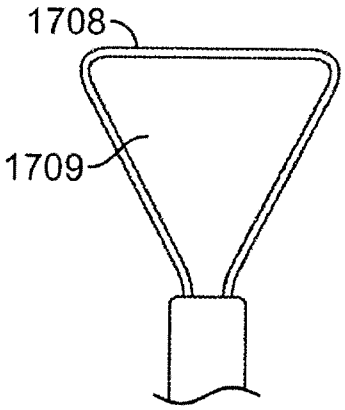

FIG. 17C

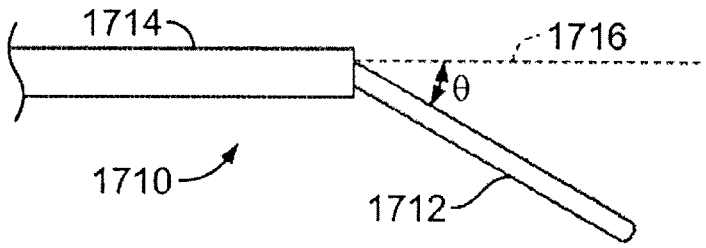

FIG. 17D

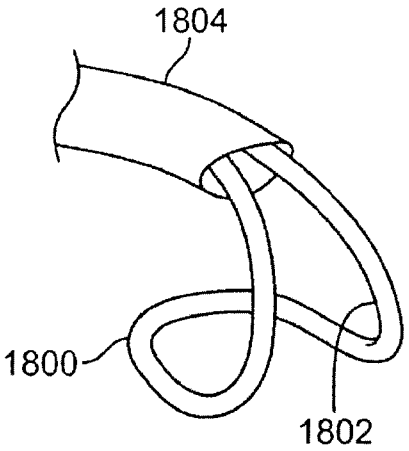

FIG. 18A

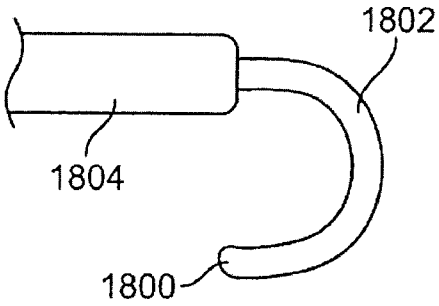

FIG. 18B

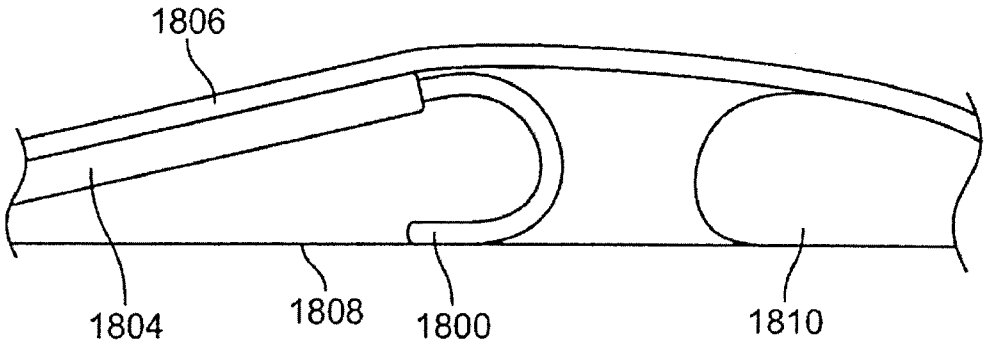

FIG. 18C

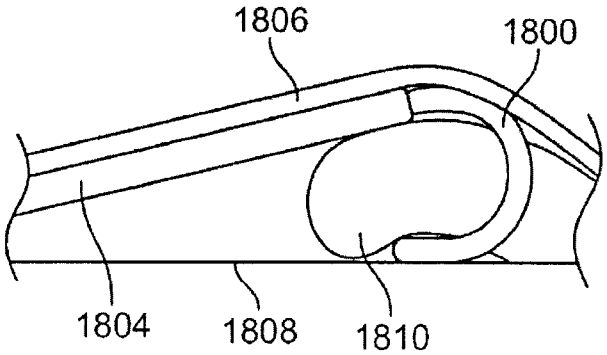

FIG. 18D

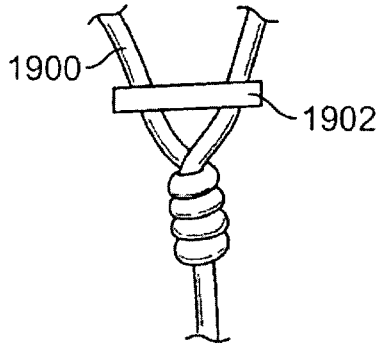

FIG. 19A

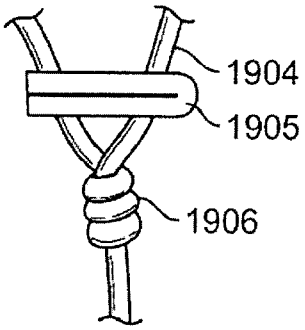

