

FIG. 1A

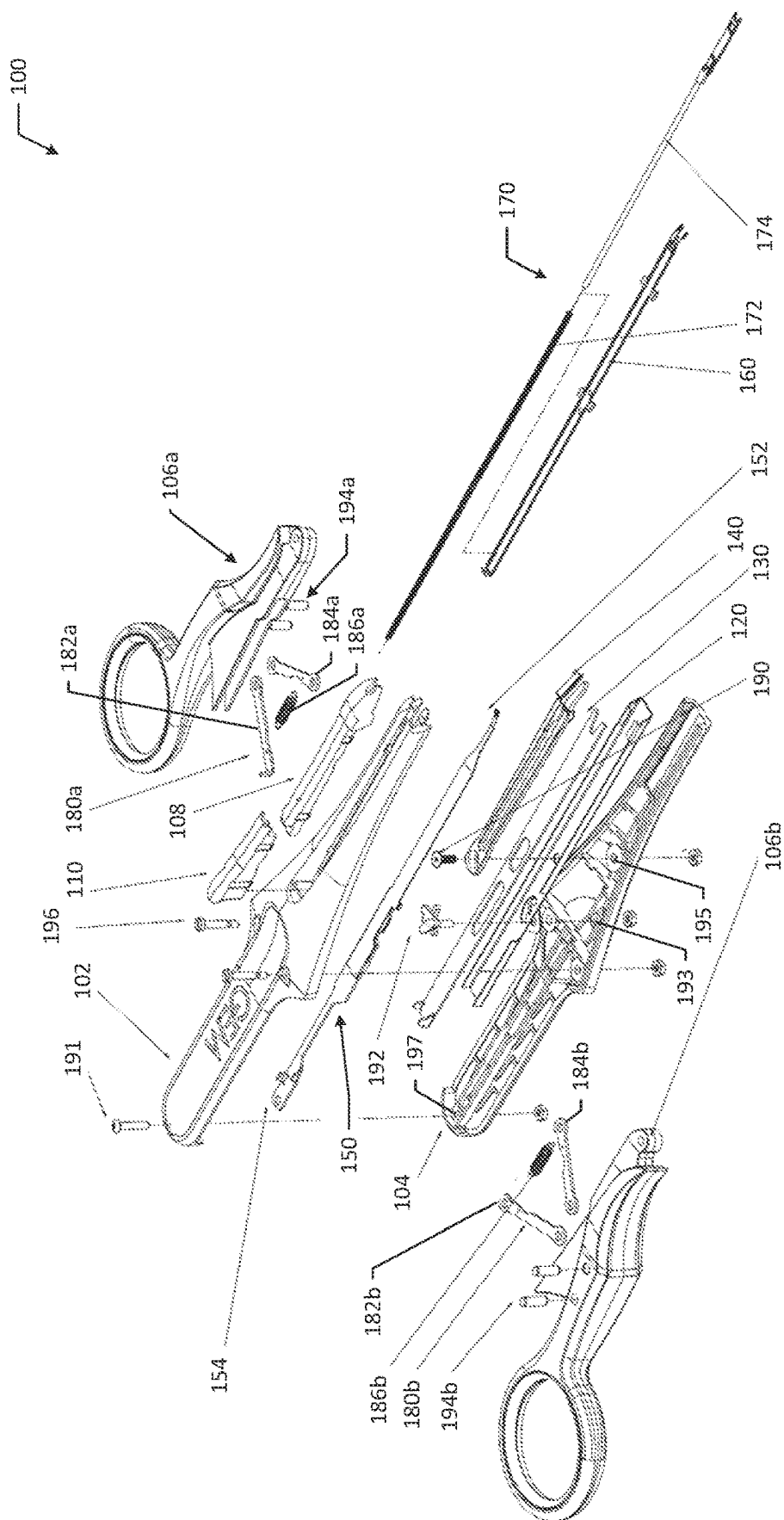
