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(54) Title: SURGICAL DEVICE WITH ANTI-BINDING FEATURES

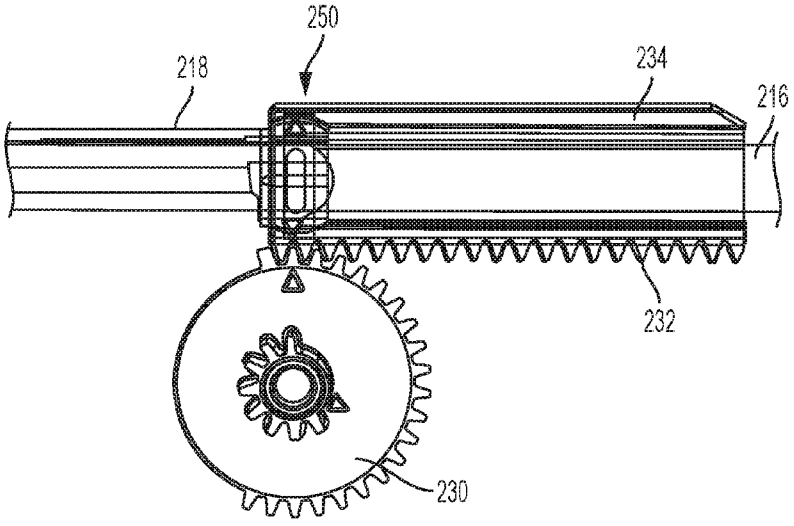

FIG. 4

(57) Abstract: Methods and devices are provided for preventing binding between components of a drive assembly of a surgical device. In an exemplary embodiment, a surgical device is provided having a ball-and-socket joint that allows bending of various drive shafts relative to the handle without causing movement of a drive rack disposed within the handle. Since the drive rack does not move in response to bending of the shaft, the drive gear and rack will remain aligned thus preventing jamming of the device.

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SURGICAL DEVICE WITH ANTI-BINDING FEATURES

FIELD

[0001] Surgical devices and methods having anti-binding features are provided.

BACKGROUND

[0002] Endoscopic surgical instruments are often preferred over traditional open surgical devices since a smaller incision, or incisions, associated with endoscopic surgical techniques tends to reduce the post-operative recovery time and complications. Consequently, significant development has gone into a range of endoscopic surgical instruments that are suitable for precise placement of a distal end effector at a desired surgical site through a cannula of a trocar. These distal end effectors engage the tissue in a number of ways to achieve a diagnostic or therapeutic effect (e.g., endocutter, grasper, cutter, staplers, clip applier, access device, drug/gene therapy delivery device, and energy device using ultrasound, RF, laser, etc.).

[0003] Endoscopic devices are passed through an access port, such as a trocar, to allow the distal end effector to engage tissue within a body cavity of a patient. The tissue can also be cut using a cutting element, such as a knife. Loading forces experienced by a shaft of the device as the end effector engages the tissue may cause the shaft to bend relative to the handle and to thus result in jamming or binding between components participating in distal advancement and proximal return of the cutting element. As a result, the cutting element can be prevented from being properly used to cut tissue. As another undesirable consequence, if the binding occurs during advancement or retraction of the cutting instrument, the device cannot be removed because the cutting element cannot be properly returned to its default position. The surgeon may be forced to open up the patient and manipulate the instrument, potentially causing serious harm to the patient.

[0004] Accordingly, there remains a need for methods and devices for preventing binding of components of a cutting assembly of a surgical device.

SUMMARY

[0005] Various methods and devices are provided for preventing binding or jamming of components of a cutting assembly of a surgical device.

[0006] In one aspect, a surgical device is provided that includes a handle, an end effector, a closure tube, a knife pusher shaft, and a rack. The handle has an elongate shaft extending distally therefrom. The end effector is disposed at a distal end of the elongate shaft and has first and second jaws that are movable between an open configuration and a closed configuration in which the first and second jaws are configured to engage tissue therebetween. The closure tube extends through the handle and the elongate shaft and is configured to move the first and second jaws between the open configuration and the closed configuration. The knife pusher shaft is disposed at least partially around the closure tube and is configured to move a cutting element through the first and second jaws for cutting tissue engaged therebetween. The rack is coupled to the knife pusher shaft by a ball-and-socket joint such that the knife pusher shaft can pivot relative to the rack. Movement of the rack is effective to drive the knife pusher shaft and thereby move the cutting element through the first and second jaws.

[0007] The surgical device can vary in any number of ways. For example, the surgical device can include a gear disposed within the handle and engaged with the rack for driving the rack. In one embodiment, the handle can include a motorized drive assembly that is effective to rotate the gear. The rack can have various configurations, for example, it be formed along an external surface of an elongate housing having a cylindrical cavity formed therethrough that receives the closure tube. In such an example, the ball-and-socket joint can include a spherical cavity formed in a distal end of the elongate housing, and a spherical ball formed on a proximal end of the knife pusher shaft and pivotally seated within the spherical cavity.

[0008] The housing can also have various configurations, and in one embodiment it includes a stationary handle and a movable handle that is configured to pivot toward the stationary handle to move the closure tube proximally and thereby move the first and second jaws to the closed configuration.

[0009] In another aspect, a surgical device is provided that includes a handle, a jaw closure assembly, and a cutting assembly. The handle can have an elongate shaft extending distally therefrom and an end effector located on a distal end of the elongate shaft. The end effector can include first and second jaws that are movable between an open configuration and a closed configuration in which the first and second jaws are configured to engage tissue therebetween. The jaw closure assembly can extend through the handle and the elongate shaft and it can be configured to move the first and second jaws between the open and closed positions. The cutting assembly can extend through the handle and the elongate shaft and it can have a gear and a rack configured to drive a cutting element through the first and second jaws to cut tissue engaged between the jaws. The cutting assembly can also include a ball-and-socket joint located within the handle that prevents binding between the gear and rack.

[0010] The surgical device can vary in any number of ways. For example, the cutting assembly can include a knife pusher tube having a ball formed on a proximal end thereof, and the rack can be formed on a housing having a socket formed therein that seats the ball. In another example, the jaw closure assembly can include a closure tube extending through the handle and the elongate shaft and it can be configured to move the first and second jaws between the open configuration and the closed configuration. The closure tube can extend through the knife pusher tube and the housing. In one embodiment, the surgical device can include a motorized drive assembly disposed within the handle and effective to rotate the gear.

