US 20220304674A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2022/0304674 A1**

LITKE et al. (43) **Pub. Date: Sep. 29, 2022**

(54) **CUTTING DEVICES FOR SUTURING TOOLS AND RELATED SYSTEMS AND METHODS**

(71) Applicant: **INTUITIVE SURGICAL OPERATIONS, INC.**, Sunnyvale, CA (US)

(72) Inventors: **Ronald G. LITKE**, Sandy Hook, CT (US); **John F. GOODMAN**, Ann Arbor, MI (US); **Justin KROM**, Southington, CT (US); **Jake A. LUCKMAN**, Milford, CT (US); **Nathan VENSKYTIS**, Woodbridge, CT (US)

(73) Assignee: **INTUITIVE SURGICAL OPERATIONS, INC.**, Sunnyvale, CA (US)

(21) Appl. No.: **17/705,985**

(22) Filed: **Mar. 28, 2022**

Related U.S. Application Data

(60) Provisional application No. 63/167,278, filed on Mar. 29, 2021.

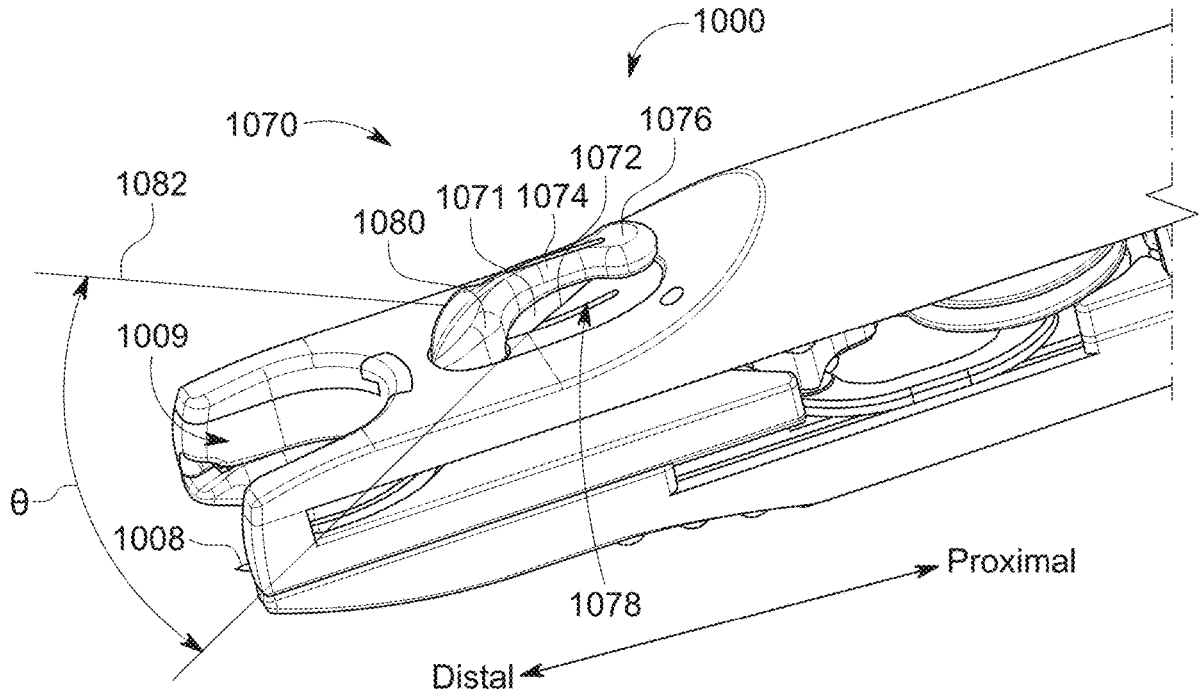
Publication Classification

(51) **Int. Cl.**
A61B 17/04 (2006.01)

(52) **U.S. Cl.**
CPC ***A61B 17/0467*** (2013.01); ***A61B 17/0491*** (2013.01); ***A61B 17/0483*** (2013.01); ***A61B 17/0482*** (2013.01)

(57) **ABSTRACT**

A needle driver device comprises an arcuate-shaped distal end portion defining an aperture opening at a distal end of the needle driver device and a cutting element disposed an exterior surface portion of the needle driver device. The cutting element is configured to cut suturing material. Devices, systems, and methods relate to cutting suturing material.