FIG. 19B

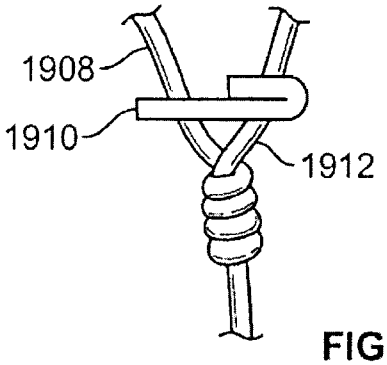

FIG. 19C

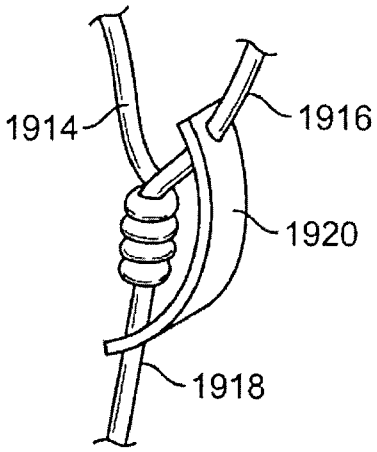

FIG. 19D

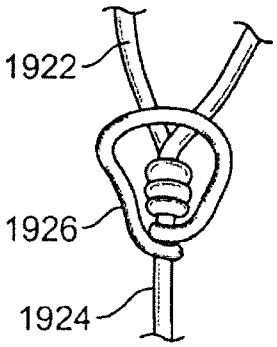

FIG. 19E

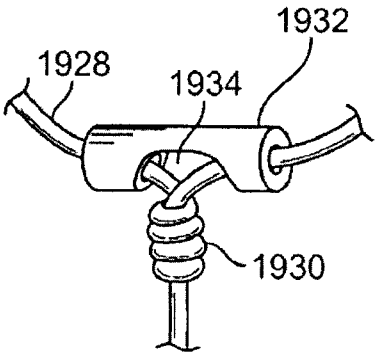

FIG. 19F

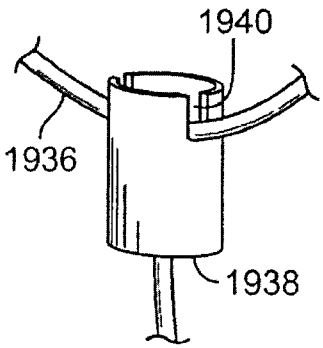

FIG. 19G

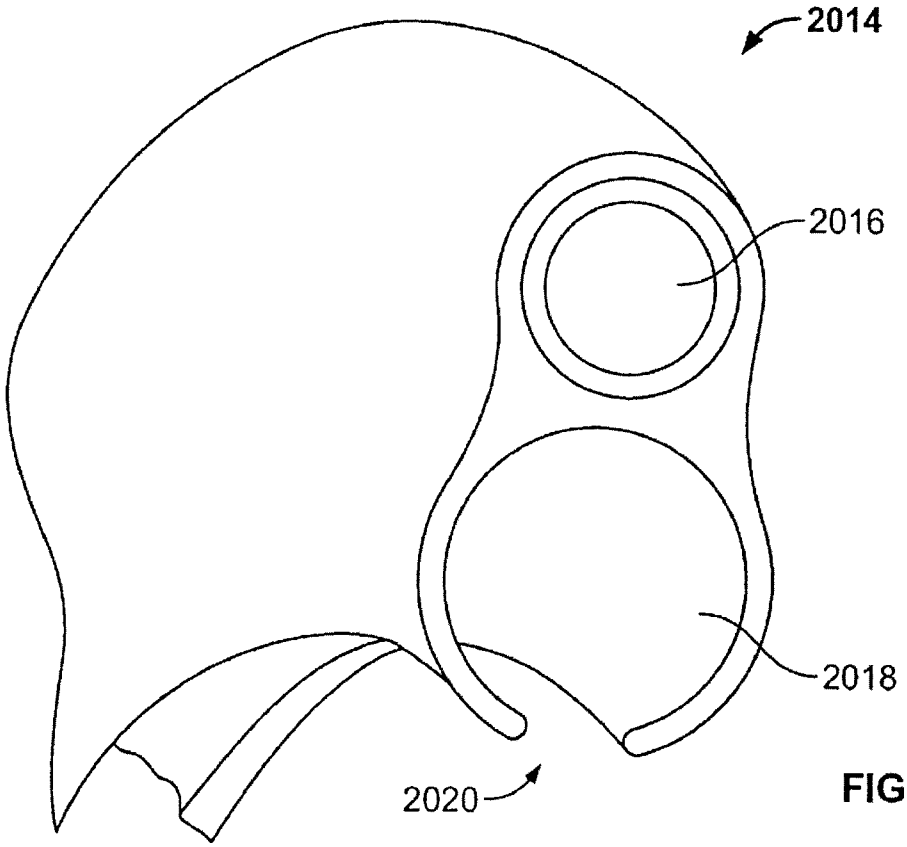

FIG. 20A

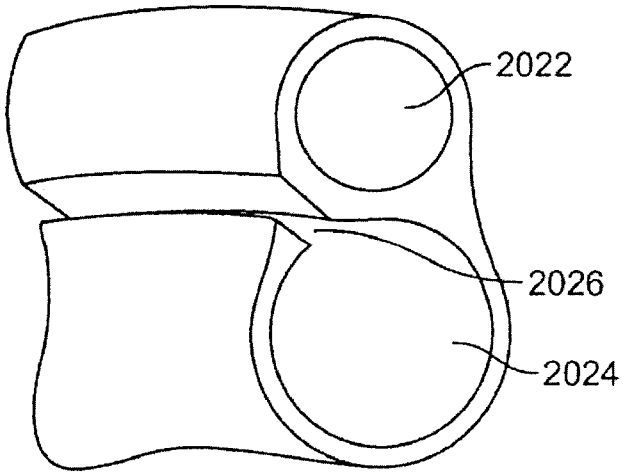

FIG. 20B

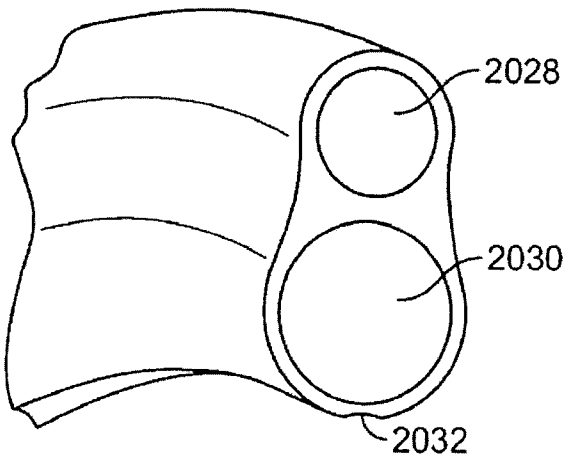