[001 1] Methods for treating tissue are also provided. In one embodiment, the method includes engaging tissue between first and second jaws of an end effector on a distal end of an elongate shaft of a surgical device, and manipulating the surgical device to move the tissue. A force applied to the elongate shaft causes a knife pusher shaft extending therethrough to pivot about a pivot joint relative to a rack housing disposed within the handle. In one embodiment, the pivot joint is a ball-and-socket joint formed between the knife pusher shaft and the rack housing.

[0012] The method can vary in any number of ways. For example, the method can further include activating the surgical device to rotate a gear within the device such that the gear drives the rack housing and the knife pusher coupled thereto to move a cutting element through the first and second jaws and thereby cut the tissue engaged therebetween. In one embodiment, the

surgical device can include a motor, and activating the device can cause a power source to deliver energy to the motor such that the motor drives the gear.

[0013] In other aspects, engaging tissue between the first and second jaws can include moving a movable handle toward a stationary handle to move a jaw closure shaft proximally. Proximal movement of the jaw closure shaft can cause the first and second jaws to approximate to engage the tissue. The jaw closure shaft can move proximally through the knife pusher shaft and the rack housing when the movable handle is moved toward the stationary handle.

BRIEF DESCRIPTION OF DRAWINGS

[0014] The embodiments described above will be more fully understood from the following detailed description taken in conjunction with the accompanying drawings. The drawings are not intended to be drawn to scale. For purposes of clarity, not every component may be labeled in every drawing. In the drawings:

[0015] FIG. 1 is a side view of one embodiment of a surgical device;

[0016] FIG. 2 is a side view of a handle portion of the surgical device of FIG. 1, with various components removed for clarity;

[0017] FIG. 3 is a side, partially transparent view of various components of the surgical device of FIGS. 1 and 2;

[0018] FIG. 4 is a side view of a ball-and-socket joint and a gear of the surgical device of FIGS. 1 and 2;

[0019] FIG. 5 is a perspective, transparent view of the ball-and-socket joint of FIG. 4;

[0020] FIG. 6 is a side view of the ball-and-socket joint of FIG. 5;

[0021] FIG. 7 is a perspective view of a knife pusher tube of the surgical device of FIGS. 1 and 2; and

[0022] FIG. 8 is a perspective view of a rack housing of the surgical device of FIGS. 1 and 2.

DETAILED DESCRIPTION

[0023] Certain exemplary embodiments will now be described to provide an overall understanding of the principles of the structure, function, manufacture, and use of the devices and methods disclosed herein. One or more examples of these embodiments are illustrated in the accompanying drawings. Those skilled in the art will understand that the devices and methods specifically described herein and illustrated in the accompanying drawings are non-limiting exemplary embodiments and that the scope of the present invention is defined solely by the claims. The features illustrated or described in connection with one exemplary embodiment may be combined with the features of other embodiments. Such modifications and variations are intended to be included within the scope of the present invention.

[0024] Further, in the present disclosure, like-named components of the embodiments generally have similar features, and thus within a particular embodiment each feature of each like-named component is not necessarily fully elaborated upon. Additionally, to the extent that linear or circular dimensions are used in the description of the disclosed systems, devices, and methods, such dimensions are not intended to limit the types of shapes that can be used in conjunction with such systems, devices, and methods. A person skilled in the art will recognize that an equivalent to such linear and circular dimensions can easily be determined for any geometric shape. Sizes and shapes of the systems and devices, and the components thereof, can depend at least on the anatomy of the subject in which the systems and devices will be used, the size and shape of components with which the systems and devices will be used, and the methods and procedures in which the systems and devices will be used.

[0025] Various exemplary methods and devices are provided for preventing binding or jamming of components of a drive assembly of a surgical device due to load on a shaft of the device. In an exemplary embodiment, the surgical has a handle with an elongate shaft extending distally therefrom and an end effector located on a distal end of the elongate shaft. The end effector includes first and second jaws that are movable between an open configuration and a closed configuration in which the first and second jaws are configured to engage tissue therebetween. The surgical device also includes, among other components, a cutting assembly extending through the handle and the elongate shaft and having a gear and a rack housing configured to

drive a cutting element through the jaws to cut tissue engaged between the jaws. In an exemplary embodiment, the cutting assembly includes a ball-and-socket joint located within the handle that prevents binding between the gear and the rack. Thus, components of the cutting assembly are not affected by possible bending of the elongate shaft of the surgical instrument due to load applied thereto in various surgical environments. This allows for proper advancement of the cutting element to cut tissue engaged between the jaws. Furthermore, the ball-and-socket joint configuration allows the cutting element to be properly retracted after it is used to cut the tissue.

[0026] FIGS. 1 and 2 illustrate one embodiment of a surgical device configured to grasp and cut tissue. As shown, the illustrated surgical device 100 generally includes a proximal handle 10, a shaft 12 extending distally from the proximal handle 10, and an end effector 14 for grasping tissue. The proximal handle 10 can be any type of pistol-grip, scissor grip, pencil-grip, or other type of handle known in the art that is configured to carry various actuators, such as actuator levers, knobs, triggers, or sliders, for actuating various functions such as rotating, articulating, approximating, and/or firing the end effector 14. In the illustrated embodiment, the proximal handle 10 includes a stationary handle 22 and a closure actuator 20 in the form of a handle that is movable toward and away from the stationary handle 22 to open and close the jaws of the end effector 14. The illustrated proximal handle 10 also includes a rotation knob 15 that is configured to rotate the shaft 12, a firing actuator 24 that is configured to drive a cutting element through the end effector, and an energy actuator 26 that is configured to cause energy to be delivered to tissue engaged between the jaws of the end effector 14. The various actuators can be coupled to the end effector by one or more drive assembly extending through the handle and through the elongate shaft 12.