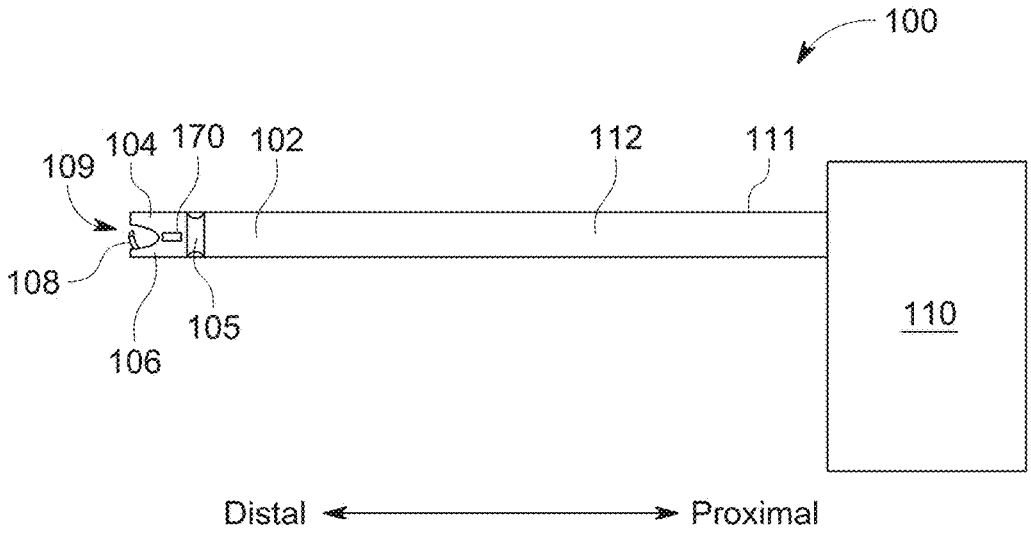

100
109
104
170
102
112
111
108
105
106
110
Distal
Proximal

FIG. 1

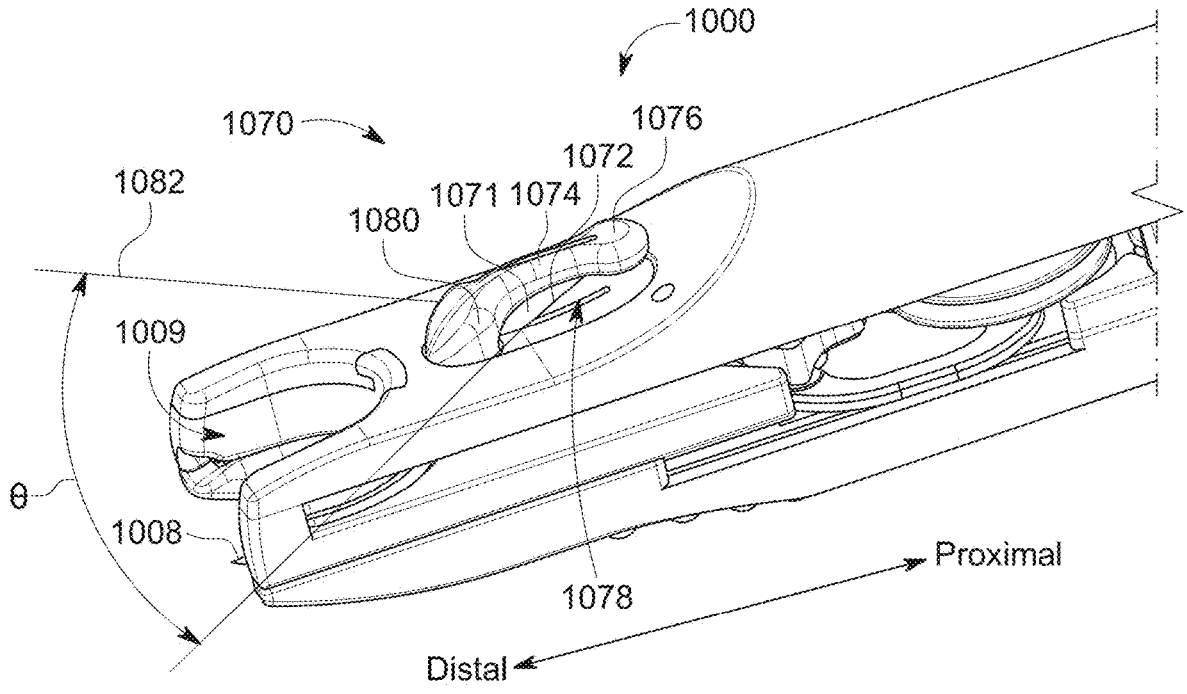

1000
1070
1076
1072
1082
1071
1074
1080
1009
θ
1008
1078
Proximal
Distal

FIG. 2

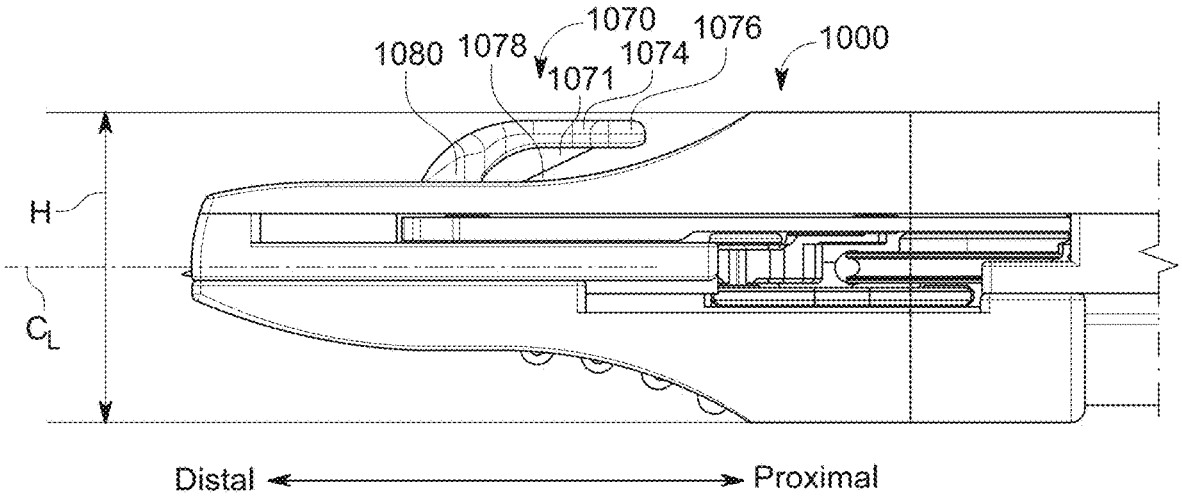

1080
1078
1070
1071
1074
1076
1000
H
C_L
Distal
Proximal

FIG. 3

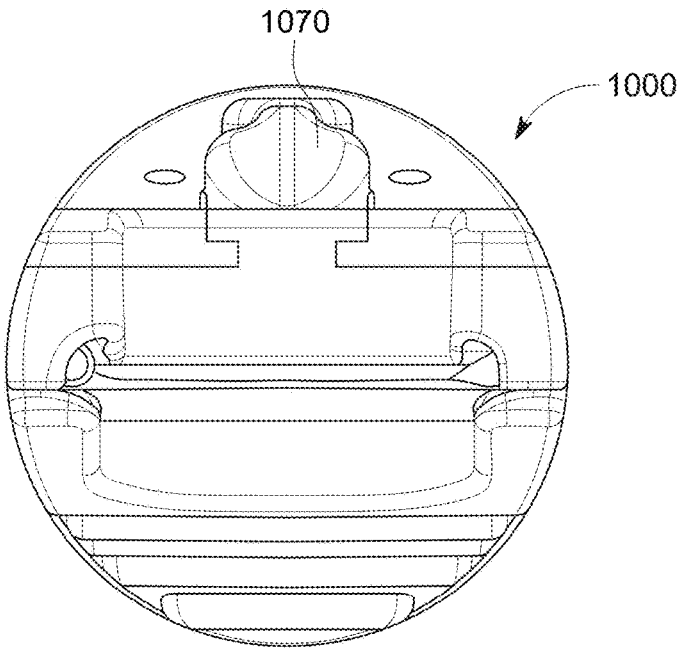

1070
1000

FIG. 4

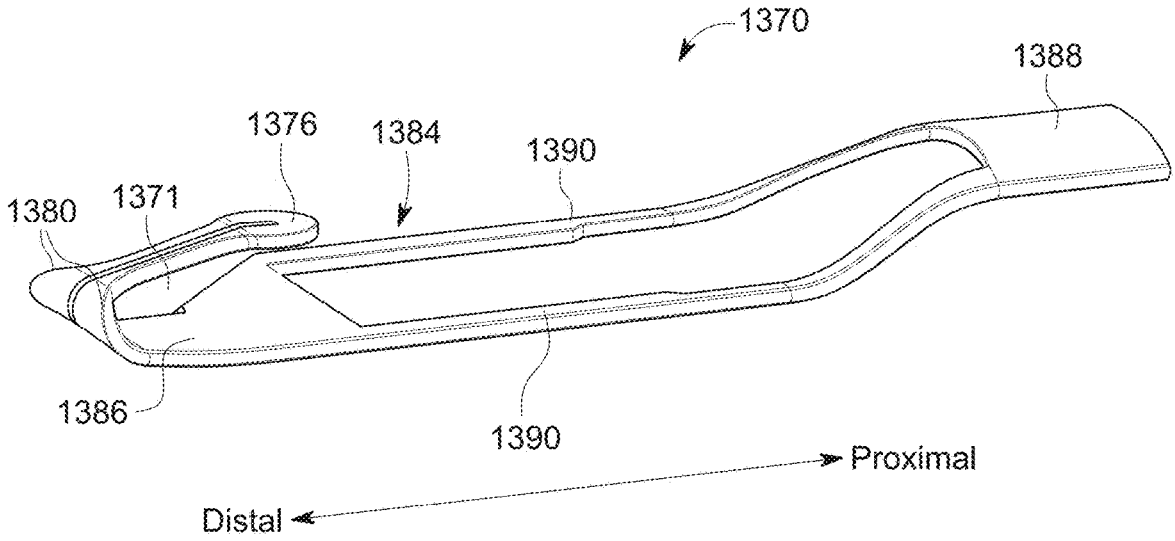

1370
1388
1376
1384
1390
1380
1371
1386
1390
Proximal
Distal

FIG. 5

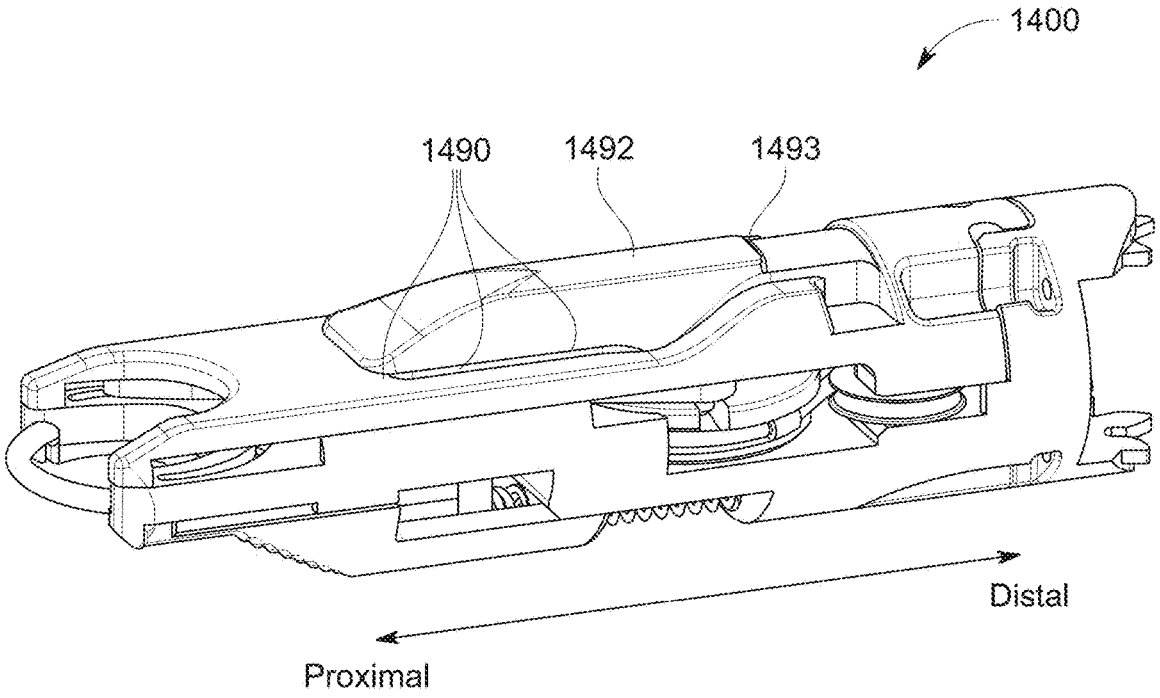

1400
1490
1492
1493
Distal
Proximal

FIG. 6

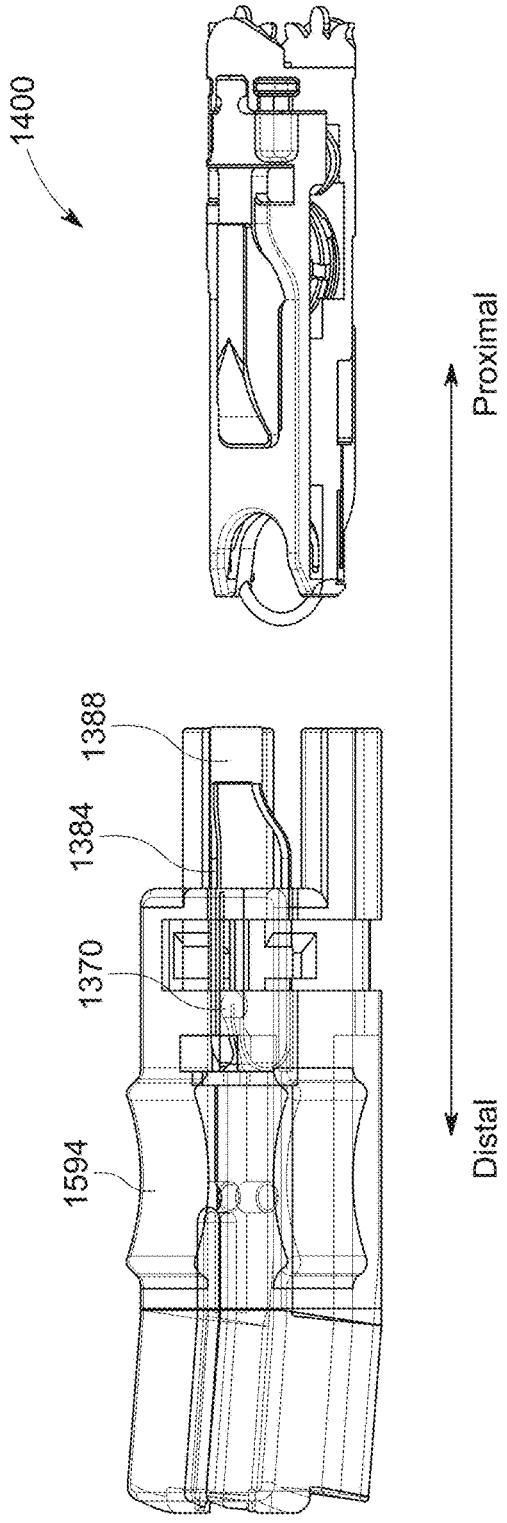

1400
1388
1384
1370
1594
Proximal
Distal

FIG. 7A

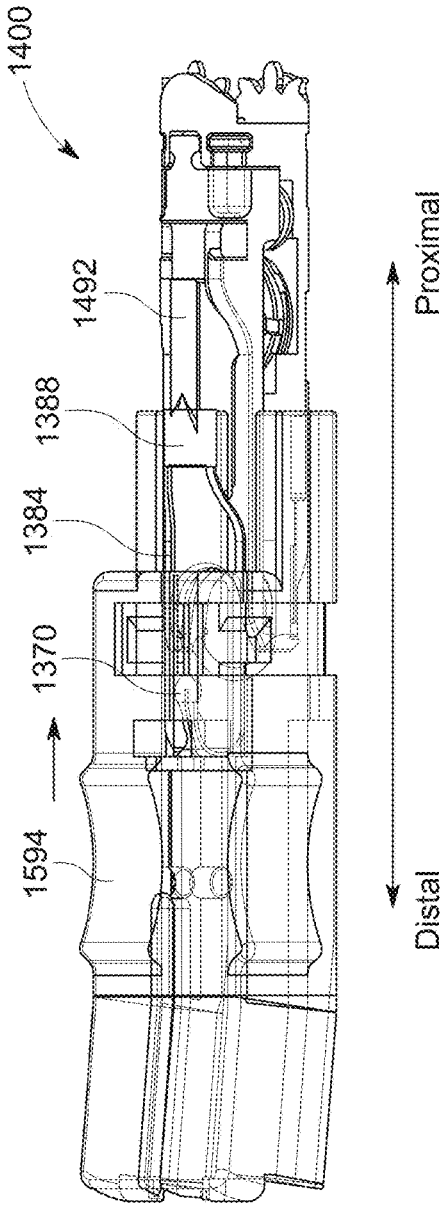

1400
1492
1388
1384
1370
1594
Proximal
Distal

FIG. 7B

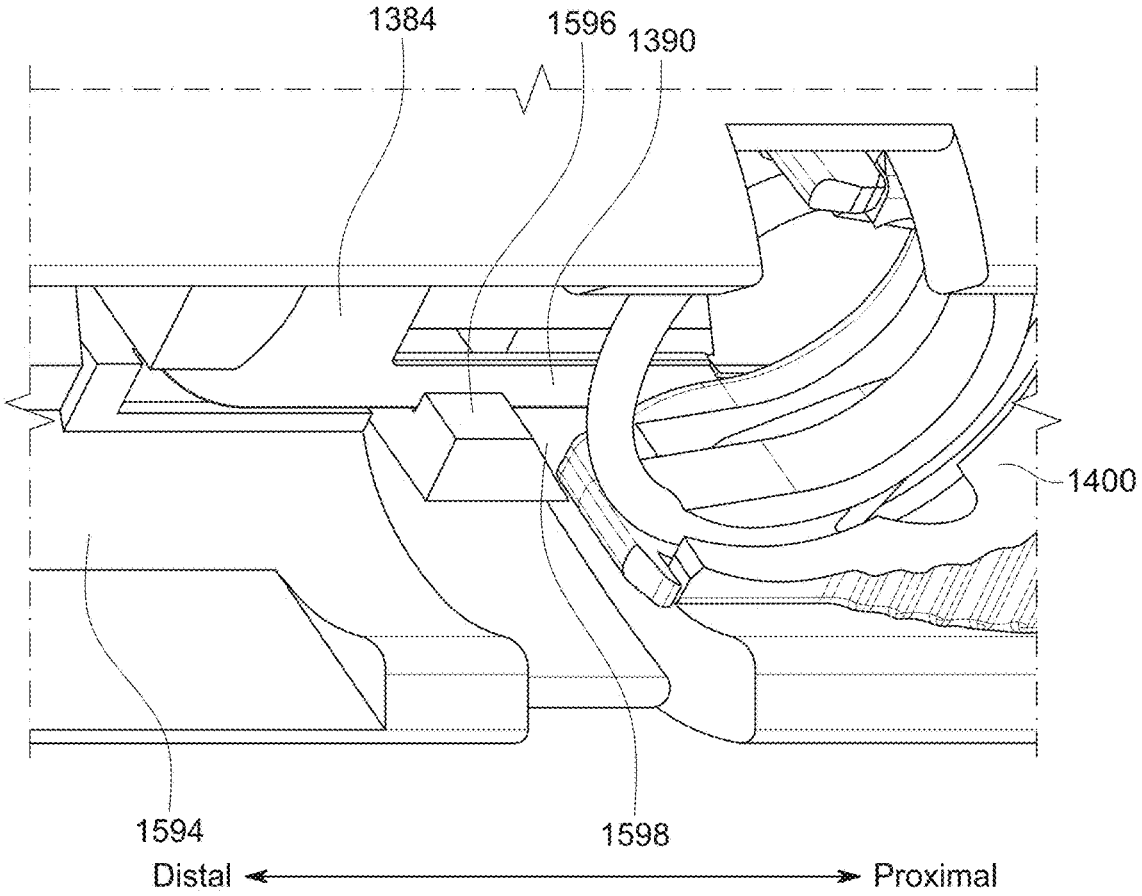

1384
1596
1390
1400
1594
1598
Distal
Proximal

FIG. 7C

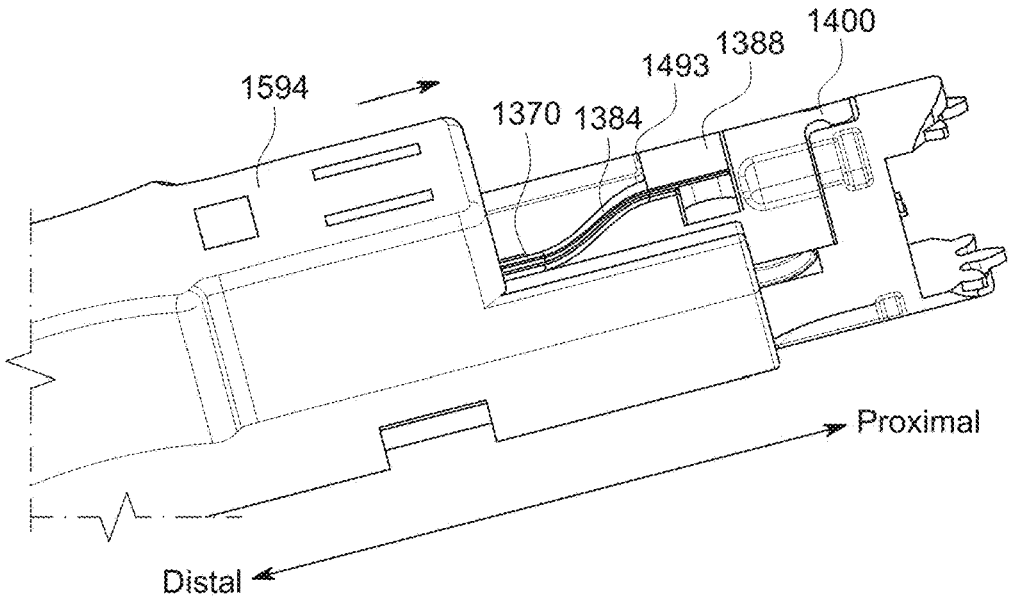

1400
1388
1493
1594
1370
1384
Proximal
Distal

FIG. 7D

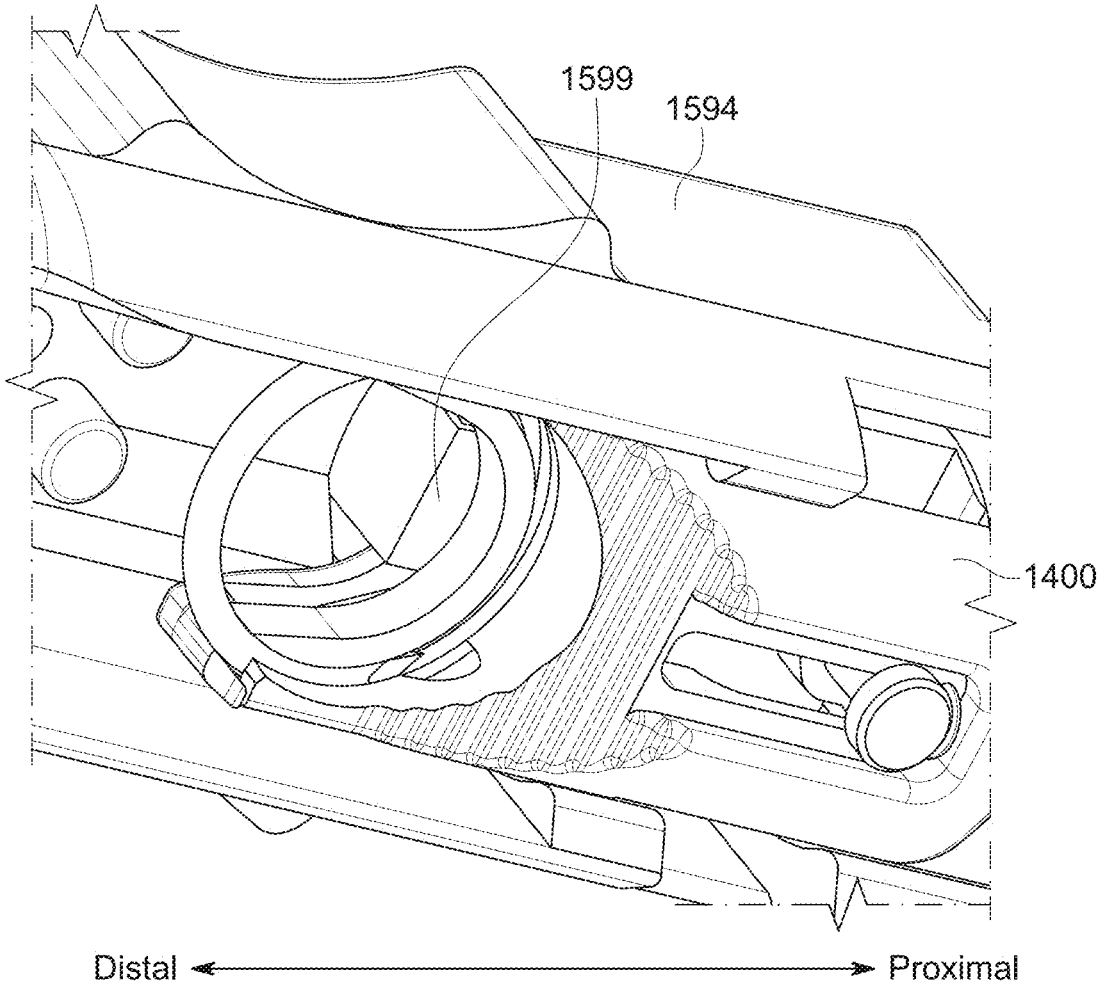


FIG. 7E

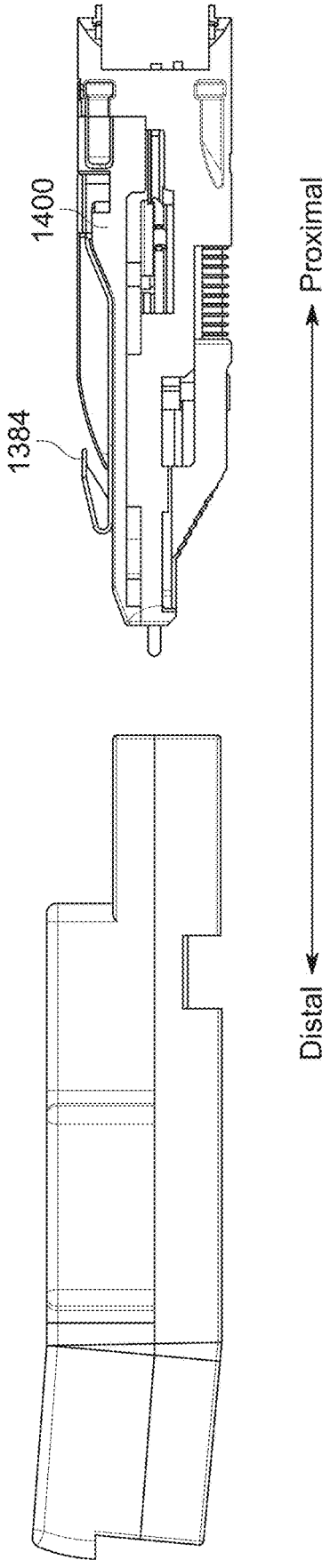


FIG. 7F

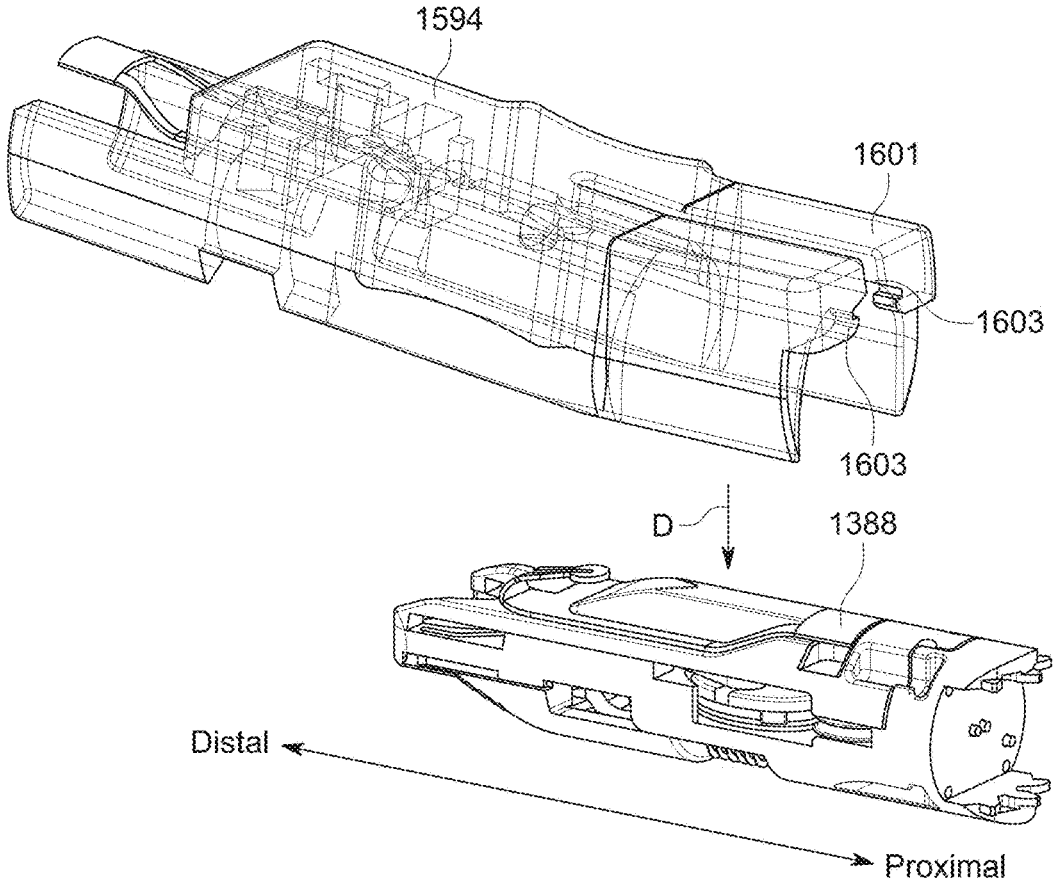

1594
1601
1603
1603
D
1388
Distal
Proximal

FIG. 8A

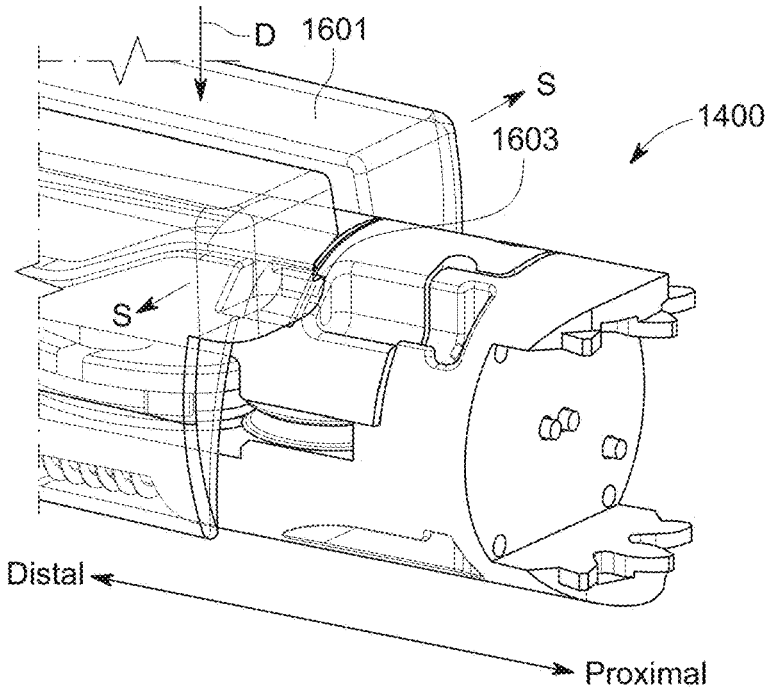

D
1601
S
1603
1400
S
Distal
Proximal

FIG. 8B

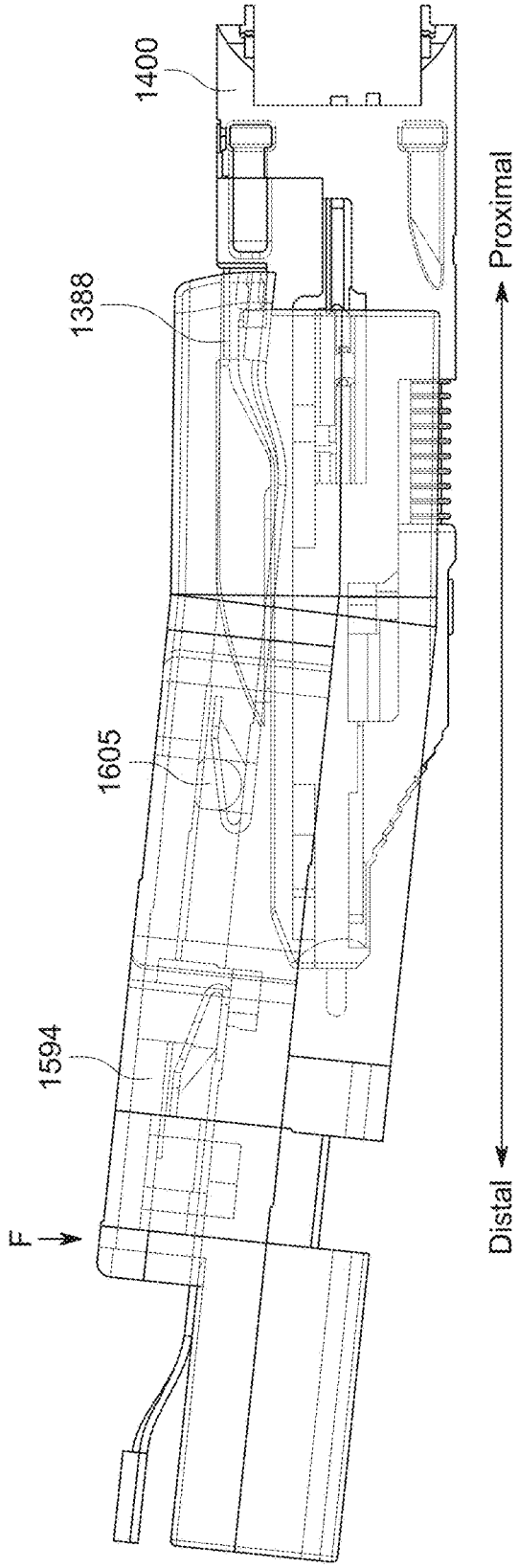

1400
1388
1605
1594
F
Proximal
Distal

FIG. 8C

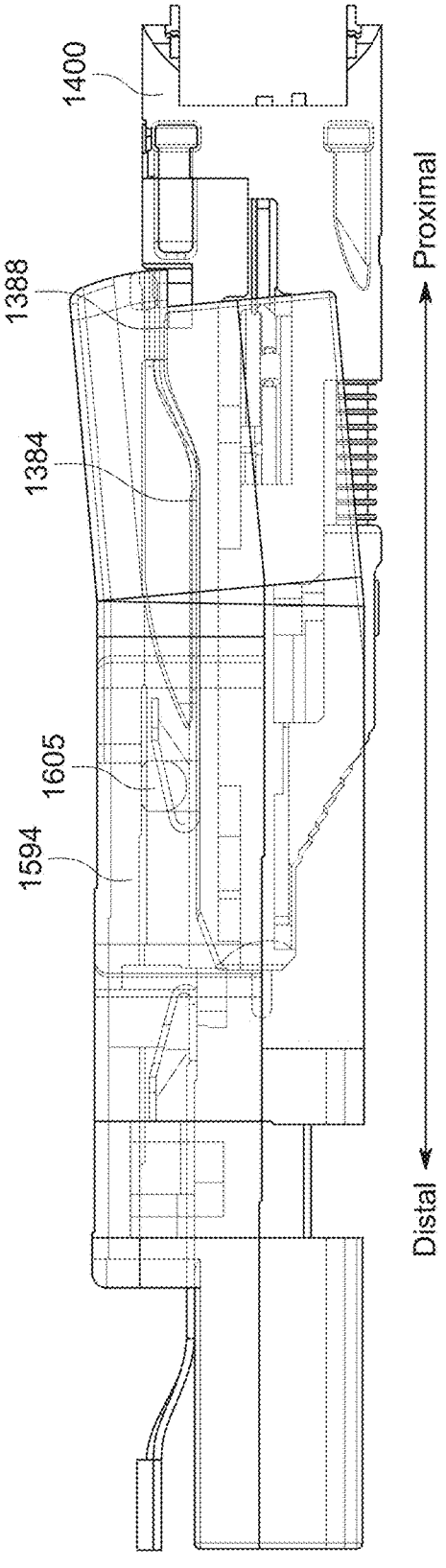

1400
1388
1384
1605
1594
Proximal
Distal

FIG. 8D

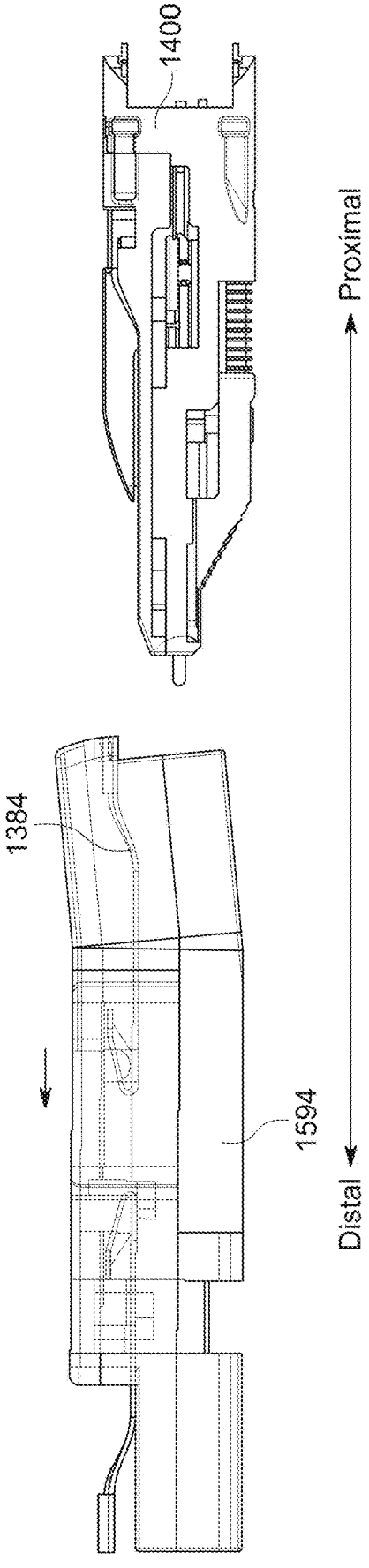


FIG. 8E

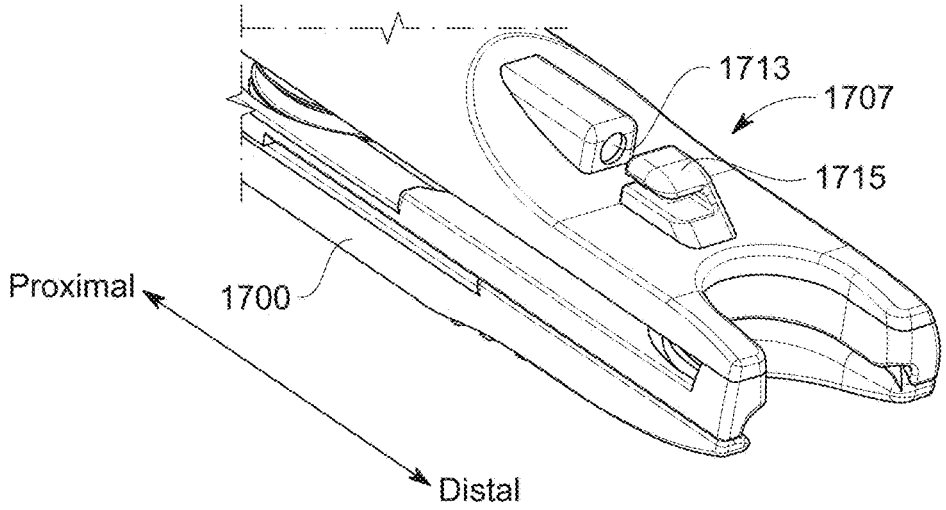


FIG. 9

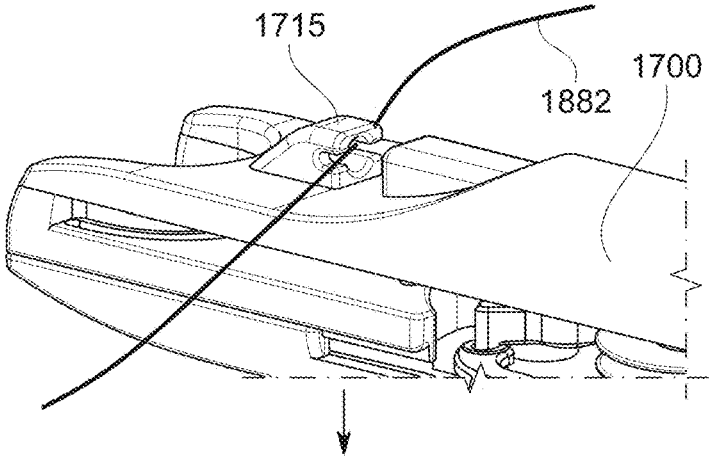


FIG. 10A

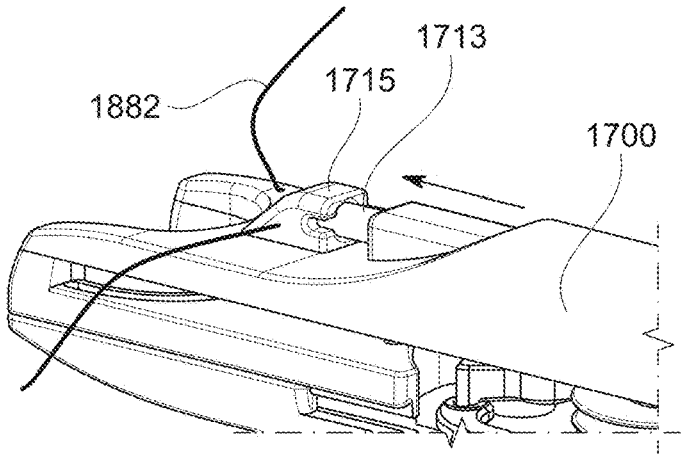


FIG. 10B

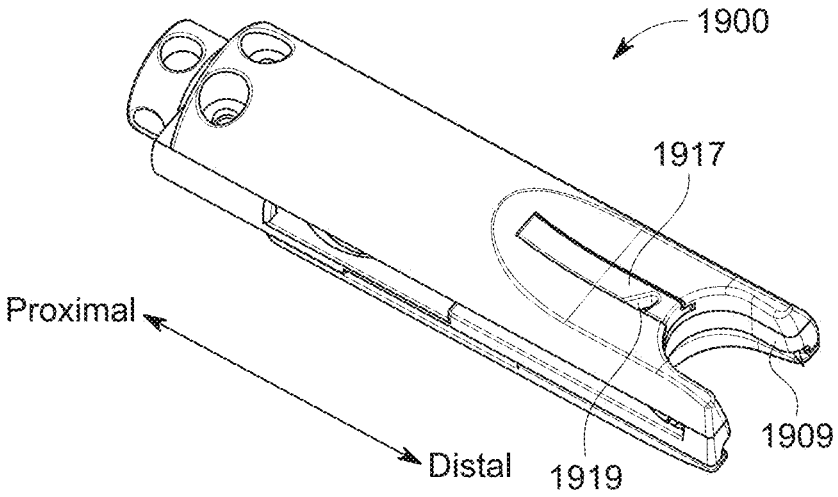


FIG. 11

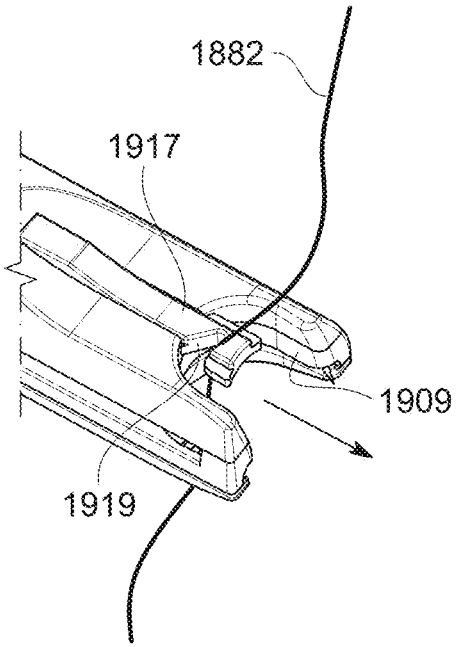


FIG. 12A

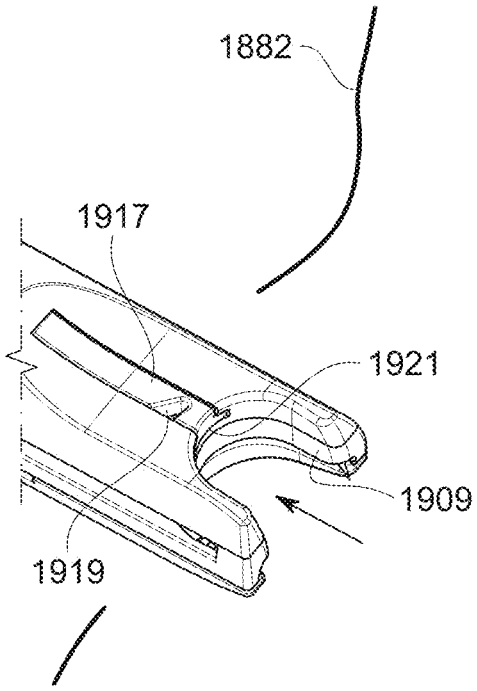


FIG. 12B

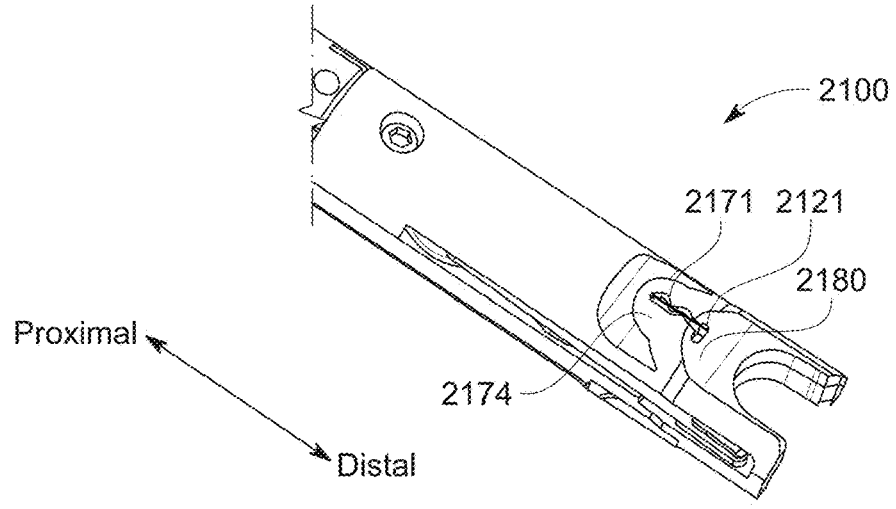


FIG. 13

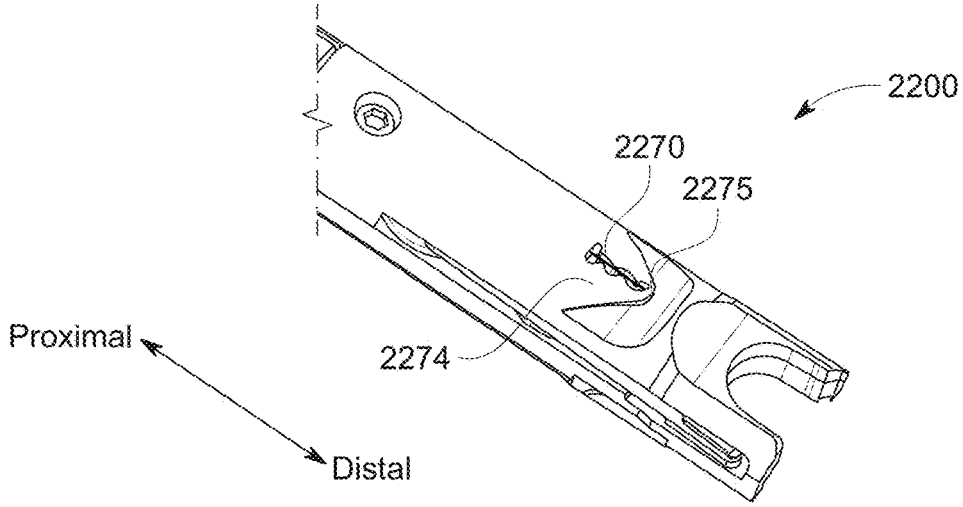


FIG. 14

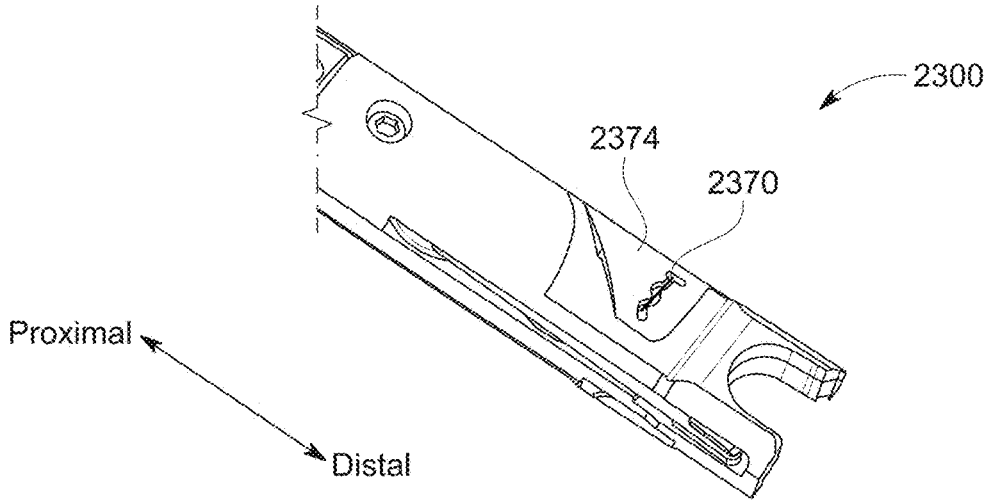


FIG. 15

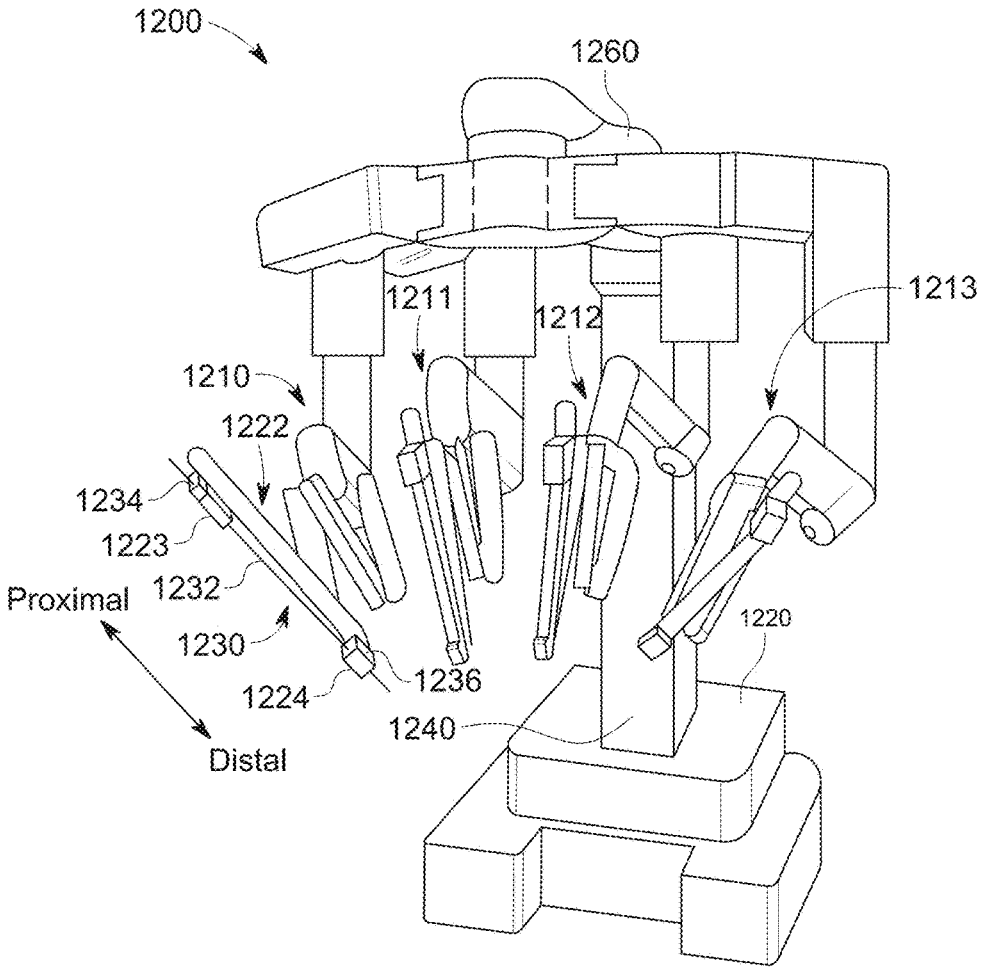

1200
1260
1211
1212
1213
1210
1222
1234
1223
1232
Proximal
1230
1224
1236
1240
Distal
1220

FIG. 16

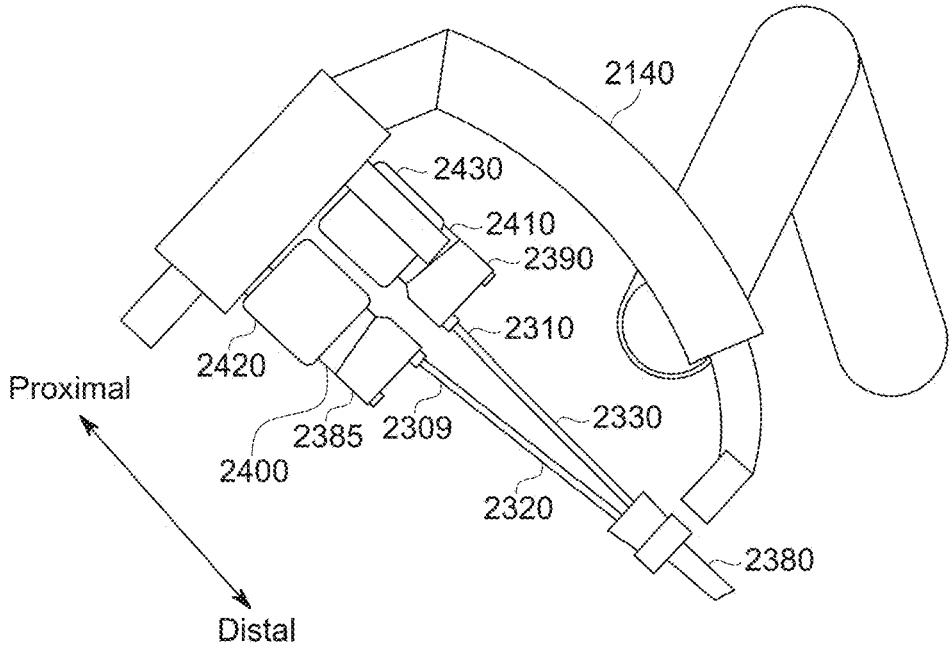

2140
2430
2410
2390
2310
2420
Proximal
2385
2309
2330
2400
2320
2380
Distal

FIG. 17

CUTTING DEVICES FOR SUTURING TOOLS AND RELATED SYSTEMS AND METHODS