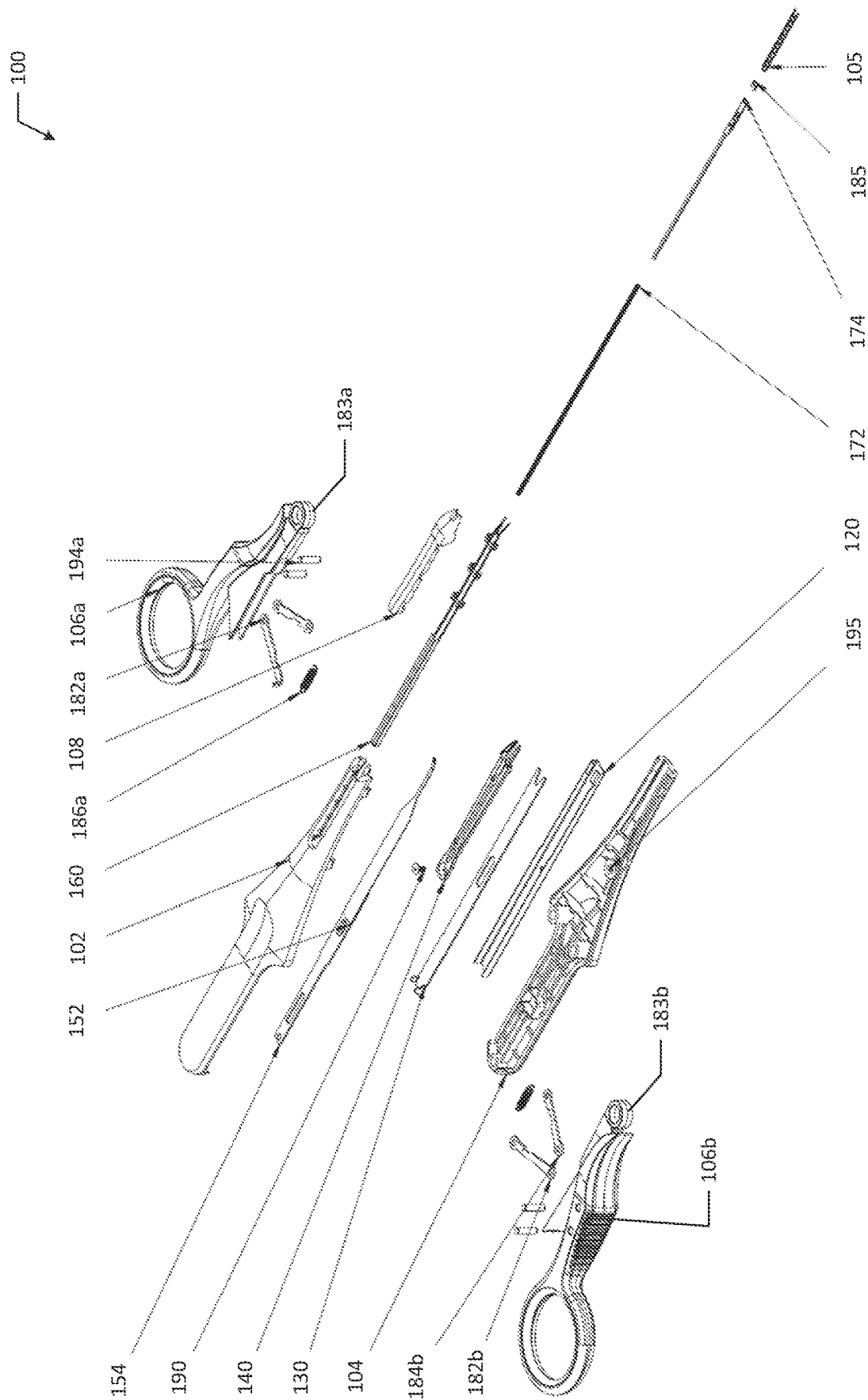