[0027] The end effector can have a variety of sizes, shapes, and configurations. As shown in FIG. 1, the end effector 14 includes a first, upper jaw 16a in the form of an anvil and a second, lower jaw 16b that houses a staple cartridge with staples. The jaws are disposed at a distal end 12d of the shaft 12. The jaws 16a, 16b are movable between an open position in which the jaws 16a, 16b are spaced a distance apart, and a closed position in which the jaws 16a, 16b are moved toward one another and are substantially opposed. When the jaws 16a, 16b are in the closed position, a longitudinal axis of the upper jaw 16a can be substantially parallel to a longitudinal

axis of the lower jaw 16b and the jaws 16a, 16b can be in direct contact for engaging tissue therebetween. In the illustrated embodiment, the upper jaw 16a pivots relative to the shaft 12 and relative to the lower jaw 16b while the lower jaw 16b remains stationary, however in other embodiments the lower jaw can pivot relative to the upper stationary jaw, or both jaws can pivot. While the illustrated jaws 16a, 16b have a substantially elongate and straight shape, a person skilled in the art will appreciate that one or both of the jaws 16a, 16b can be curved and/or can extend in various directions. The jaws 16a, 16b can have any suitable axial length for engaging tissue, and the length can be selected based on the targeted anatomical structure for transection and/or sealing.

[0028] As indicated above, the surgical device 100 has a stationary handle 22 that is configured to open and close the jaws 16a, 16b of the end effector 14. Manipulation of the closure actuator 20 can pivot or otherwise move the jaws relative to one another such that the jaws can engage tissue, move anatomical structures, or perform other surgical functions. The closure actuator 20 can have various sizes, shapes, and configurations, but in the illustrated embodiment the closure actuator 20 pivots about a pivot point to move toward and away from stationary handle 22. In particular, the closure actuator 20 can have a first position in which it is angularly offset and spaced apart from the stationary handle 22. In this position, as shown in FIG. 1, the jaws 16a, 16b of the end effector 14 are open. The closure actuator 20 can have a second position where it is positioned adjacent to, or substantially in contact with, the stationary handle 22. In this position, the jaws 16a, 16b of the end effector 14 are approximated to the closed position to engage tissue and apply a force to tissue disposed therebetween. The closure actuator 20 can be biased to the first open position with the jaws 16a, 16b of the end effector 14 being open, as shown in FIG. 1. The closure actuator 20 can also include a locking mechanism for maintaining the closure actuator 20 in the second position. As shown in FIG. 2, the stationary handle includes a locking element 23 that is configured to engage a locking feature 21 on the closure actuator 20 to lock the closure actuator 20 relative to the stationary handle 22. The illustrated locking mechanism is configured to automatically engage when the closure actuator 20 substantially contacts the stationary handle 22, however, in other embodiments, the locking mechanism can automatically engage at each position the closure actuator 20 is pivoted through, such as via ratcheting.

[0029] In order to effect closing of the jaws, the closure actuator 20 can be coupled to a drive assembly that is operatively associated with the jaws to move the jaws between the open and closed positions. In the embodiment shown in FIG. 2, the closure actuator 20 is coupled to a yoke 236 via a linkage 238. The yoke 236 in turn is coupled to a jaw closure tube 216, that extends through the handle 10 and the elongate shaft 12 and that is coupled to the first jaw 16a. Movement of the closure actuator 20 toward the stationary handle 22 will move the linkage 238 and thus the yoke 236 proximally, thereby moving the closure tube 216 proximally. The closure tube 216 will in turn pull the proximal end of the first jaw 16a to cause the jaw to move to the closed position. The locking mechanism will maintain the closure actuator 20 in the second configuration adjacent to the stationary handle 22. A person skilled in the art will appreciate that the drive assembly can have a variety of other configurations and various drive mechanisms, including a drive screw, motorized drive assemblies, other gears configurations, etc., can be used.

[0030] As also indicated above, the surgical device 100 has a cutting assembly that includes a firing actuator 24 that is configured to advance a cutting element through the jaws 16a, 16b to cut tissue engaged therebetween. The firing actuator 24 can have various sizes, shapes, and configurations, but in the illustrated embodiment it is in the form of a button or trigger that can be depressed and move proximally into the housing. In another embodiment, the firing actuator 24 can be in the form of a switch, lever, etc., that can be slid, pivoted, or otherwise moved by a user. Depressing or pivoting the firing actuator 24 can cause a cutting assembly to advance through the end effector. As shown in FIG. 2, the firing actuator 24 has a cut-out formed therein and defining a firing rack 229. The firing rack 229 is coupled to a gear 230 via one or more additional gears. Gear 230 has teeth formed thereon that threadably engage a toothed drive rack 232 that is formed on an elongate rack housing 234. When the firing actuator 24 is pivoted proximally, the firing rack 229 drives the gear 230 (via one or more additional gears), and rotation of the gear 230 drives the rack housing 234 distally.

[003 1] Advancement of the rack housing 234 drives a cutting assembly through the first and second jaws to cut tissue engaged between the jaws. While the cutting assembly can have various configurations, as shown in more detail in FIG. 3, the cutting assembly generally includes a knife pusher shaft 218 that is coupled at its proximal end to the rack housing 234 and

at its distal end to a cutting element. The knife pusher shaft 218 is generally in the form of an elongate hollow shaft having the jaw closure tube 216 extending therethrough. As shown in FIG. 3, the jaw closure tube 216 extends proximally beyond the knife pusher shaft 218, through the rack housing 234, and proximally beyond the rack housing 234 to couple to the yoke 236 that is driven by the closure actuator 20 via the linkage 238.

[0032] The cutting element or knife 242 can have any suitable configuration for transecting tissue captured between the jaws, and it can be sized and shaped to transect or cut various thicknesses and types of tissue. In an exemplary embodiment, the cutting assembly includes a cutting element having a sharp or serrated edge configured to transect the tissue. In some embodiments, the cutting assembly can include, for example, an E-beam compression member that travels through slots formed in each jaw to pull the jaws into a parallel orientation and to compress tissue therebetween. The cutting element can be coupled to or integrally formed on the compression member. In other embodiments, the cutting assembly can include a shaft having a knife blade that is not attached to a compression member such that the cutting assembly can advance and retract relative to the jaws without applying compression to the tissue.

[0033] As further noted above, the device 100 can also include a third actuator in the form of an energy actuator 26 that is effective to cause energy to be delivered to tissue engaged between the jaws. The energy actuator 26 can be configured to operatively couple to a generator, which can be a separate unit that is electrically connected to the surgical device 100. The energy actuator 26 and the generator can be operatively coupled so that the device is configured to apply energy to tissue engaged by the end effector when the energy actuator 26 is activated. The generator can be any suitable generator known in the art, such as an RF generator, an ultrasound generator, or other type of a generator. A lumen (not shown) of the shaft 12 can carry electrical leads or wires that can deliver electrical energy to components of the end effector 14.