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Application No. 63/167,728, filed Mar. 29, 2021, the entire contents of which is incorporated by reference in its entirety.

TECHNICAL FIELD

[0002] Aspects of the present disclosure relate to devices, systems, and methods for cutting suturing material. For example, aspects of the present disclosure relate to devices including, but not limited to, devices configured to cut suturing material during remote surgical, diagnostic, therapeutic, and other medical procedures. Further aspects of the disclosure relate to methods of operating such devices.

INTRODUCTION

[0003] Sutures are used in a variety of medical applications, such as closing ruptured or incised tissue, soft tissue attachment, attachment of grafts, etc. Additionally, sutures may have other medical and/or non-medical uses. Conventionally, suturing is accomplished by penetrating tissue with the sharpened tip of a suturing needle that has a thread of suturing material attached to the opposite blunt end of the needle. The needle is then pulled through the tissue, causing the attached thread of suturing material to follow the path of the needle. Typically, a knot is tied at the trailing end of the thread to anchor the first stitch. This action is performed repetitively with application of tension to the needle to pull a length of the thread through the tissue using subsequent stitches until the tissue is sutured as desired with one or more stitches. At the conclusion of a suturing procedure, any excess amount of suturing material may be trimmed from the amount remaining after the knot at the trailing end.

[0004] While the above-described suturing process can be performed manually, automated suturing systems have also been developed. For example, some systems include a needle driver device configured to draw suturing material through tissue segments, similar to the manual suturing procedure described above.

[0005] Some automated suturing procedures utilize an additional tool, such as graspers, to manipulate tissue and/or suturing material at the surgical site to assist the suturing procedure. In some cases, the grasping tool can be swapped for a cutting tool to trim the suturing material. However, swapping the grasping tool for a cutting tool can incur additional procedure time, and introduction of an additional tool is undesirable from a clinical standpoint. Further, particularly in situations in which multiple suture lines are being inserted in the same general surgical area, multiple tool swaps would be required over the course of the procedure, further adding to overall procedure time.