FIG. 20C

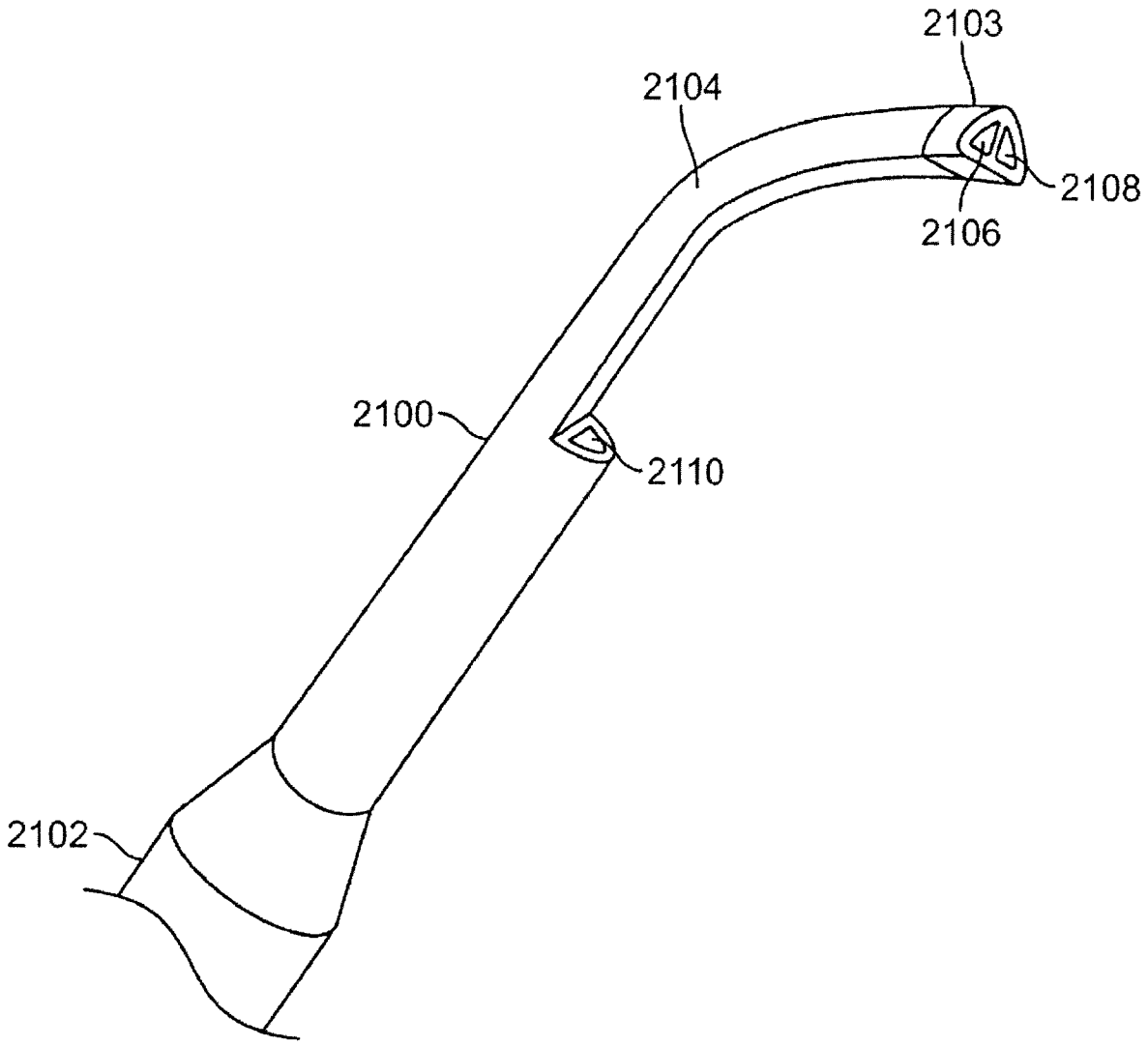

FIG. 21

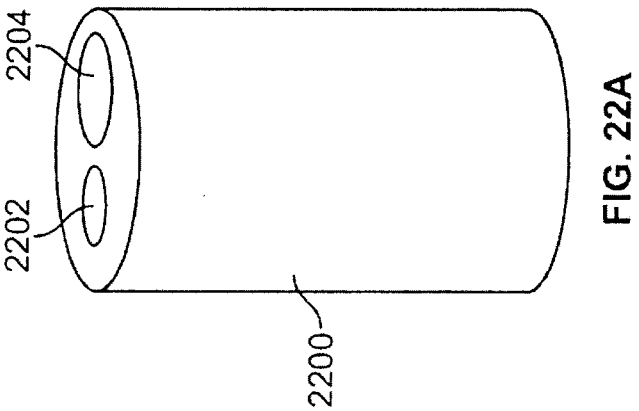

FIG. 22A

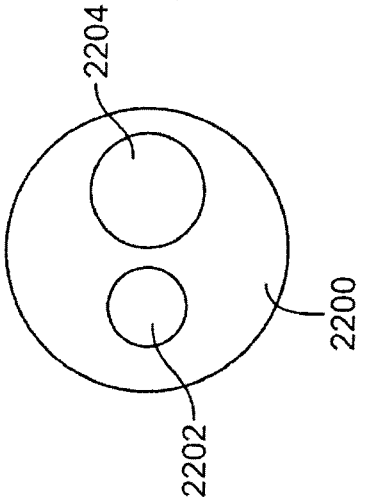

FIG. 22B

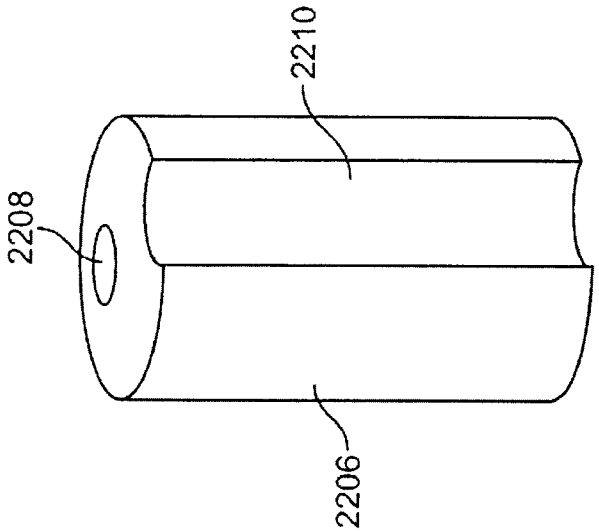

FIG. 22C

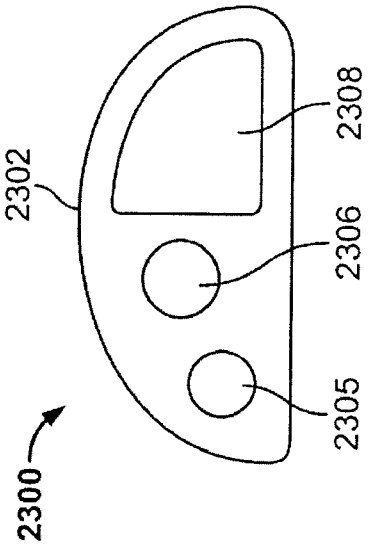

FIG. 23A

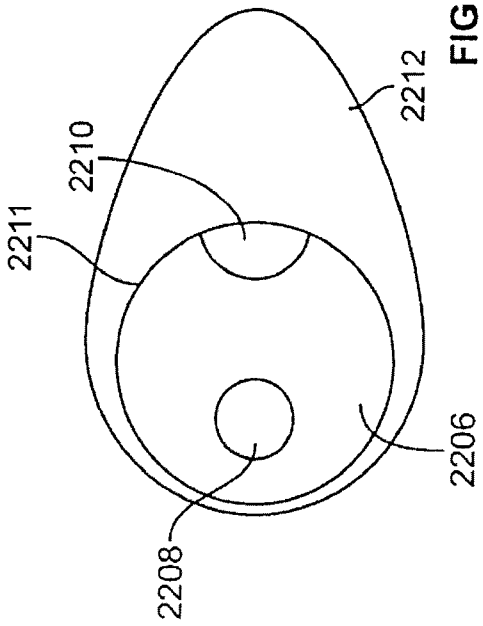

FIG. 22D

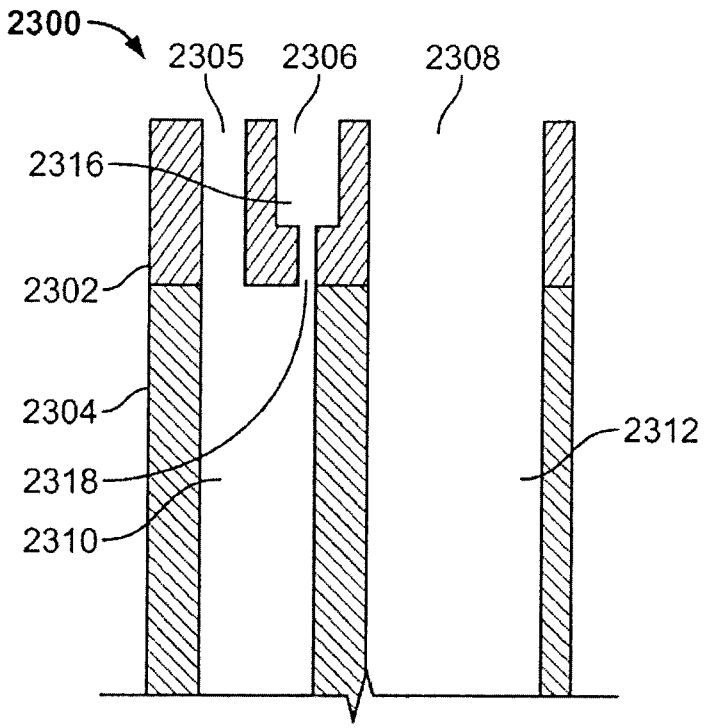

FIG. 23B