FIG. 1B



U
F
G
L

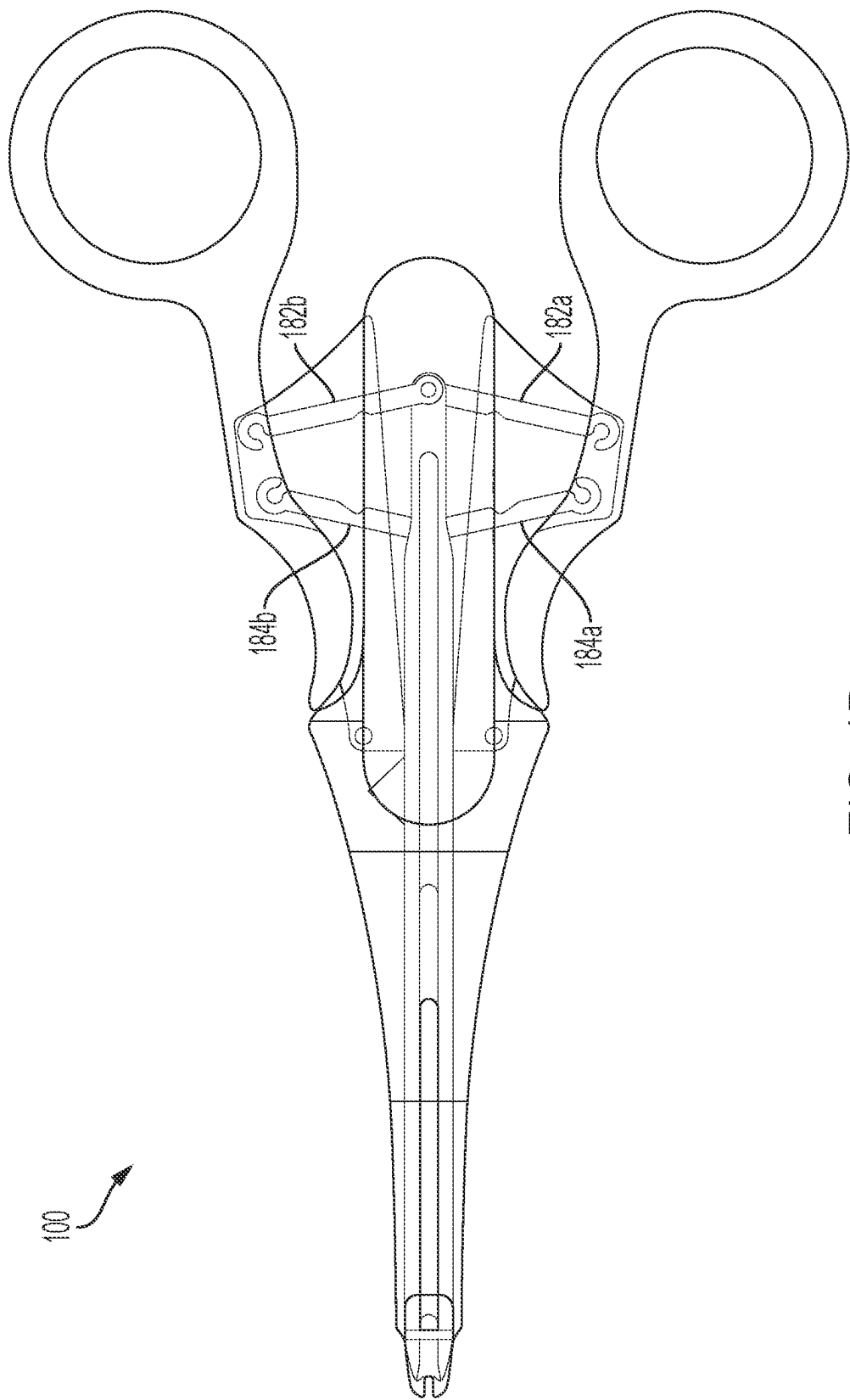