[0006] It is desirable when performing certain suturing procedures to provide needle driver devices that occupy a minimal amount of space relative to a size (e.g., gauge and/or radius) of the needle. Such needle-drive devices are useful in space-limited applications, such as in the case of minimally invasive medical procedures, for example laparoscopic surgery or computer-assisted surgery.

[0007] A need exists to provide needle driver devices with an overall relatively small working end. A need also exists to streamline workflow of a suturing procedure, including trimming excess suturing material at the conclusion of suture insertion and/or when the suturing procedures uses long lengths of suturing material with multiple tie-off points.

SUMMARY

[0008] Embodiments of the present disclosure may solve one or more of the above-mentioned problems and/or may demonstrate one or more of the above-mentioned desirable features. Other features and/or advantages may become apparent from the description that follows.

[0009] In accordance with at least one aspect of the present disclosure, a needle driver device comprises an arcuate-shaped distal end portion defining an aperture opening at a distal end of the needle driver device and a cutting element disposed an exterior surface portion of the needle driver device. The cutting element is configured to cut suturing material.

[0010] In yet another aspect of the present disclosure, a method of using a needle driver device comprising a cutting element comprises inserting the needle driver device to a site to perform a suturing procedure. The needle driver device comprises a cutting element carried at an exterior housing portion. The method further comprises driving a needle carrying suturing material through tissue to perform the suturing procedure and cutting excess suturing material using the cutting element.

[0011] Additional objects, features, and/or advantages will be set forth in part in the description which follows, and in part will be obvious from the description, or may be learned by practice of the present disclosure and/or claims. At least some of these objects and advantages may be realized and attained by the elements and combinations particularly pointed out in the appended claims.