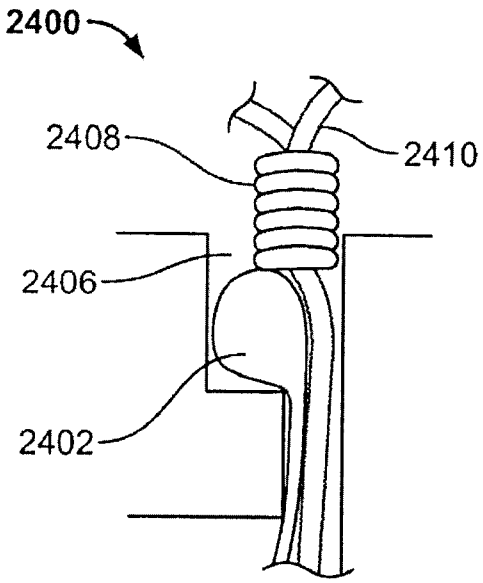

FIG. 24A

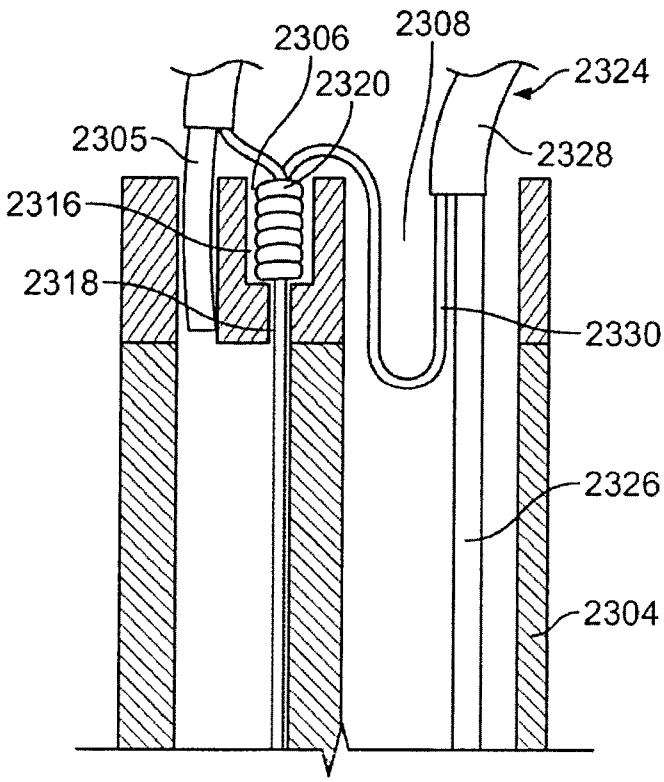

FIG. 23C

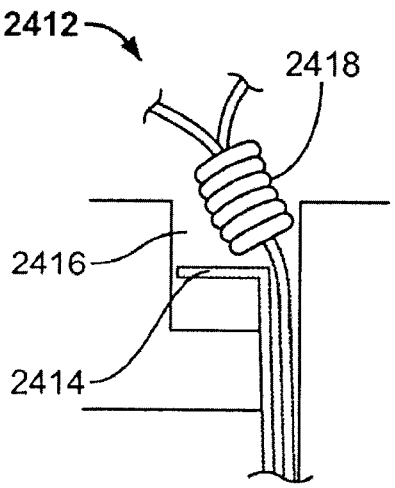

FIG. 24B

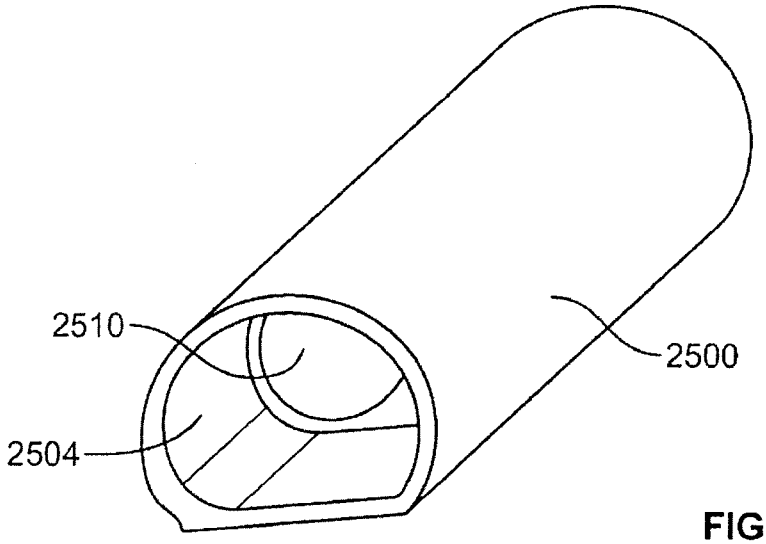

FIG. 25A

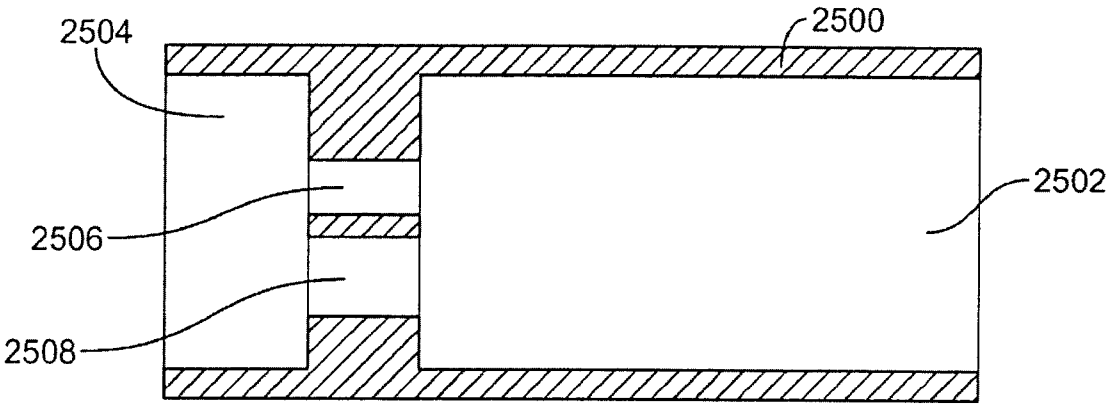

FIG. 25B

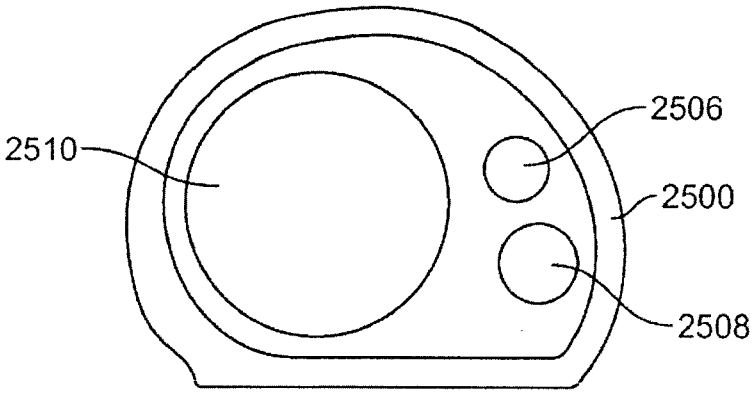

FIG. 25C

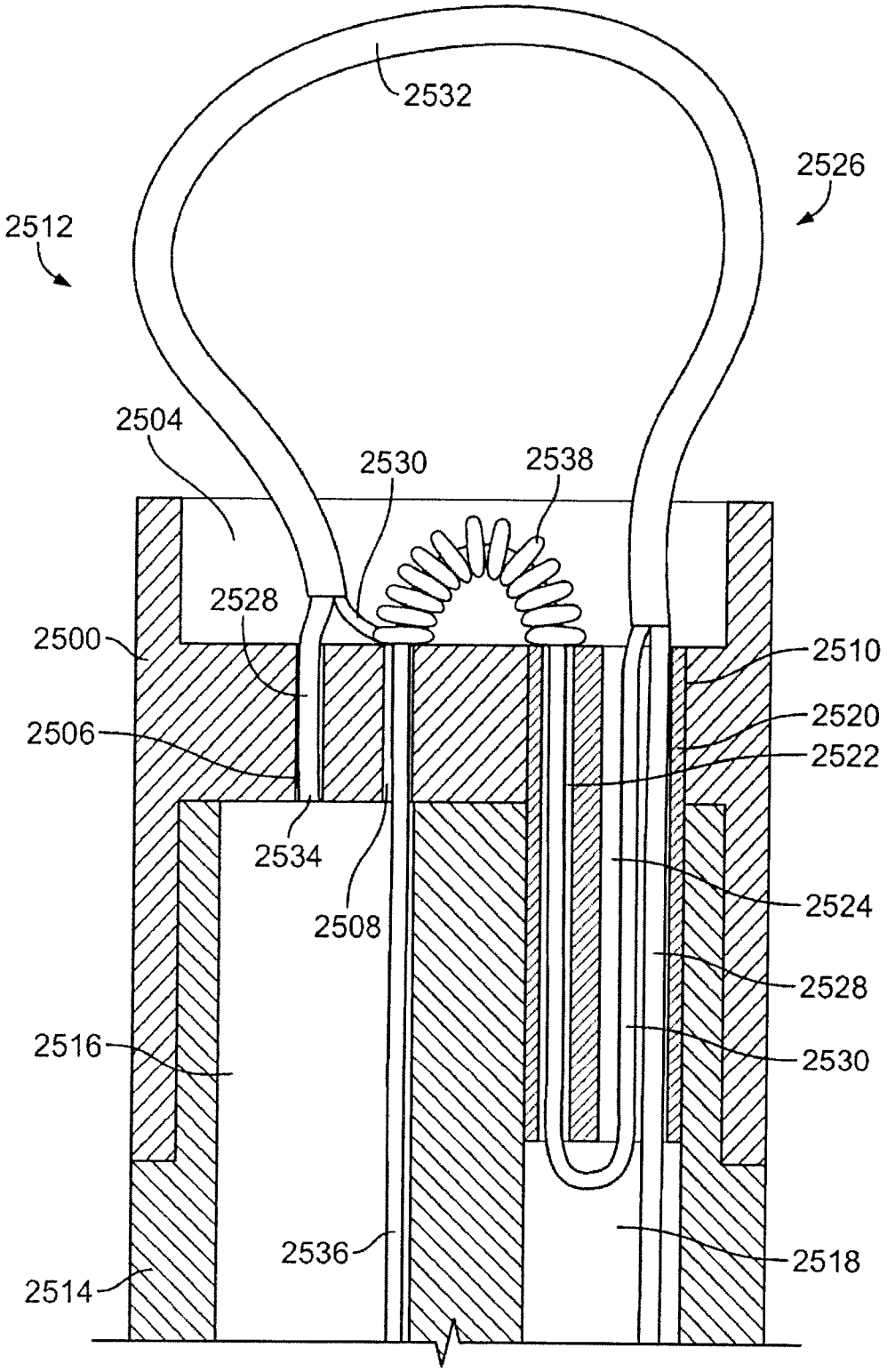
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FIG. 25D