[0034] While not shown, a person skilled in the art will appreciate that the jaw closing assembly and/or the cutting assembly can be powered rather than being manually driven. For example, the closure actuator can be coupled to a motor disposed in the proximal handle 10 and manual movement of the closure actuator 20 can cause a processor to send a control signal to the motor, which can interact with various gears or other components to cause the jaws 16a, 16b to open

and close. By way of further example, the firing actuator 24 can be in electrical communication with a motor disposed in the proximal handle 10 and activation of the firing actuator 24 can similarly activate the motor which can be operatively coupled to one or more gears and a rack for driving a cutting element through the jaws. Energy delivery can likewise be controlled by a processor that controls the closure and/or firing systems. The device can also include other power-driven features, such as powered articulation and/or powered rotation of the end effector and/or shaft.

[0035] In an exemplary embodiment, the device 100 includes features that prevent binding of components of the cutting assembly. In particular, during use of the end effector to engage and manipulate tissue, a load is often applied to the elongate shaft 12 that can cause the elongate shaft 12 to bend or pivot relative to the handle 10. A person skilled in the art will appreciate that the term "bend" is used herein to refer to movement out of the longitudinal axis, including pivotal movement or flexion that causes various portions of the component to be misaligned with respect to its longitudinal axis. Since the jaw closure tube 216 extends through the rack housing 234 and through at least a portion of the knife pusher shaft 218, any bending of the elongate shaft 12, and thus the jaw closure tube 216 and knife pusher shaft 218 extending therethrough, will cause the rack housing 234 to bend or pivot out of axis. As a result, the drive rack 232 on the rack housing 234 will become misaligned with respect to the gear 230, thereby potentially resulting in jamming or binding of the gears. When the gear 230 is jammed or misaligned with the drive rack 232 on the rack housing 234, the firing actuator 24 will be prevented from driving the cutting element.

[0036] Accordingly, in an exemplary embodiment, the device 100 includes features to prevent such binding or jamming from occurring. Specifically, the knife pusher shaft 218 can be configured such that the bending of the knife pusher shaft 218 and the closure tube 216 disposed therein does not cause the rack housing 234 to bend or otherwise move out of axis. As shown in FIGS. 2-6, the knife pusher shaft 218 is coupled to the rack housing 234 by a ball-and-socket joint 250 such that the knife pusher shaft 218 can pivot or angulate relative to the rack housing 234. In this way, in the event the elongate shaft 12 of the surgical device 100 bends or otherwise moves, the rack housing 234 does not bend or move with it. The drive rack 232 and the gear 230 therefore remain in alignment.

[0037] FIGS. 4-8 illustrate the components of the ball-and-socket joint 250 in more detail. As shown, the ball-and-socket joint 250 includes a spherical socket or spherical cavity 252 formed in a distal end 234d of the elongate rack housing 234 having the drive rack 232 formed on an external surface thereof, and a spherical ball 254 formed on a proximal end 218p of the knife pusher shaft 218. As shown in FIGS. 5 and 6, the spherical ball 254 is pivotally seated within the spherical cavity 252 such that the knife pusher shaft 218 can pivot or angulate relative to the rack housing 234.

[0038] FIG. 7 illustrates the spherical ball 254 on the knife pusher shaft 218 in more detail. As shown, the knife pusher shaft 218 has a generally elongate cylindrical or semi-cylindrical configuration such that the knife pusher shaft 218 is disposed at least partially around the closure tube 216. While not shown, the distal portion of the knife pusher shaft can be in the form of a fully enclosed cylindrical tube. The spherical ball 254 is formed on the proximal end 218p of the knife pusher shaft 218 and is fully cannulated to receive the closure tube 216 therethrough. In the illustrated embodiment, the spherical ball 254 is integrally formed with the knife pusher shaft 218. However, it will be appreciated that the spherical ball 254 can be formed on the knife pusher shaft 218 in any suitable manner, for example, it can be coupled to the knife pusher shaft 218.

[0039] The rack housing 234 is shown in more detail in FIG. 8. The drive rack 232 is formed along an external bottom surface 260 of the rack housing 234 such that the drive rack 232 faces and engages with the gear (e.g., gear 230 in FIGS. 2-4). The rack housing 234 has a generally elongate rectangular configuration with an elongate cavity 262 formed therethrough that receives the closure tube 216. The closure tube 216 thus extends through the knife pusher shaft 218 and the rack housing 234, as shown in FIGS. 5 and 6.

[0040] The spherical ball 254 formed on the proximal end 218p of the knife pusher shaft 218 and the spherical cavity 252 formed in the distal end 234d of the rack housing 234 can have any suitable size, but preferably the size is configured to allow free rotation of the knife pusher shaft 218 relative to the rack housing 234. The spherical cavity 252 can be formed on an inner wall of the cavity 262 in the rack housing 234 by forming concave seating surfaces within the inner wall,

as shown in FIGS. 6 and 8. The spherical cavity 252 is sized and shaped to pivotally receive therein the spherical ball 254.

[0041] The spherical cavity 252 and the spherical ball 254 of the ball-and-socket joint 250 are configured such that the knife pusher shaft 218 can be disposed at various angles with respect to the rack housing. At the same time, the fit between the knife pusher shaft 218 and the drive rack 232 can be sufficiently tight, without a slack. The configuration of the ball-and-socket joint 250 allows the knife pusher shaft 218 and the closure tube 216 to bend without affecting a position of the rack housing 234. In this way, because the drive rack 232 and the gear 230 remain aligned, the gear 230 can drive the drive rack 232 to push the knife pusher shaft 218 as intended. Bending of the knife pusher shaft 218 and the closure tube 216 does not affect the movement of the rack housing 234.

[0042] The devices disclosed herein can be designed to be disposed of after a single use, or they can be designed to be used multiple times. In either case, however, the device can be reconditioned for reuse after at least one use. Reconditioning can include any combination of the steps of disassembly of the device, followed by cleaning or replacement of particular pieces, and subsequent reassembly. In particular, the device can be disassembled, and any number of the particular pieces or parts of the device can be selectively replaced or removed in any combination. Upon cleaning and/or replacement of particular parts, the device can be reassembled for subsequent use either at a reconditioning facility, or by a surgical team immediately prior to a surgical procedure. Those skilled in the art will appreciate that reconditioning of a device can utilize a variety of techniques for disassembly, cleaning/replacement, and reassembly. Use of such techniques, and the resulting reconditioned device, are all within the scope of the present application.