[0012] It is to be understood that both the foregoing general description and the following detailed description are for example and explanatory only and are not restrictive of the claims; rather the claims should be entitled to their full breadth of scope, including equivalents.

BRIEF DESCRIPTION OF THE DRAWINGS

[0013] The present disclosure can be understood from the following detailed description, either alone or together with the accompanying drawings. The drawings are included to provide a further understanding of the present disclosure and are incorporated in and constitute a part of this specification. The drawings illustrate one or more embodiments of the present teachings and together with the description explain certain principles and operation. In the drawings,

[0014] FIG. **1** is a schematic, side view of an embodiment of a needle driver comprising a cutting element according to some embodiments of the present disclosure.

[0015] FIG. **2** is a perspective view of a distal end portion of a needle driver device comprising a cutting element according to some embodiments of the present disclosure.

[0016] FIG. **3** is a side view of the distal end portion of the needle driver device shown in FIG. **2**.

[0017] FIG. **4** is a distal end view of the distal end portion of the medical device shown in FIGS. **2** and **3**.

[0018] FIG. **5** is a perspective view of a cutting element and cutting element retainer according to some embodiments of the present disclosure.

[0019] FIG. **6** is a perspective view of a distal end portion of a needle driver device configured to receive the cutting element and retainer of FIG. **5**.

[0020] FIGS. **7**A-**7**F are various perspective views of the distal end portion of the needle driver device according to the embodiment of FIG. **6** and a cutting element retainer installation/removal tool according to some embodiments of the present disclosure showing a workflow for installing the cutting element retainer on the needle driver device.

[0021] FIGS. **8**A-**8**E are various perspective view of the distal end portion of the needle driver device according to the embodiment of FIG. **6** and the cutting element retainer installation/removal tool of FIGS. **7**A-**7**F showing a workflow for removing the cutting element retainer from the medical device.