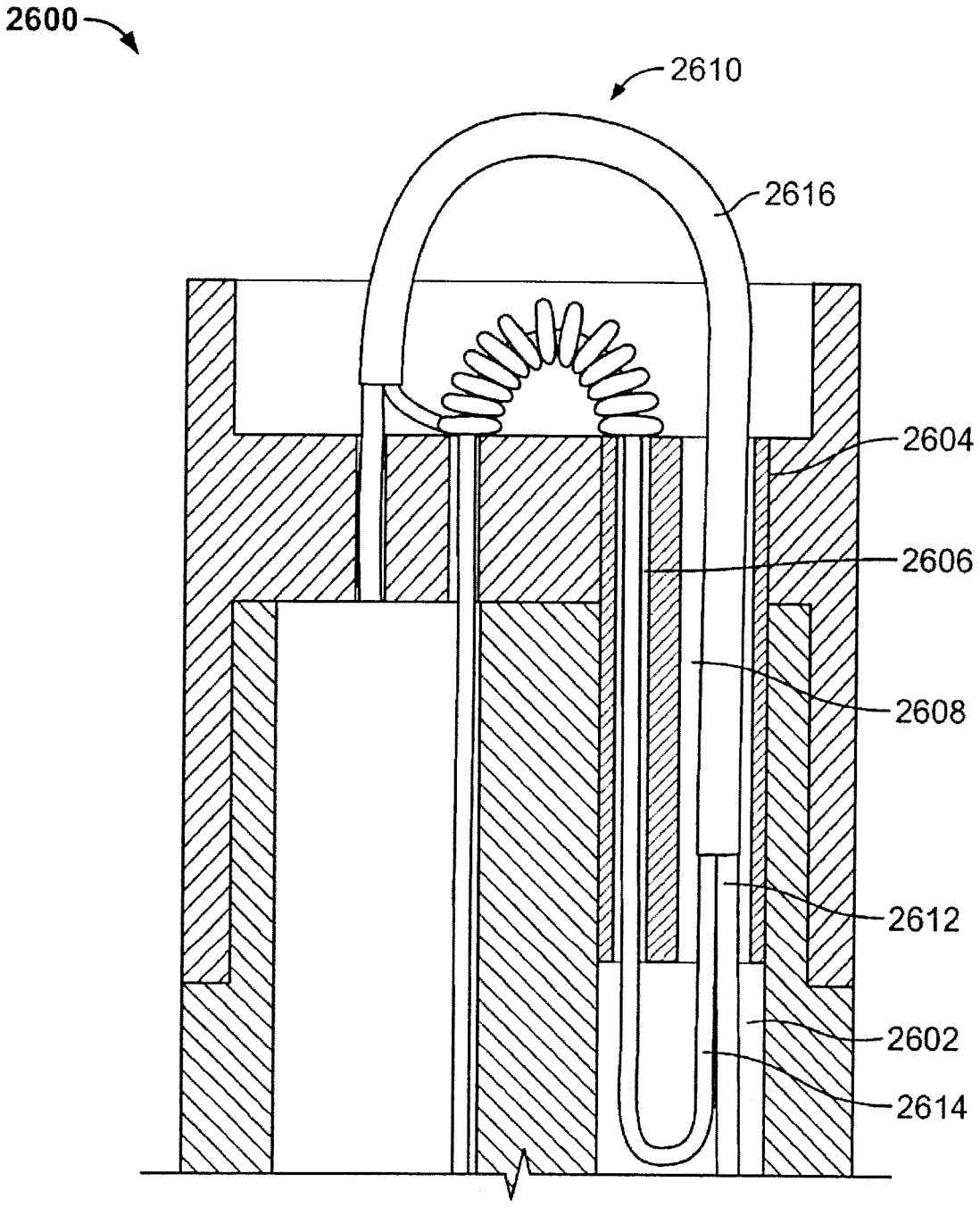

FIG. 26A

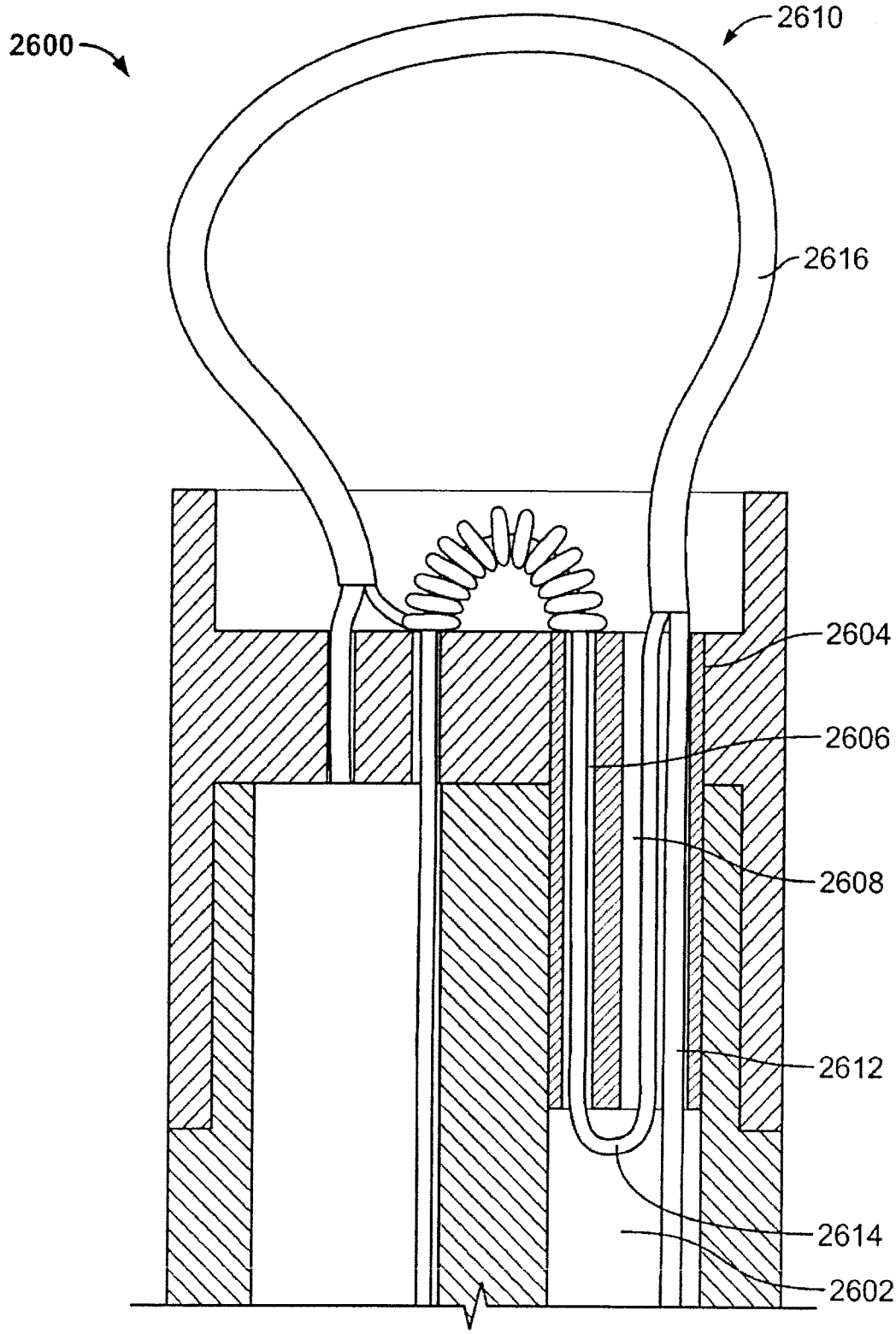

FIG. 26B

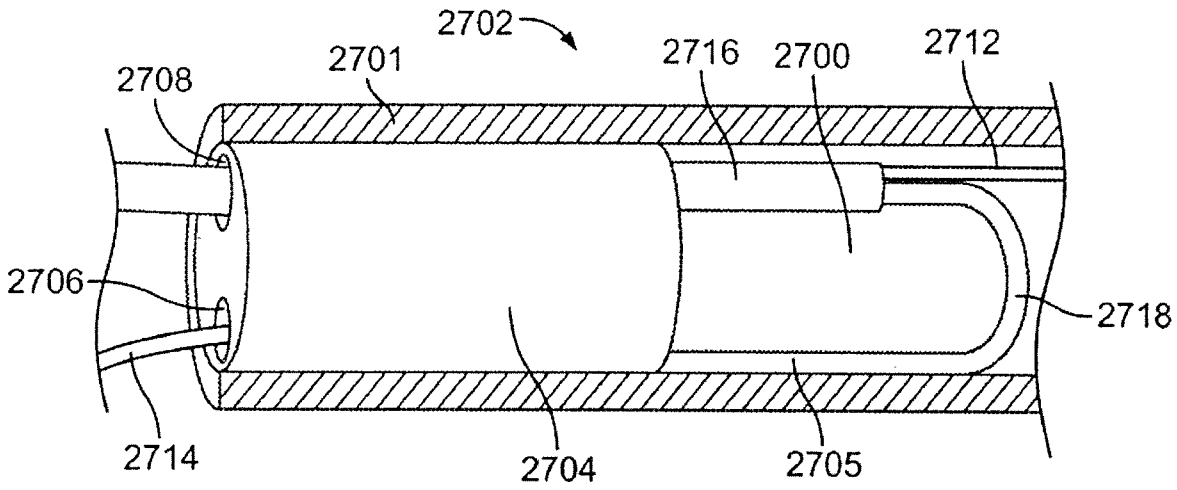

FIG. 27

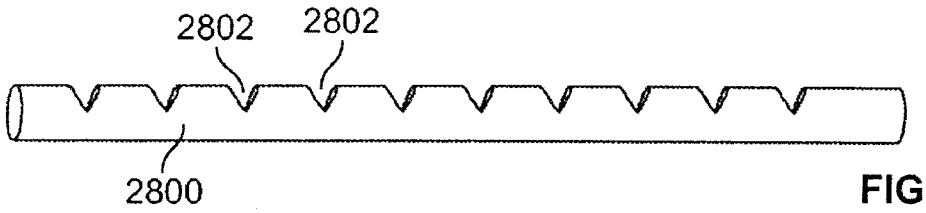

FIG. 28A