[0043] Preferably, the devices and components described herein will be processed before use. First, a new or used instrument is obtained and if necessary cleaned. The instrument can then be sterilized. In one sterilization technique, the instrument is placed in a closed and sealed container, such as a plastic or TYVEK bag. The container and instrument are then placed in a field of radiation that can penetrate the container, such as gamma radiation, x-rays, or high-energy electrons. The radiation kills bacteria on the instrument and in the container. The

sterilized instrument can then be stored in the sterile container. The sealed container keeps the instrument sterile until it is opened in the medical facility.

[0044] It is preferred that device is sterilized. This can be done by any number of ways known to those skilled in the art including beta or gamma radiation, ethylene oxide, steam, and a liquid bath (e.g., cold soak). An exemplary embodiment of sterilizing a device including internal circuitry is described in more detail in U.S. Pat. Pub. No. 2009/0202387 filed February 8, 2008 and entitled "System And Method Of Sterilizing An Implantable Medical Device." It is preferred that device, if implanted, is hermetically sealed. This can be done by any number of ways known to those skilled in the art.

[0045] One skilled in the art will appreciate further features and advantages of the described devices and methods based on the above-described embodiments. Accordingly, the present disclosure is not to be limited by what has been particularly shown and described, except as indicated by the appended claims. All publications and references cited herein are expressly incorporated herein by reference in their entirety.

Claims:

1. A surgical device, comprising:

a handle having an elongate shaft extending distally therefrom;

an end effector at a distal end of the elongate shaft and having first and second jaws that are movable between an open configuration and a closed configuration in which the first and second jaws are configured to engage tissue therebetween;

a closure tube extending through the handle and the elongate shaft and configured to move the first and second jaws between the open configuration and the closed configuration;

a knife pusher shaft disposed at least partially around the closure tube and configured to move a cutting element through the first and second jaws for cutting tissue engaged therebetween; and

a rack coupled to the knife pusher shaft by a ball-and-socket joint such that the knife pusher shaft can pivot relative to the rack, wherein movement of the rack is effective to drive the knife pusher shaft and thereby move the cutting element through the first and second jaws.

2. The device of claim 1, further comprising a gear disposed within the handle and engaged with the rack for driving the rack.

3. The device of claim 1, wherein the rack is formed along an external surface of an elongate housing having a cylindrical cavity formed therethrough that receives the closure tube.

4. The device of claim 3, wherein the ball-and-socket joint comprises a spherical cavity formed in a distal end of the elongate housing, and a spherical ball formed on a proximal end of the knife pusher shaft and pivotally seated within the spherical cavity.

5. The device of claim 1, wherein the housing includes a stationary handle and a movable handle that is configured to pivot toward the stationary handle to move the closure tube proximally and thereby move the first and second jaws to the closed configuration.

6. A surgical device, comprising:

a handle having an elongate shaft extending distally therefrom and an end effector located on a distal end of the elongate shaft, the end effector including first and second jaws that

are movable between an open configuration and a closed configuration in which the first and second jaws are configured to engage tissue therebetween;

a jaw closure assembly extending through the handle and the elongate shaft and configured to move the first and second jaws between the open and closed positions; and

a cutting assembly extending through the handle and the elongate shaft and having a gear and a rack configured to drive a cutting element through the first and second jaws to cut tissue engaged between the jaws, wherein the cutting assembly includes a ball-and-socket joint located within the handle that prevents binding between the gear and rack.

7. The surgical device of claim 6, wherein the cutting assembly includes a knife pusher tube having a ball formed on a proximal end thereof, and wherein the rack is formed on a housing having a socket formed therein that seats the ball.

8. The surgical device of claim 7, wherein the jaw closure assembly includes a closure tube extending through the handle and the elongate shaft and configured to move the first and second jaws between the open configuration and the closed configuration, the closure tube extending through the knife pusher tube and the housing.

9. A method for treating tissue, comprising:

engaging tissue between first and second jaws of an end effector on a distal end of an elongate shaft of a surgical device; and

manipulating the surgical device to move the tissue, wherein a force applied to the elongate shaft causes a knife pusher shaft extending therethrough to pivot about a pivot joint relative to a rack housing disposed within the handle.

10. The method of claim 9, wherein the pivot joint comprises a ball-and-socket joint formed between the knife pusher shaft and the rack housing.

11. The method of claim 9, further comprising activating the surgical device to rotate a gear within the device, the gear driving the rack housing and the knife pusher coupled thereto to move a cutting element through the first and second jaws and thereby cut the tissue engaged therebetween.

12. The method of claim 9, wherein engaging tissue between the first and second jaws comprising moving a movable handle toward a stationary handle to move a jaw closure shaft proximally, the proximal movement of thejaw closure shaft causing the first and second jaws to approximate to engage the tissue.

13. The method of claim 12, wherein thejaw closure shaft moves proximally through the knife pusher shaft and the rack housing when the movable handle is moved toward the stationary handle.