[0022] FIG. **9** is a perspective view of a distal end portion of a needle driver device comprising a cutting element according to some embodiments of the present disclosure.

[0023] FIGS. **10**A and **10**B are perspective views of the distal end portion of the needle driver device of FIG. **9** cutting suturing material.

[0024] FIG. **11** is a perspective view of a distal end portion of a needle driver device comprising a cutting element according to some embodiments of the present disclosure.

[0025] FIGS. **12**A and **12**B are perspective views of the distal end portion of the needle driver device of FIG. **11** cutting suturing material.

[0026] FIGS. **13-15** are perspective views of distal end portions of needle driver devices comprising cutting elements according to some embodiments of the present disclosure.

[0027] FIG. **16** is a perspective view of a manipulator system according to some embodiments of the disclosure.

[0028] FIG. **17** is a partial schematic view of an embodiment of a manipulator system having a manipulator arm with two instruments in an installed position according to some embodiments of the present disclosure.

DETAILED DESCRIPTION

[0029] Automated suturing systems can have particular application in conjunction with minimally-invasive surgical procedures. Minimally-invasive surgical procedures involve the use of remotely-controlled surgical instruments including, for example, teleoperated surgical instruments (e.g., surgical instruments operated at least in part with computer assistance, such as instruments operated with robotic technology) as well as manually operated (e.g., laparoscopic, thoracoscopic) surgical instruments. During such procedures, a surgical instrument, which may extend through a cannula inserted into a patient's body, can be remotely manipulated to perform a procedure at a surgical site. For example, in a teleoperated surgical system, cannulas and surgical instruments can be mounted at manipulator arms of a patient side cart and can be remotely manipulated via teleoperation at a surgeon console.

[0030] Following insertion of sutures at a site of a medical or other procedure, such as surgery, excess suturing material may be trimmed from the inserted sutures. Often in order to do so, an additional tool, such as surgical shears, may be introduced to the surgical site, for example, together with or after withdrawal of a needle driver device for applying sutures. This approach of using an additional tool to trim the suturing material can be undesirable in that it requires introduction of an additional tool at the surgical site and can result in increased procedure times. This may be particularly true in applications using long lengths of suture with multiple tie-off points or with the need to cut multiple lengths of suturing material.

[0031] According to various embodiments of the present disclosure, an automated suturing device, such as a needle driver device or other suturing tool can include a cutting element which can be used to trim the suturing material during or at the conclusion of a suturing procedure. The cutting element can be positioned at or on an exterior surface portion (such as an exterior housing portion) of the end effector portion of the needle driver device, and may be positioned so that the cutting element is conveniently located to trim the suturing material without requiring the suturing device to be removed from the surgical workspace (e.g., without entirely removing the suturing device from the cannula or other access device). In some embodiments, the cutting element may optionally be positioned at a distal end portion of the end effector portion.

[0032] In various embodiments, the cutting element can be arranged, such as via its positioning and/or orientation, so as to avoid a cutting edge of cutting element inadvertently snagging or otherwise catching on tissue or material other than the desired suturing material. In some embodiments, a cutting edge of the cutting element is positioned facing generally in a proximal direction. Further, the cutting element can be positioned so that the cutting element is close to a longitudinal centerline of the end effector portion of the needle driver device. In some embodiments, the cutting edge can be provided with a shroud to help protect the cutting edge. These arrangements can ensure that the cutting edge does not cause any inadvertent contact to tissue and/or other material or surfaces, as the needle driver device is being used in a procedure, is handled by a user, and/or is inserted or removed through a cannula to or from a remote site of a suturing procedure.

[0033] In some embodiments, the cutting element can be integrated with the suturing device as a permanent part of the device. Alternatively, the cutting element can be part of a replaceable and removable structure fitted to the suturing device.

[0034] In some embodiments, the cutting element is a passive cutting mechanism fixed in position relative to the suturing device and configured to be used by tensioning suturing material against the cutting edge to cut the suturing material. Alternatively, in some embodiments, the cutting element is actively movable, and upon actuation, shears the suturing material. In embodiments with an actively movable cutting element, a cutting edge can be completely enclosed in a housing in a retracted position and extendable from the housing so as to be exposed to perform the cutting operation.

[0035] Referring now to FIG. **1**, a schematic, side view of a needle driver device **100** according to some embodiments of the disclosure is shown. The needle driver device **100** includes an end effector **104**, a shaft **112**, and a transmission mechanism **110**. The end effector **104** is located at a distal end portion **102** of the shaft **112**. The end effector **104** comprises an arcuate-shaped distal end portion **106** (e.g., generally C-shaped and following a circular arc), which is configured to receive and house a curved needle **108** (e.g., also generally C-shaped, a sharpened tip portion of which is illustrated). In some embodiments, the needle **108** may be removable from the distal end portion **106** (e.g., for cleaning and sterilization). In some embodiments, the needle **108** has

a curvature corresponding generally to the arc of the arcuate-shaped portion (e.g., generally C-shaped) of the end effector **104**. The transmission mechanism **110** is coupled to a proximal end portion **111** of the shaft **112**. The transmission mechanism **110** can be operably coupled with a computer-controlled (e.g., teleoperated) surgical manipulator system, such as the manipulator systems described in further detail below in connection with FIGS. **16** and **17**, and/or the transmission mechanism **110** can be manually controlled with manually operated (e.g., handheld) actuators (not shown). The end effector **104** can optionally be coupled to the shaft **112** by a joint structure **105**, such as a wrist, imparting one or more degrees of freedom to the end effector **104** relative to the shaft **112**.

[0036] Drive inputs received at the transmission mechanism **110**, whether through manual actuation or via a manipulator system, can actuate the end effector **104**, such as by driving the needle **108** around a path defined partly by the arcuate-shaped distal end portion **106**. The arcuate-shaped distal end portion **106** can face a distal direction of the end effector **104** and can define an opening or aperture **109**, which may serve as a tissue gap for suturing tissue. Movement of the needle **108** across the aperture **109** of the arcuate-shaped distal end portion **106** can be used to, for example, suture tissue or other materials positioned within or adjacent the aperture **109** of the distal end portion **106**. For example, the needle **108** may have a sharp or pointed leading portion that is configured to penetrate tissue or other material positioned in or adjacent the aperture **109**. In some example embodiments, the arcuate-shaped distal end portion **106** includes an arcuate-shaped needle track, as discussed further below, exhibiting a radius of curvature similar to a radius of curvature of the needle **108**, and the needle **108** rotates about a center of curvature of the arcuate-shaped track.

[0037] In the embodiment of FIG. **1**, the needle driver device **100** includes a cutting element **170** located at the end effector **104** of the needle driver device **100**. The cutting element **170** is configured to cut suture material. The cutting element **170** is located so as to be accessible during suturing of tissue or other material penetrated by the needle **108**, and to cut off excess suturing material following suturing. The cutting element **170** may be located on an exterior of the needle driver device **100** and may be located on any suitable location of the exterior. In some embodiments, the cutting element **170** may be located proximal to the aperture **109**. In other embodiments, the cutting element **170** may be located on the exterior of the needle driver device **100** at or near the aperture **109**. In some embodiments, the cutting element **170** may be positioned adjacent the distal end portion **106** of the end effector **104**. As discussed further herein, a preferred location of the cutting element may depend on a variety of factors, such as an overall size (e.g., diameter) of the needle driver device, an overall diameter of a needle of the needle driver device, and the resulting packaging constraints introduced by the relative size of the needle driver device and needle. The cutting element **170** can be a passive cutting element that passively cuts suturing material as discussed above or can be an active cutting element that shears the suturing material upon actuation of a movable cutting edge. Moreover, the cutting element can be integrated as part of the needle driver device **100** or can be removably attachable to the needle driver device **100**.

[0038] Referring now to FIGS. **2-4**, an end effector portion of a needle driver device **1000** is shown according to some embodiments. The needle driver device **1000** includes a reciprocating curved needle **1008** (the tip portion of which can be seen in FIG. **2**) configured to move across an aperture **1009** to suture tissue or other materials positioned adjacent the aperture **1009**. The needle driver device **1000** further includes a blade holder **1070** with a coupled blade **1071**. The blade holder **1070** is positioned on an exterior of the end effector portion of the needle driver device **1000**. The blade holder **1070** is located so as to be accessible during suturing of tissue or other material penetrated by the needle **1008**, and to cut off excess suturing material following suturing. In the embodiment in FIG. **2**, the blade holder **1070** is depicted as being proximal to the arcuate-shaped aperture **1009**. However, the disclosure is not limited thereto or thereby, and the blade holder **1070** may be located on any suitable portion of the exterior of the needle driver device **1000**. In some embodiments, the blade holder **1070** may be located on the exterior of the needle driver device **100** at or near the aperture **1009**. In some embodiments, the blade holder **1070** may be positioned adjacent a distal end of the end effector portion.

[0039] As noted above, the location of the blade holder **1070** and blade **1071**, or any of the cutting devices disclosed herein, can be chosen based on the overall size of the needle driver device (e.g., radial diameter of the device as required by a particular instrument/cannula system size, such as an 8 mm diameter system, 12 mm diameter system, 14 mm diameter system, or other size system) and the overall diameter of the needle relative to the overall size of the needle driver device. For example, the maximum depth of tissue penetration of which the needle driver device is capable can depend on an overall diameter of the needle (i.e., the diameter of a circular arc the needle traces during use). That is, a larger needle overall diameter can enable a greater depth of tissue penetration. It may be desired to maximize the overall diameter of the needle relative to the size of the needle driver device in order to enable a relatively greater depth of penetration capability for a given outside diameter of the needle driver device. As the needle overall diameter approaches the diameter of the needle driver device, there is less available room at the distal end of the needle driver device for other components, such as the blade holder **1070** and blade **1071**, or any of the cutting element devices disclosed herein. As such, to accommodate a larger sized curved needle at the distal end of the device, the blade holder **1070** and blade **1071** may be positioned proximal to the aperture **1009**.

[0040] Conversely, configuring a needle driver device with a needle having an overall diameter significantly less than the overall size (e.g., width or diameter) of the needle driver device could enable more components, e.g., including any of the cutting devices according to this disclosure, to be placed at or near the distal end of the needle driver device (e.g., adjacent the aperture **1009**).

[0041] Accordingly, positioning of the cutting device may involve a compromise between overall needle diameter relative to the needle driver device and providing the cutting device near the distal end of the needle driver device to facilitate trimming of the suture closer to the work site. In other words, a relatively proximal location of the cutting device can facilitate configuration of the needle driver device for a needle diameter approaching a radial diameter

of the needle driver device, thereby allowing for a relatively greater maximum possible tissue penetration depth for a given instrument size, such as an 8 mm instrument/cannula system, a 12 mm instrument/cannula system, 14 mm instrument/cannula system, or other size of system.

[0042] The blade **1071** can comprise a material suitable for forming a cutting edge **1072**. For example, the blade can comprise materials, such as, for example, stainless steel, hardened steel, titanium, or other metals, alloys, or nonmetal materials (e.g., composite materials, ceramic, glass, etc.). The cutting edge **1072** can be arranged on the needle driver device **1000** to protect the cutting edge **1072** from undesired contact with other components and materials during use, during handled by a user, and/or during insertion and/or removal of the needle driver device **1000** for a procedure.

[0043] For example, in the embodiments of FIGS. **2-4**, the cutting blade is arranged along a central axis of the end effector portion of the needle driver device **1000** extending between a proximal end and a distal end of the end effector portion (e.g., with a length of the cutting blade oriented approximately collinear with the central axis). The cutting edge **1072** of the blade **1071** is oriented (e.g., faces) towards a generally proximal direction. The blade holder **1070** includes a shroud **1074** partially covering the blade **1071**. The shroud **1074** has a widened, rounded proximal portion **1076** that is configured to deflect components and tissue from entering a throat area **1078** proximate the blade **1071**. Shoulders **1080** of the shroud **1074** located at a distal portion of the blade holder **1070** similarly deflect components and materials away from the blade **1071** to prevent such components and materials from inadvertently entering the throat area **1078**. The proximal portion **1076** of the blade holder **1070** forms a free end of the shroud **1074**. The shroud **1074** protrudes outwardly from the exterior of the needle driver device **1000** and extends in the proximal direction towards the free end of the proximal portion **1076**.

[0044] The overall profile of the shroud **1074** and blade **1071** can be configured such that they do not protrude beyond an overall exterior surface profile of the needle driver device **1000**. For example, as shown in FIG. **3**, which shows a partial side view of the needle driver device **1000** of FIG. **2**, the shroud **1074** does not extend beyond the largest overall height H dimension of the distal end portion of needle driver device **1000**. As is also apparent from FIG. **2**, the cutting edge **1072** of the blade **1071** is oriented in a generally proximal direction and extends from the exterior of the distal end portion of the needle driver device **1000** at an acute angle. However, in alternate embodiments, the cutting edge **1072** of the blade **1071** may be oriented in a generally distal direction. In yet other alternative embodiments, the cutting edge **1072** of the blade **1071** may be oriented at an angle with respect to a central or longitudinal axis of the of the end effector portion of the needle driver device **1000**. For example, the cutting the cutting edge **1072** may be oriented generally perpendicular to a longitudinal axis of the end effector portion of the needle driver device **1000**. Referring now to FIG. **4**, which shows an end view of the needle driver device **1000** of FIG. **2**, the blade holder **1070** including the shroud **1074** is within the largest external surface profile of the needle driver device **1000**.