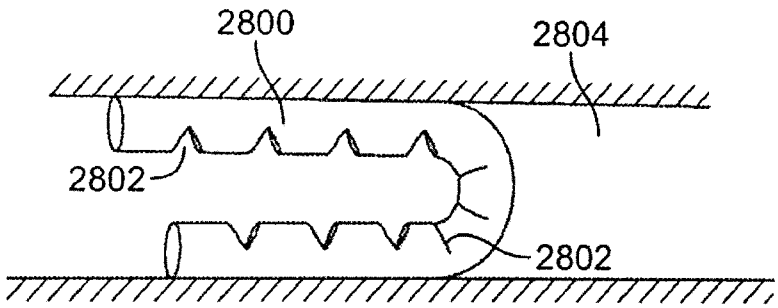

FIG. 28B

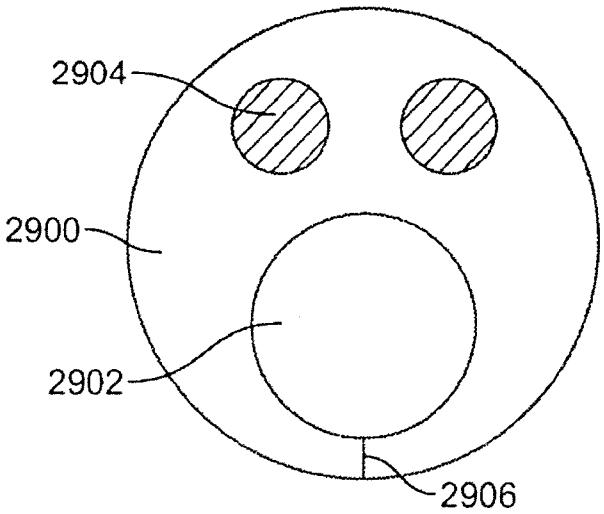

FIG. 29

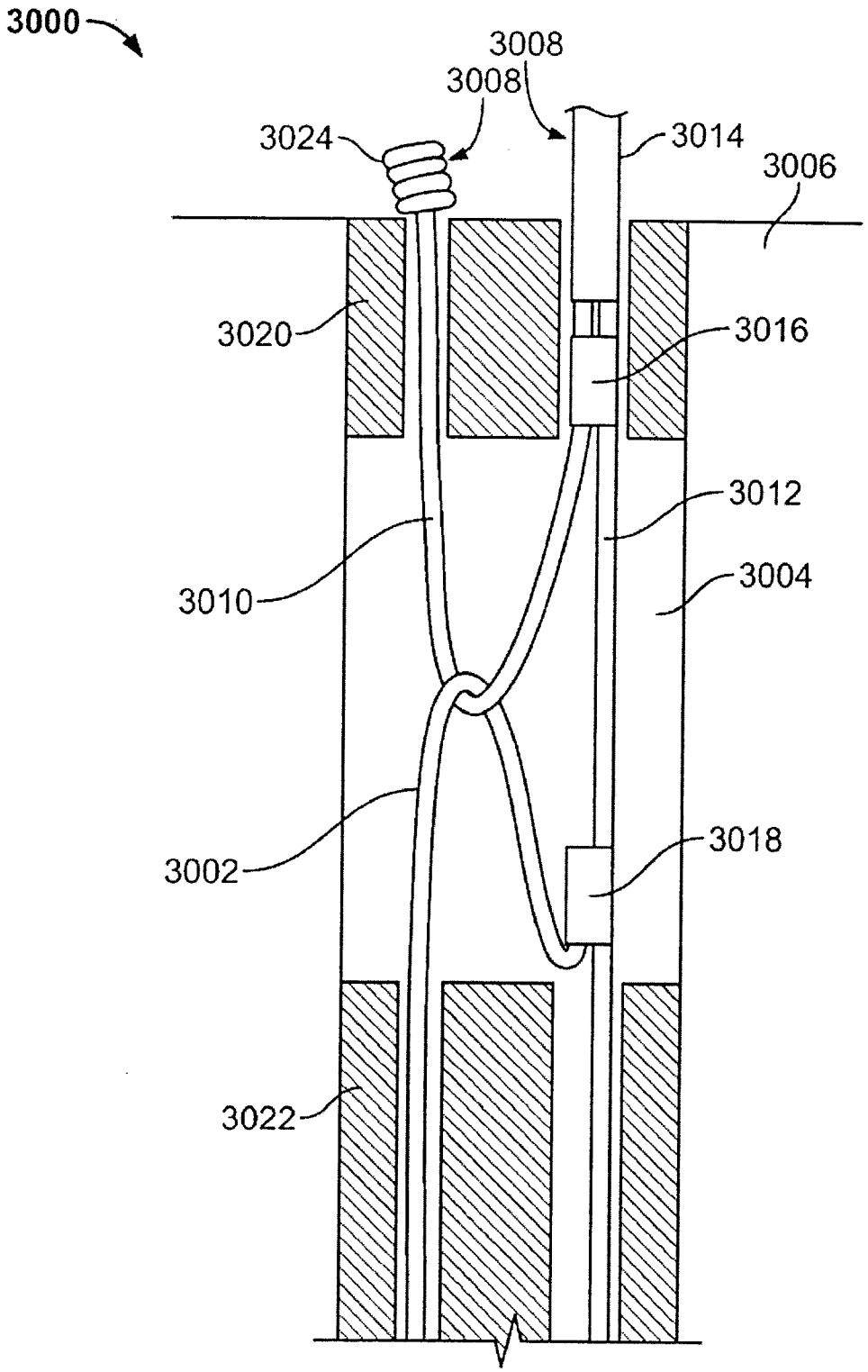
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FIG. 30A