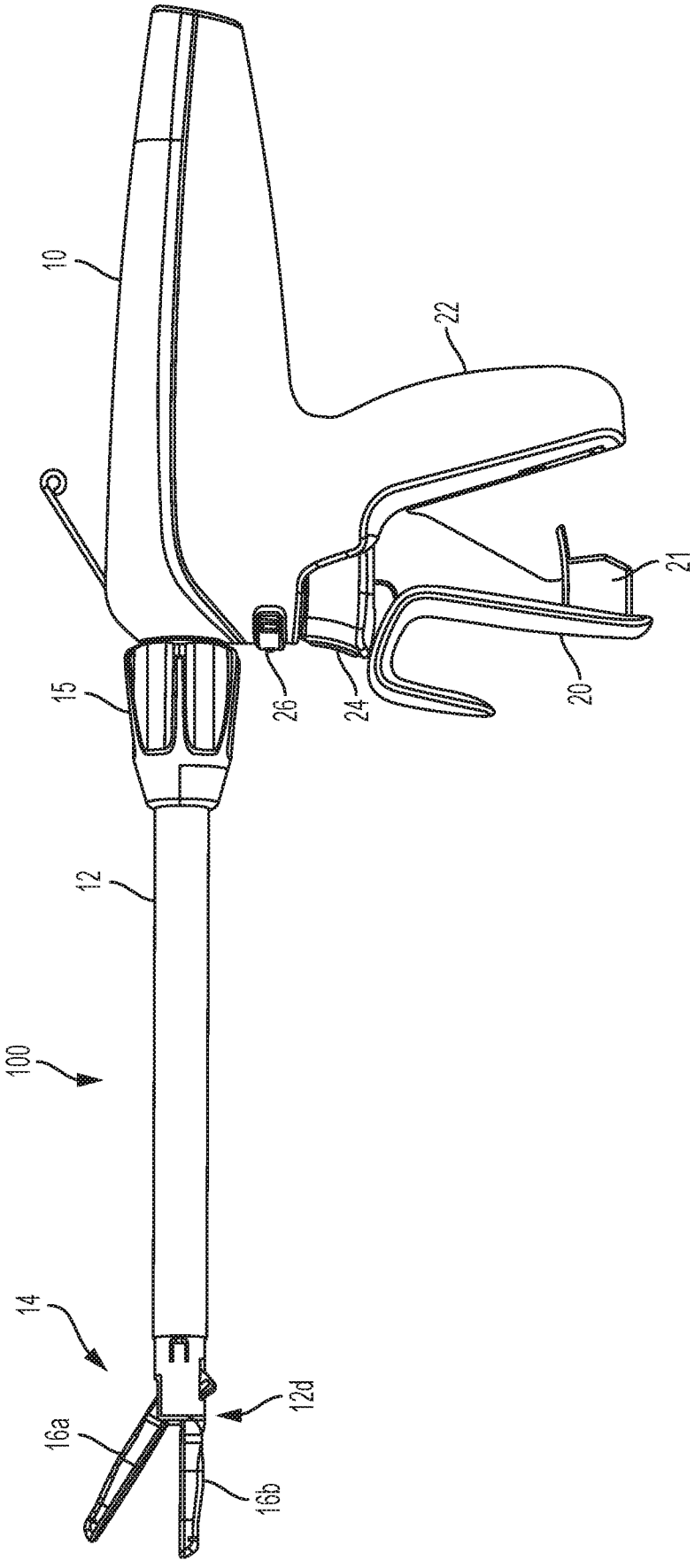

FIG. 1

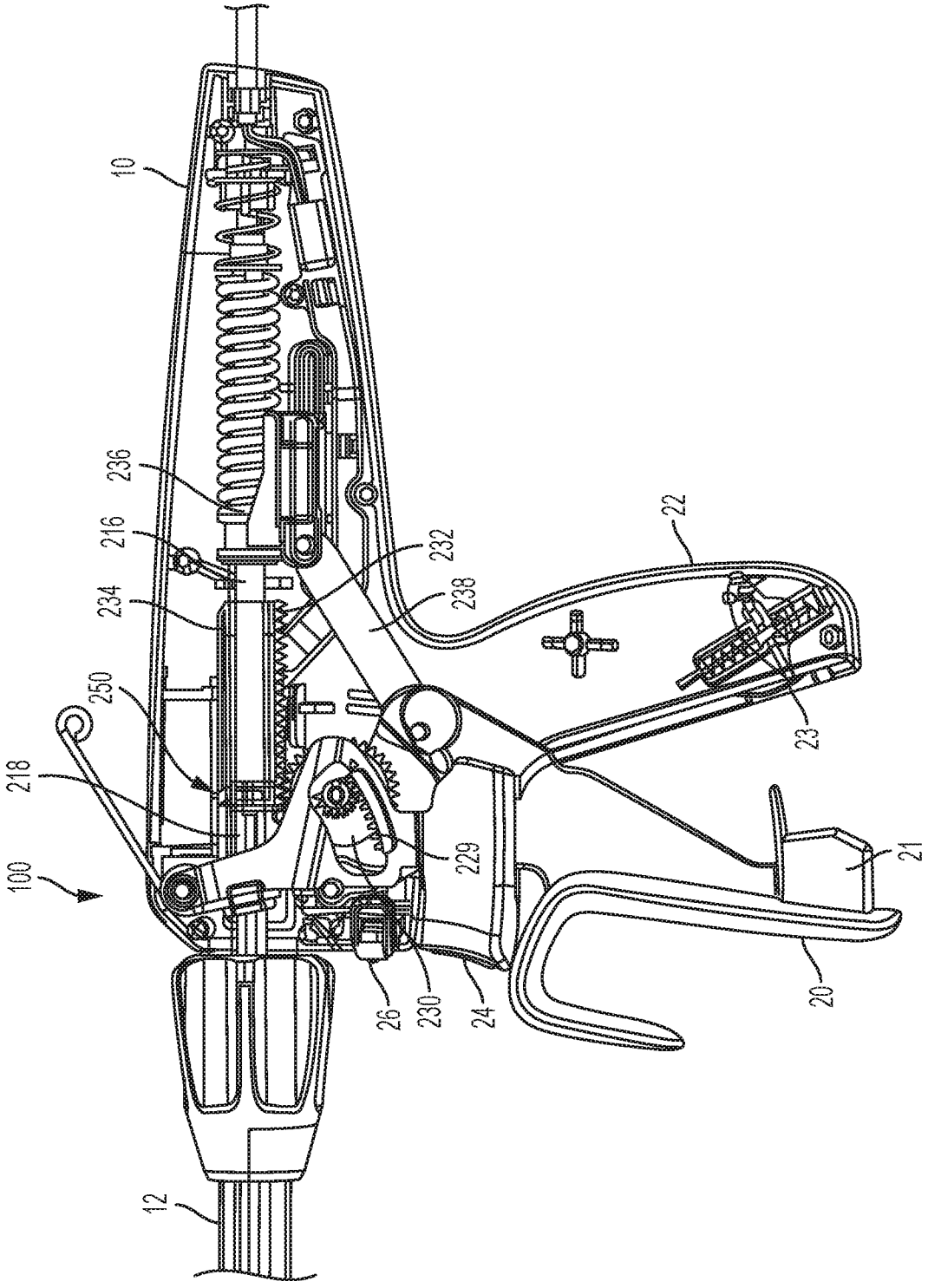

FIG. 2

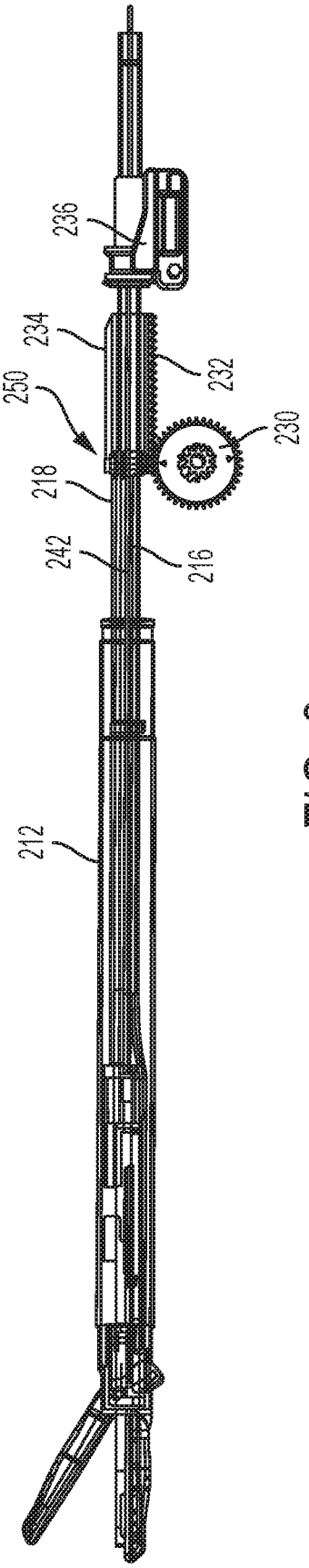

FIG. 3