[0045] Referring again to FIG. **2**, to trim excess suturing material **1082**, the needle driver device **1000** and/or the excess suturing material **1082** can be moved relative to one another (e.g., rotated, withdrawn, advanced, etc.) until the excess suturing material **1082** is positioned within the throat area **1078**. Once the excess suturing material **1082** is in the desired position in the throat area, the needle driver device **1000** and/or the suturing material **1082** can be moved relative to one another (e.g., the needle driver device **1000** being moved in the proximal direction relative to the excess suturing material **1082** and/or the excess suturing material **1082** being moved in the distal direction) such that the excess suturing material is tensioned against and cut through by the cutting edge **1072**.

[0046] The effectiveness of the cutting edge **1072** in cutting the excess suturing material **1082** can depend, at least in part, on the angle at which the excess suturing material **1082** contacts the cutting edge **1072**. Stated another way, the excess suturing material **1082** must be pulled over the cutting edge **1072** at a relatively sharp acute angle to improve (e.g., maximize) the effectiveness of the cutting action. For example, in FIG. **2**, the angle θ is equal to 90 degrees or less. To achieve this, the shoulders **1080** may be configured such that an angle formed between the cutting edge **1072** and an outermost profile of the shoulders **1080** matches the desired angle for the excess suturing material **1082**. In other words, the shoulders **1080** may be configured and positioned so as to not interfere with the excess suturing material **1082** obtaining the desired angle θ for cutting effectiveness.

[0047] In the embodiment of FIGS. **2-4**, the cutting element is permanently fixed to and integrated with the needle driver device **1000**. However, in some applications, it may be desired to provide a cutting element that is removably attachable to a needle driver device. Such a removeable cutting element can facilitate replacement, e.g., of a dull cutting blade, without having to replace the entire needle drive device. In various embodiments, a removably attachable cutting element can be relatively simply installed and removed from the needle driver device without the use of separate attachment mechanisms, such as, for example, screws, clips, and the like. In this manner, field attachment and removal of the cutting element may be facilitated.

[0048] Referring now to FIGS. **5** and **6**, a needle driver device that is configured to be fitted with a removably attachable cutting element is shown according to some embodiments. FIG. **5** shows a removably attachable cutting element **1370** that includes a blade **1371** and a blade retainer **1384** that can be installed on and removed from the needle driver device **1400** of FIG. **6**. The blade **1371** can be attached to the blade retainer **1384** by, e.g., welding, crimping, or other attachment methods, or may be formed integrally with the blade retainer **1384**, e.g., through molding or stamping. In some embodiments, the blade **1371** can be removably attached to the blade retainer **1384**. The blade retainer **1384** comprises a blade mount portion **1386** and a retention tab **1388** coupled to one another by one or more rails **1390**. When multiple rails **1390** are present, they may run parallel to one another and generally parallel to a longitudinal axis of the end effector of the needle driver device when coupled. The rails curve upward away from a plane in which the rails **1390** generally lie in the orientation of FIG. **5** to the location at which they couple to the retention tab **1388**. The blade mount portion **1386** can be similar to the shroud **1074** discussed in connection with the embodiment of FIGS. **2-4**, in that the blade mount portion **1386** has a rounded proximal end portion **1376** and shoulders **1380** extending outwardly

over the blade **1371**, all of which help to protect the blade **1371** from contacting tissue or other material or surfaces, as has been described above.

[0049] Referring now to FIG. **6**, the needle driver device **1400** is shown without the removably attachable cutting element **1370** of FIG. **5** so as to better show various features that interact with the cutting element **1370** to couple the cutting element to the needle driver device **1400**. The needle driver device **1400** has an undercut portion **1490** that receives a portion of the blade mount portion **1386** and the rails **1390**. The needle driver device **1400** further has a ridge portion **1492**, a proximal end of which has a proximally-facing registration surface **1493** configured to engage the retention tab **1388** of the blade retainer **1384** to hold the blade retainer **1384** and coupled cutting element **1370** on the needle driver device **1400**.

[0050] In some embodiments, a tool may be used to install and/or remove the blade retainer **1384** from the needle driver device **1400**. For example, FIGS. **7**A-**7**F show how an installation/removal tool **1594** can be used install the cutting element **1370**. In FIG. **7**A, the cutting element **1370** is held within the tool **1594**, and the tool **1594** is advanced proximally toward and over the distal end portion of the needle driver device **1400**, as shown in FIG. **7**B. The retention tab **1388** of the blade retainer **1384** flexes slightly upward over the ridge portion **1492** of the needle driver device **1400** as the blade retainer **1384** moves proximally over the needle driver device **1400**.

[0051] FIG. **7**C shows a view of the needle driver device **1400** and tool **1594** from beneath (i.e., from the side of the needle driver device **1400** opposite the side shown in FIG. **7**A). The tool **1594** includes lateral tabs **1596** that are engaged with the rails **1390** to releasably couple the blade retainer **1384** with the tool **1594** until installation of the blade retainer **1384** with the needle driver device **1400**. As the tool **1594** is advanced proximally over the end effector portion of the needle driver device **1400**, ramps **1598** on the lateral tabs **1596** bear against the needle driver device **1400** and the lateral tabs **1596** are deflected outward relative to the rails **1390** such that the rails engage the undercut portion **1490**. Continued movement of the tool **1594** proximally over the needle driver device **1400** brings the retention tab **1388** of the blade retainer **1384** over the proximally-facing registration surface **1493**, and the blade retainer **1384** snaps into place as shown in FIG. **7**D, with the retention tab **1388** engaged against the proximally-facing registration surface **1493** as the lateral tabs **1596** release from the rails **1390**.

[0052] Referring now to FIG. **7**E, which shows a view similar to FIG. **7**C, as the blade retainer **1384** (FIG. **7**D) seats within the undercut portion **1490** (FIG. **6**) and the retention tab **1388** (FIG. **7**D) engages the proximally-facing registration surface **1493** (FIG. **7**D), a distal tab **1599** disengages the blade mount portion **1386** (FIG. **5**) of the blade retainer **1384**. The tool **1594** can then be pulled distally from the needle driver device **1400**, leaving the cutting element **1370** installed on the needle driver device **1400** as shown in FIG. **8**F. Use of the needle driver device **1400**, and cutting element **1370**, can then proceed as discussed above in connection with the embodiment of FIGS. **2**-**4**, such as by manipulating the needle driver device **1400** as needed to cut excess suturing material with cutting element **1370**.

[0053] To remove the cutting element **1370** from the needle driver device **1400**, a removal end **1601** of the tool **1594** opposite the installation side can be advanced over the needle driver device **1400** in direction D, as shown in FIGS. **8**A and **8**B. The removal end **1601** of the tool **1594** includes proximal removal tabs **1603** (only one of which is visible in FIG. **8**B) that, as shown in FIG. **8**B, deflect around the retention tab **1388** as indicated by directional arrows S and engage the retention tab **1388** from underneath as the tool **1594** is pushed down over the needle driver device **1400** in direction D. The tool **1594** is rocked downward from the configuration shown in FIG. **8**C to the configuration shown in FIG. **8**D by a downward force F, which pulls the retention tab **1388** up and over the proximally-facing registration surface **1493** (FIG. **6**), releasing the blade retainer **1384** from engagement with the needle driver device **1400**. Distal removal tabs **1605** engage the blade mount portion **1386** of the blade retainer **1384**, and the tool **1594** is pulled from the needle driver device **1400** as shown in FIG. **8**E with the blade retainer **1384** held by proximal removal tabs **1603** and distal removal tabs **1605**.

[0054] As noted above, the embodiments of FIGS. **2**-**4** and **5**-**8** are passive cutting elements in which cutting the suturing material is accomplished by relative motion between the needle driver device and the suturing material while the blade of the cutting element remains stationary relative to the needle drive device. In some embodiments of the present disclosure, active cutting elements are contemplated. Such active cutting elements are actuatable to move a cutting blade relative to the needle driver device in order access and cut suturing material. Such active cutting mechanisms can comprise shears, punches, anvils, and other various other actuatable cutting mechanisms. The active cutting mechanisms can be actuated by an actuator through the transmission mechanism (e.g., transmission mechanism **110**) and a drive member that extends through a shaft of the instrument, or by other actuation components, such as other mechanical, electromechanical, hydraulic, pneumatic, or other actuation systems controlled manually or as part of a computer-assisted surgical system, such as the surgical systems disclosed in connection with FIGS. **16** and **17**. The suturing material can be placed in the active cutting mechanism by, e.g., manipulating the position of the instrument of which the active cutting element forms a part, and/or by manipulating the suturing material directly, such as with a separate grasper instrument.

[0055] Referring now to FIG. **9**, a needle driver device end effector portion **1700** with an active cutting element **1707** is shown according to some embodiments. The active cutting element **1707** is positioned at the needle driver device end effector portion **1700** in a location similar to that described above with reference to the embodiment of FIGS. **2** and **3**. The active cutting element **1707** includes a movable element (e.g., pin) **1713** and an anvil **1715**. The anvil **1715** is stationary with respect to the housing of the needle driver device **1700** and the movable element **1713** is actuatable to move relative to the needle drive device housing. The movable element **1713** and/or the anvil **1715** can comprise a hardened material such as stainless steel or may comprise another metal or nonmetal material.

[0056] Referring now to FIGS. **10**A and **10**B, to cut excess suturing material **1882**, the needle driver device end effector portion **1700** and/or the suturing material is manipulated until the excess suturing material **1882** is brought against the proximal-facing side of the anvil **1715**, as shown in FIG. **10**A. The movable element **1713** is actuated and moves distally to the anvil **1715** to reach an extended position as

shown in FIG. **10**B. The excess suturing material **1882** is sheared between the moveable element **1713** and the anvil **1715**, as shown in FIG. **10**B. One or both of the movable element **1713** and the anvil **1715** may include cutting edges configured to shear the excess suturing material **1882** between the movable element **1713** and the anvil **1715**.

[0057] FIGS. **11**, **12**A, and **12**B show another example embodiment of an active cutting element. Referring to FIG. **11**, a needle driver device **1900** includes a movable element **1917** (e.g., a translating plunger) comprising notch **1919** extending from a lateral side of the movable element **1917**. In the view of FIG. **11**, the movable element **1917** is in a retracted position. To trim excess suturing material **1882**, the movable element **1917** is extended distally to the fully extended position shown in FIG. **12**A, so that the notch **1919** is exposed within the arcuate-shaped aperture **1909** of the needle driver device **1900**. The suturing material **1882** is placed within the notch **1919**, e.g., by manipulating the needle driver device **1900** and/or the suturing material **1882**. Once the suturing material **1882** is placed in the notch **1919**, the movable element **1917** is retracted proximally, and the suturing material **1882** is cut between an edge of the movable element **1917** within the notch and a cutting edge **1921** located on the needle driver device **1900** adjacent the movable element **1917**, as shown in FIG. **12**B. Positioning the movable element **1917** within the aperture **1909** can facilitate trimming the excess suturing material because the excess suturing material **1882** may be located within the aperture **1909** due to the action of the needle driver device, and thus require little manipulation of the needle driver device to position the excess suturing material **1882** within the notch **1919**. While in the embodiment of FIGS. **11**, **12**A, and **12**B, the cutting edge **1921** is located within the aperture **1909** adjacent the movable element **1917**, in other example embodiments, the cutting edge may alternatively be positioned on in the notch **1919** of the movable element **1917**, or each location can include a separate cutting element.

[0058] Referring now to FIGS. **13-15**, additional configurations of passive cutting elements that are integrated with a needle drive device are shown. Referring to FIG. **13**, a needle driver device **2100** includes a slot **2121** configured to hold a blade **2171** (e.g., similar to blade **1071** in FIG. **2**). The general location and orientation of the blade **2171** is similar to that disclosed in connection with FIG. **2**. However, in FIG. **13**, a blade shroud **2174** comprises shoulders **2180** wider than the shoulders **1080** to further protect other components of the surgical system from contact with the blade **2171**. Similar to the example embodiment of FIG. **2**, in the embodiment of FIG. **13**, excess suturing material must be positioned behind the blade shroud **2174**, and the needle driver device **2100** moved proximally relative to the suturing material to cut the suturing material with the blade **2171**.

[0059] FIG. **14** shows a needle driver device **2200** in which a cutting element is positioned facing generally distally. The needle driver device **2200** comprises a blade **2270** received in a blade shroud **2274**, the blade shroud **2274** comprising a free end **2275** oriented in a distal direction. To trim excess suturing material, the excess suturing material is positioned underneath the blade shroud **2274** and adjacent the blade **2270**, and the needle driver device **2200** is moved distally relative to the suturing material to cut the excess suturing material. The orientation of FIG. **14** can facilitate insertion and removal of the device **2200** through, e.g., a cannula, by preventing interference between the blade **2270** and/or blade shroud **2274** and other components, such as a cannula seal.

[0060] FIG. **15** shows another needle driver device **2300**, in which the cutting element is positioned such that a cutting edge of a blade **2370** is positioned perpendicular to a longitudinal axis of the needle driver device **2300**. A blade shroud **2374** extends in a direction perpendicular to the longitudinal axis of the needle driver device **2300**. To trim excess suturing material, the excess suturing material is positioned behind the blade shroud **2374** and adjacent the blade **2370**, and the needle driver device **2300** is rotated or moved laterally to cut the excess suturing material.