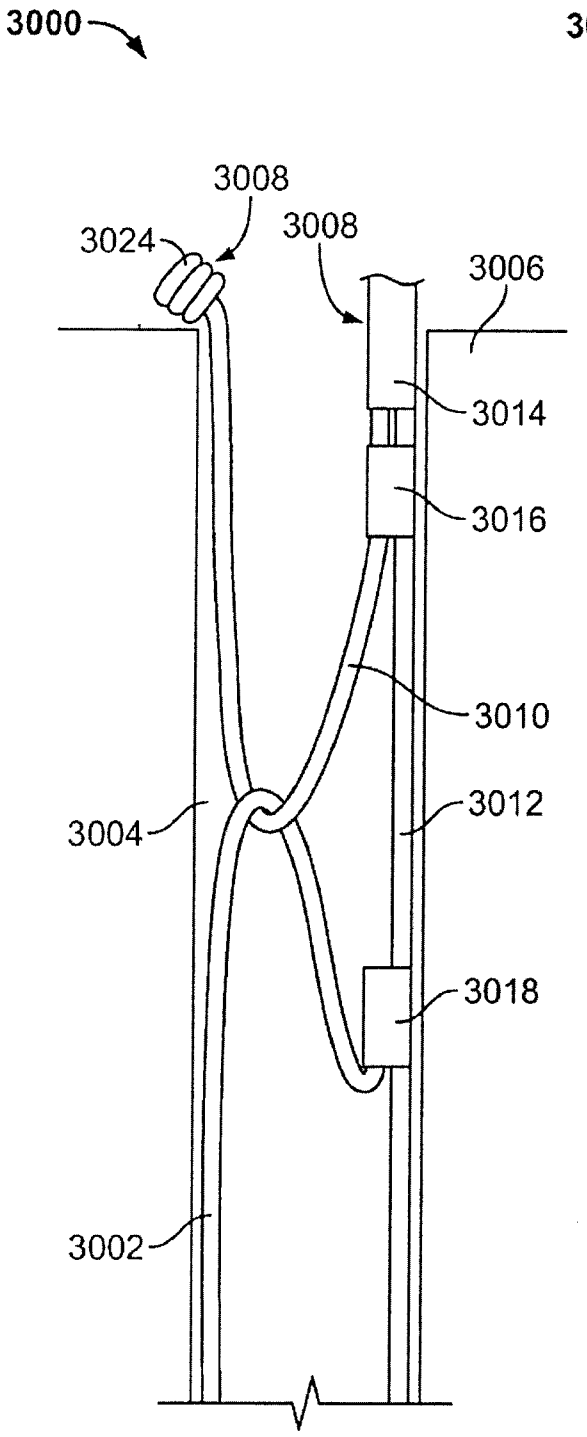


FIG. 30B

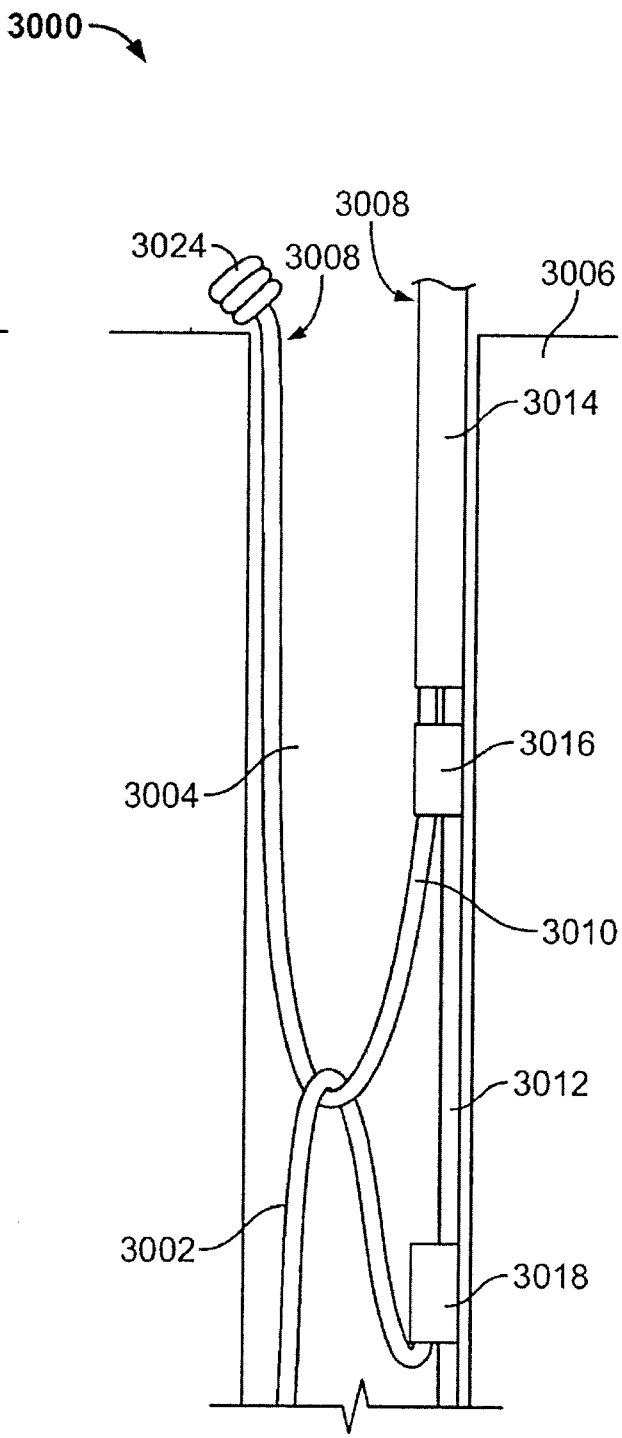


FIG. 30C