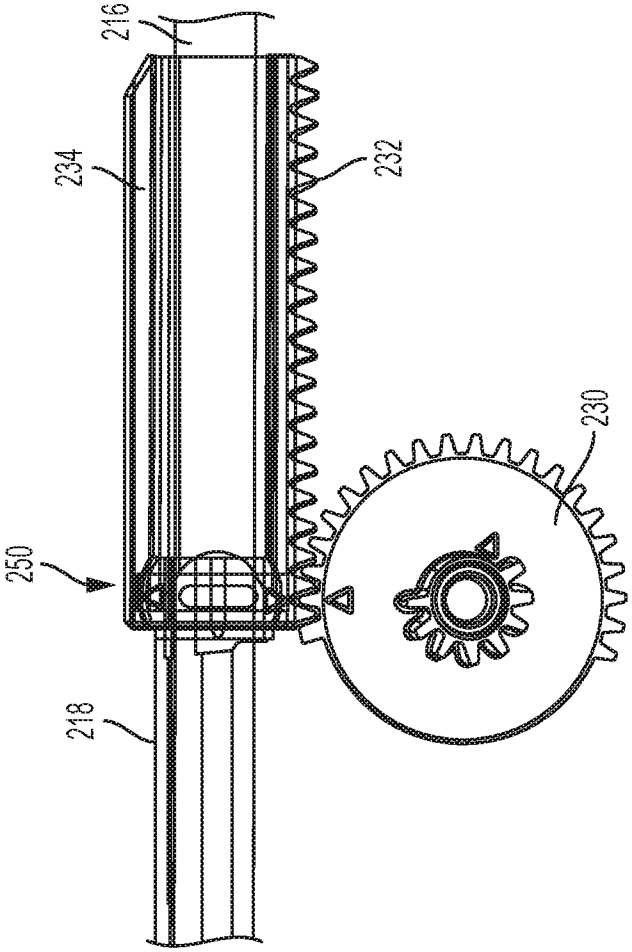

FIG. 4

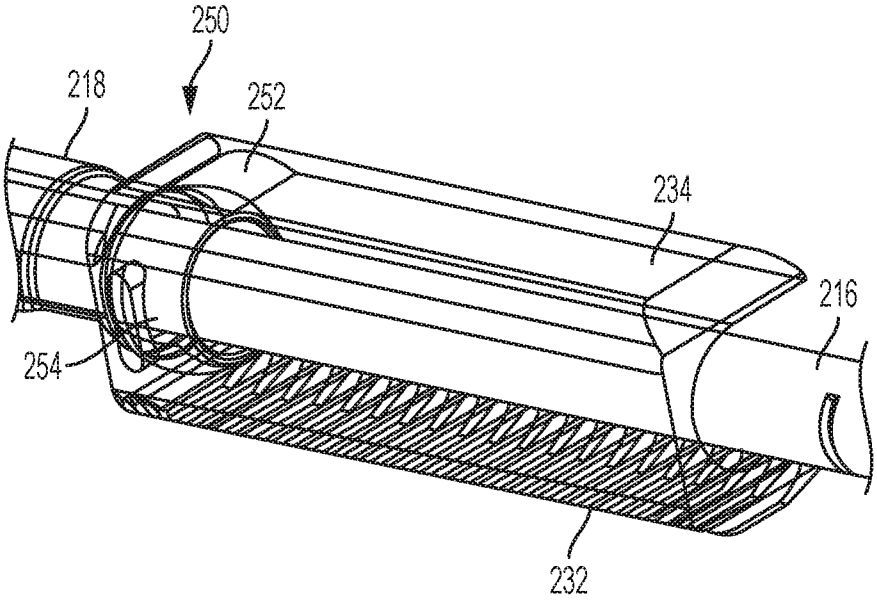
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FIG. 5