[0061] Embodiments of cutting elements according to the example embodiments of FIGS. **2-15** herein can be included with needle driver devices, e.g., any of the devices disclosed in connection with U.S. patent application Ser. No. 17/118,746 (filed Dec. 11, 2020) titled NEEDLE DRIVER DEVICES AND RELATED SYSTEMS AND METHODS, U.S. Provisional Patent Application No. [UNFILED—ATTORNEY DOCKET NO. P06395-US-PRV] titled DEVICES, SYSTEMS, AND METHODS FOR PERFORMING SUTURING PROCEDURES, or other devices. Additionally, cutting elements as disclosed herein in the embodiments of FIGS. **2-15** can be included on other medical devices, such as other needle driver devices including those configured to insert sutures using straight needles, or other medical devices such as manual suturing instruments.

[0062] Embodiments described herein may be used, for example, with remotely operated, computer-assisted systems (such, for example, teleoperated surgical systems) such as those described in, for example, U.S. Pat. No. 9,358,074 (filed May 31, 2013) to Schena et al., entitled "Multi-Port Surgical Robotic System Architecture", U.S. Pat. No. 9,295,524 (filed May 31, 2013) to Schena et al., entitled "Redundant Axis and Degree of Freedom for Hardware-Constrained Remote Center Robotic Manipulator", and U.S. Pat. No. 8,852,208 (filed Aug. 12, 2010) to Gomez et al., entitled "Surgical System Instrument Mounting", each of which is hereby incorporated by reference in its entirety. Further, embodiments described herein may be used, for example, with a da Vinci® Surgical System, such as the da Vinci Si® Surgical System, da Vinci X® Surgical System, the da Vinci Xi® Surgical System, all with or without Single-Site® single orifice surgery technology, or the daVinci SP® Surgical System, all commercialized by Intuitive Surgical, Inc., of Sunnyvale, Calif.

[0063] The embodiments described herein are not limited to the surgical systems noted above, and various other teleoperated, computer-assisted surgical system configurations may be used with the embodiments described herein. Further, although various embodiments described herein are discussed in connection with a manipulating system of a teleoperated surgical system, the present disclosure is not limited to use with a teleoperated surgical system. Various embodiments described herein can optionally be used in conjunction with hand-held, manual instruments.

[0064] As discussed above, in accordance with various embodiments, surgical instruments of the present disclosure are configured for use in teleoperated, computer-assisted surgical systems employing robotic technology (sometimes referred to as robotic surgical systems). Referring now to FIG. **16**, an embodiment of a manipulator system **1200** of a

computer-assisted surgical system, to which surgical instruments are configured to be mounted for use, is shown. Such a surgical system may further include a user control system, such as a surgeon console (not shown) for receiving input from a user to control instruments coupled to the manipulator system **1200**, as well as an auxiliary system, such as auxiliary systems associated with the da Vinci® systems noted above.

[0065] As shown in the embodiment of FIG. **16**, a manipulator system **1200** includes a base **1220**, a main column **1240**, and a main boom **1260** connected to main column **1240**. Manipulator system **1200** also includes a plurality of manipulator arms **1210**, **1211**, **1212**, **1213**, which are each connected to main boom **1260**. Manipulator arms **1210**, **1211**, **1212**, **1213** each include an instrument mount portion **1222** to which an instrument **1230** may be mounted, which is illustrated as being attached to manipulator arm **1210**. While the manipulator system **1200** of FIG. **16** is shown and described having a main boom **1260** to which the plurality of manipulator arms are coupled and supported thereby, in other embodiments, the plurality of manipulator arms can be coupled and supported by other structures, such as an operating table, a ceiling, wall, or floor of an operating room, etc.

[0066] Instrument mount portion **1222** comprises a drive assembly **1223** and a cannula mount **1224**, with a transmission mechanism **1234** (which may generally correspond to the transmission mechanism **110** discussed in connection with FIG. **1**) of the instrument **1230** connecting with the drive assembly **1223**, according to an embodiment. Cannula mount **1224** is configured to hold a cannula **1236** through which a shaft **1232** of instrument **1230** may extend to a surgery site during a surgical procedure. Drive assembly **1223** contains a variety of drive and other mechanisms that are controlled to respond to input commands at the surgeon console and transmit forces to the transmission mechanism **1234** to actuate the instrument **1230**. Although the embodiment of FIG. **16** shows an instrument **1230** attached to only manipulator arm **1210** for ease of viewing, an instrument may be attached to any and each of manipulator arms **1210**, **1211**, **1212**, **1213**.

[0067] Other configurations of surgical systems, such as surgical systems configured for single-port surgery, are also contemplated. For example, with reference now to FIG. **17**, a portion of an embodiment of a manipulator arm **2140** of a manipulator system with two surgical instruments **2309**, **2310** in an installed position is shown. The surgical instruments **2309**, **2310** can generally correspond to instruments discussed above, such as needle driver device **100** disclosed in connection with FIG. **1**. For example, the embodiments described herein may be used with a DA VINCI SP® Surgical System, commercialized by Intuitive Surgical, Inc. of Sunnyvale, Calif. The schematic illustration of FIG. **17** depicts only two surgical instruments for simplicity, but more than two surgical instruments may be mounted in an installed position at a manipulator system as those having ordinary skill in the art are familiar with. Each surgical instrument **2309**, **2310** includes a shaft **2320**, **2330** that at a distal end has a moveable end effector or an endoscope, camera, or other sensing device, and may or may not include a wrist mechanism (not shown) to control the movement of the distal end.

[0068] In the embodiment of FIG. **17**, the distal end portions of the surgical instruments **2309**, **2310** are received through a single port structure **2380** to be introduced into the patient. As shown, the port structure includes a cannula and an instrument entry guide inserted into the cannula. Individual instruments are inserted into the entry guide to reach a surgical site.

[0069] Other configurations of manipulator systems that can be used in conjunction with the present disclosure can use several individual manipulator arms. In addition, individual manipulator arms may include a single instrument or a plurality of instruments. Further, as discussed above, an instrument may be a surgical instrument with an end effector or may be a camera instrument or other sensing instrument utilized during a surgical procedure to provide information, (e.g., visualization, electrophysiological activity, pressure, fluid flow, and/or other sensed data) of a remote surgical site.

[0070] Transmission mechanisms **2385**, **2390** (which may generally correspond to transmission mechanism **110** disclosed in connection with FIG. **1**) are disposed at a proximal end of each shaft **2320**, **2330** and connect through a sterile adaptor **2400**, **2410** with drive assemblies **2420**, **2430**. Drive assemblies **2420**, **2430** contain a variety of internal mechanisms (not shown) that are controlled by a controller (e.g., at a control cart of a surgical system) to respond to input commands at a surgeon side console of a surgical system to transmit forces to the transmission mechanisms **2385**, **2390** to actuate surgical instruments **2309**, **2310**.

[0071] The embodiments described herein are not limited to the embodiments of FIG. **16** and FIG. **17**, and various other teleoperated, computer-assisted surgical system configurations may be used with the embodiments described herein. The diameter or diameters of an instrument shaft and end effector are generally selected according to the size of the cannula with which the instrument will be used and depending on the surgical procedures being performed.

[0072] This description and the accompanying drawings that illustrate various embodiments should not be taken as limiting. Various mechanical, compositional, structural, electrical, and operational changes may be made without departing from the scope of this description and the invention as claimed, including equivalents. In some instances, well-known structures and techniques have not been shown or described in detail so as not to obscure the disclosure. Like numbers in two or more figures represent the same or similar elements. Furthermore, elements and their associated features that are described in detail with reference to one embodiment may, whenever practical, be included in other embodiments in which they are not specifically shown or described. For example, if an element is described in detail with reference to one embodiment and is not described with reference to another embodiment, the element may nevertheless be claimed as included in the other embodiment.

[0073] For the purposes of this specification and appended claims, unless otherwise indicated, all numbers expressing quantities, percentages, or proportions, and other numerical values used in the specification and claims, are to be understood as being modified in all instances by the term "about," to the extent they are not already so modified. Accordingly, unless indicated to the contrary, the numerical parameters set forth in the following specification and attached claims are approximations that may vary depending upon the desired properties sought to be obtained. At the very least, and not as an attempt to limit the application of the doctrine of equivalents to the scope of the claims, each numerical parameter should at least be construed in light of

the number of reported significant digits and by applying ordinary rounding techniques.

[0074] It is noted that, as used in this specification and the appended claims, the singular forms "a," "an," and "the," and any singular use of any word, include plural referents unless expressly and unequivocally limited to one referent. As used herein, the term "include" and its grammatical variants are intended to be non-limiting, such that recitation of items in a list is not to the exclusion of other like items that can be substituted or added to the listed items.

[0075] Further, this description's terminology is not intended to limit the invention. For example, spatially relative terms—such as "beneath", "below", "lower", "above", "upper", "proximal", "distal", and the like—may be used to describe one element's or feature's relationship to another element or feature as illustrated in the figures. These spatially relative terms are intended to encompass different positions (i.e., locations) and orientations (i.e., rotational placements) of a device in use or operation in addition to the position and orientation shown in the figures. For example, if a device in the figures is turned over, elements described as "below" or "beneath" other elements or features would then be "above" or "over" the other elements or features. Thus, the term "below" can encompass both positions and orientations of above and below. A device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly.

[0076] Further modifications and alternative embodiments will be apparent to those of ordinary skill in the art in view of the disclosure herein. For example, the devices and methods may include additional components or steps that were omitted from the diagrams and description for clarity of operation. Accordingly, this description is to be construed as illustrative only and is for the purpose of teaching those skilled in the art the general manner of carrying out the present teachings. It is to be understood that the various embodiments shown and described herein are to be taken as examples. Elements and materials, and arrangements of those elements and materials, may be substituted for those illustrated and described herein, parts and processes may be reversed, and certain features of the present teachings may be utilized independently, all as would be apparent to one skilled in the art after having the benefit of the description herein. Changes may be made in the elements described herein without departing from the spirit and scope of the present teachings and following claims.

[0077] It is to be understood that the particular examples and embodiments set forth herein are non-limiting, and modifications to structure, dimensions, materials, and methodologies may be made without departing from the scope of the present teachings.

[0078] Other embodiments in accordance with the present disclosure will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with the following claims being entitled to their fullest breadth, including equivalents, under the applicable law.

What is claimed is:

1. A needle driver device, comprising:

an arcuate-shaped distal end portion defining an aperture opening at a distal end of the needle driver device; and

a cutting element disposed an exterior surface portion of the needle driver device, the cutting element being configured to cut suturing material.

2. The needle driver device of claim **1**, wherein the cutting element comprises a blade.

3. The needle driver device of claim **2**, wherein the blade is fixed in position relative to the arcuate-shaped distal end portion.

4. The needle driver device of claim **3**, wherein the blade comprises a cutting edge oriented in a generally proximal direction.

5. The needle driver device of claim **3**, wherein the blade comprises a cutting edge oriented in a generally distal direction.

6. The needle driver device of claim **3**, wherein the blade comprises a cutting edge oriented generally perpendicular to a longitudinal axis of the needle driver device.

7. The needle driver device of claim **4**, wherein the cutting edge forms an acute angle with a longitudinal axis of the needle driver device.

8. The needle driver device of claim **7**, wherein the cutting element further comprises a shroud at least partially covering the blade.

9. The needle driver device of claim **1**, wherein the cutting element is removably engageable with the needle drive device.

10. The needle driver device of claim **9**, wherein the cutting element comprises a blade and a blade retainer configured to be removably engageable with the needle driver device.

11. The needle driver device of claim **10**, wherein the blade retainer comprises a blade mount portion, a retention tab configured to interface with a portion of the needle driver device, and one or more rails connecting the blade mount portion and the retention tab.

12. The needle driver device of claim **11**, further comprising a housing comprising an undercut portion configured to receive one or both of a portion of the blade mount portion and a portion of the one or more rails.

13. The needle driver device of claim **1**, wherein the cutting element is actuatable.

14. The needle drive device of claim **13**, wherein the cutting element comprises a blade moveable in response to actuation of the cutting element.

15. The needle driver device of claim **14**, wherein the blade is a pin moveable from a retracted position within a housing to an extended position external the housing in response to actuation of the cutting element.

16. The needle driver device of claim **15**, wherein the pin is received in an anvil in the extended position.

17. The needle driver device of claim **16**, wherein:

the cutting element further comprises a translating plunger having a notch in a lateral side, and

the blade is located within the notch.

18. The needle driver device of claim **17**, wherein:

the translating plunger is configured to move distally into the aperture; and

wherein on the condition that the translating plunger is in a fully extended position, the notch of the translating plunger is located within the aperture.

19. The needle driver device of claim **1**, wherein the cutting element is located proximal to the arcuate-shaped distal end portion.

20. A method of using a needle driver device comprising a cutting element, the method comprising:

inserting the needle driver device to a site to perform a suturing procedure, wherein the needle driver device comprises a cutting element carried at an exterior housing portion;

driving a needle carrying suturing material through tissue to perform the suturing procedure; and

cutting excess suturing material using the cutting element.

21. The method of claim **20**, wherein cutting the excess suturing material using the cutting element comprises actuating a movable cutting element.

22. The method of claim **20**, wherein cutting the excess suturing material comprises manipulating the needle driver device to cut the excess suturing material using the cutting element.

23. The method of claim **20**, wherein cutting excess suturing material comprises cutting the excess suturing material in a central region of an arcuate-shaped path around which the needle traverses during a suturing procedure.

* * * * *