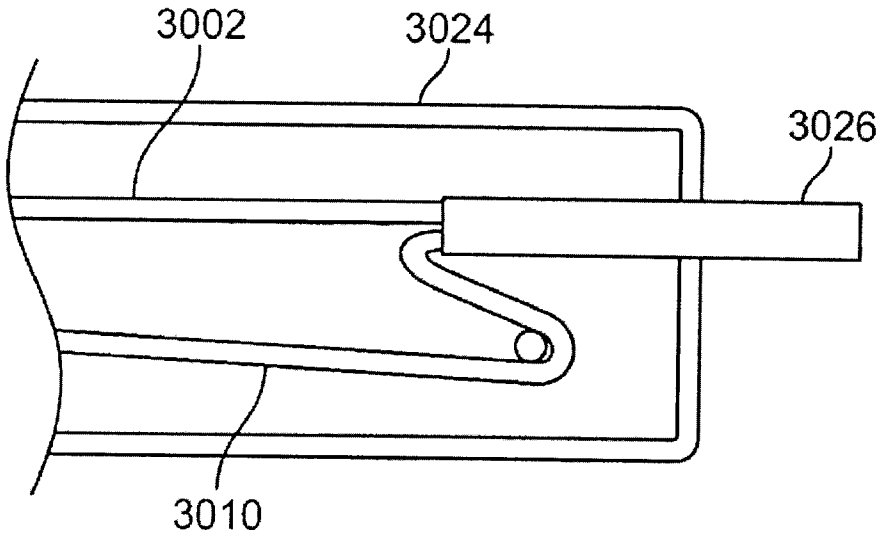
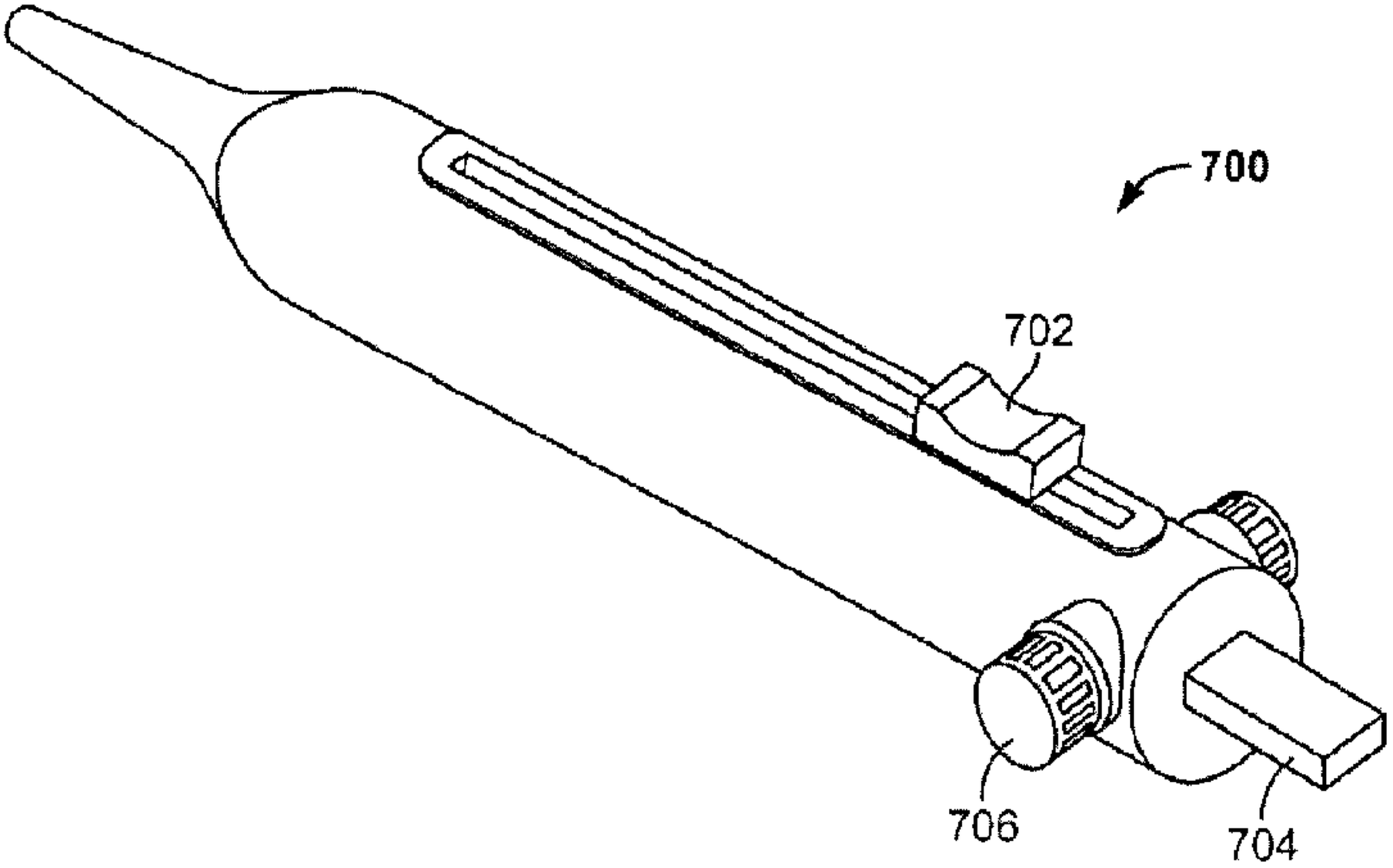


FIG. 30D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