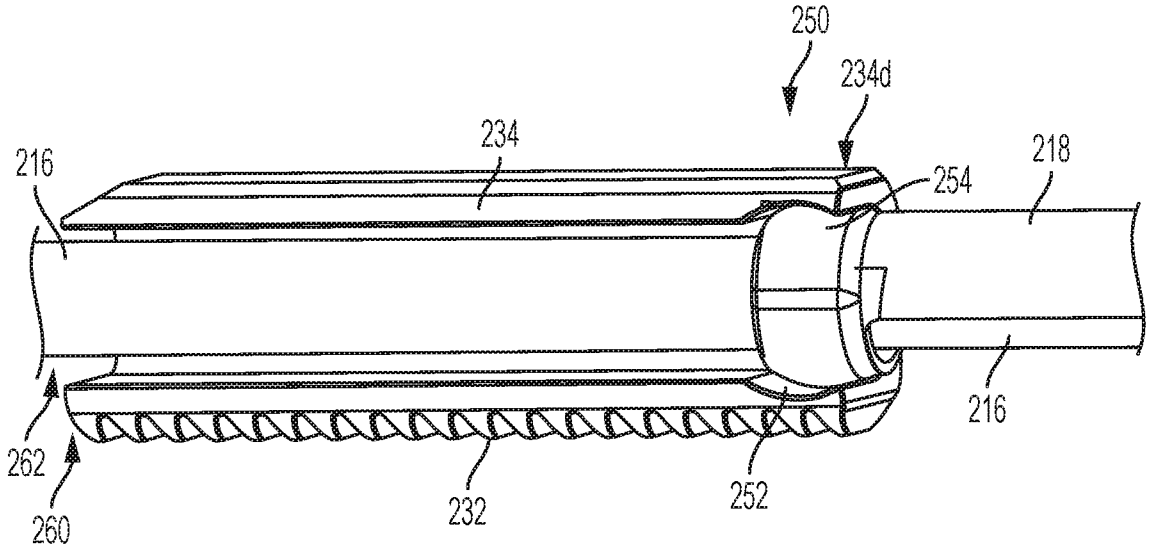
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FIG. 6

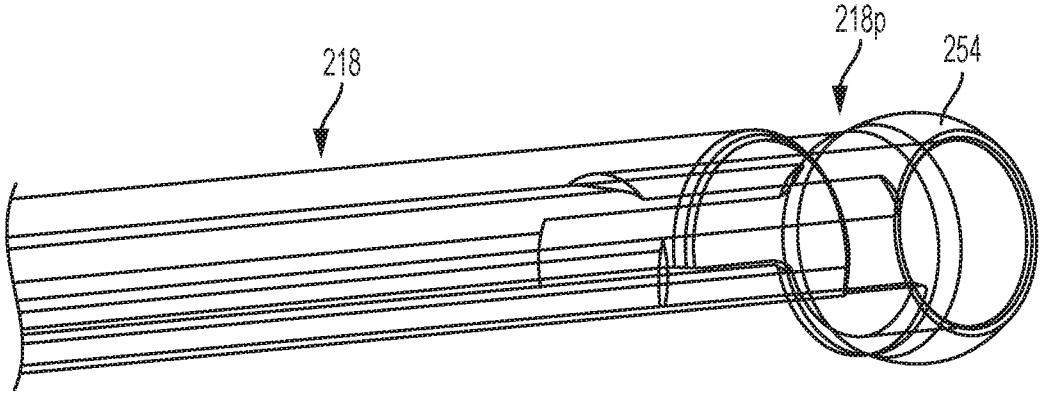

FIG. 7

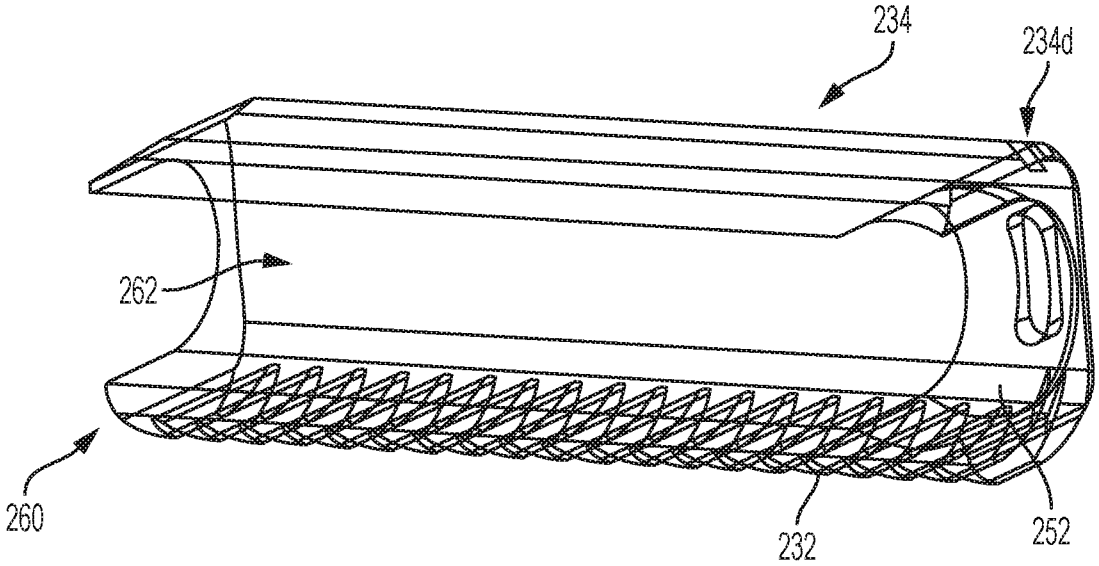

FIG. 8

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2016/060909

A. CLASSIFICATION OF SUBJECT MATTER
INV. A61B17/29 A61B17/295
ADD.

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

B. FIELDS SEARCHED

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

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

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

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2015/272660 Al (BOUDREAUX CHAD P [US] ET AL) 1 October 2015 (2015-10-01) figure 5 paragraph [0035] paragraph [0039] paragraph [0040]	1-5 , 7 , 8
A	W0 2015/069719 Al (ETHIC0N END0 SURGERY INC [US]) 14 May 2015 (2015-05-14) figures 1-26	1-5 , 7 , 8
X	US 2011/087208 Al (BOUDREAUX CHAD P [US] ET AL) 14 Apri l 2011 (2011-04-14)	6
Y	paragraph [0111] ; figure 4	1-5 , 7 , 8

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents :

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

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
23 February 2017	02/03/2017

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

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/06Q909

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

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

1. [X] Claims Nos.: 9-13
because they relate to subject matter not required to be searched by this Authority, namely:

Rule 39.1(iv) PCT - Method for treatment of the human or animal body by surgery

2. [ ] Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. [ ] Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

1. [ ] As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. [ ] As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. [ ] As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos. :

4. [ ] No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

[ ] The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

[ ] The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

[ ] No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/US2016/060909

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2015272660 A1	01-10-2015	NONE	
Wo 2015069719 A1	14--05 -2015	CN 105705103 A	22 -06 -2016
		EP 3065653 A1	14 -09 -2016
		US 2015133915 A1	14 -05 -2015
		Wo 2015069719 A1	14 -05 -2015
us 2011087208 A1	14--04 -2011	NONE	