FIG. 1D

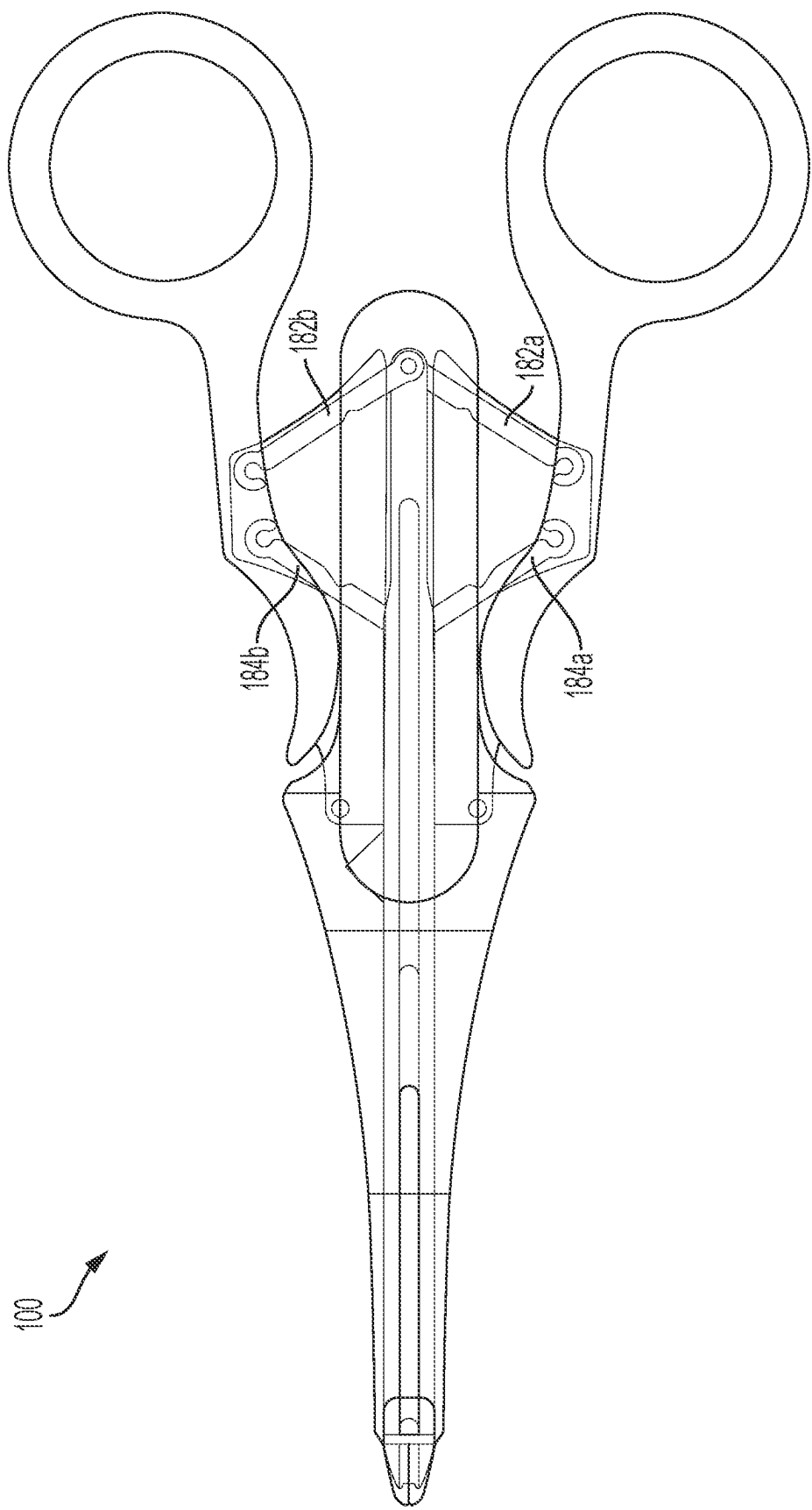


FIG. 1E

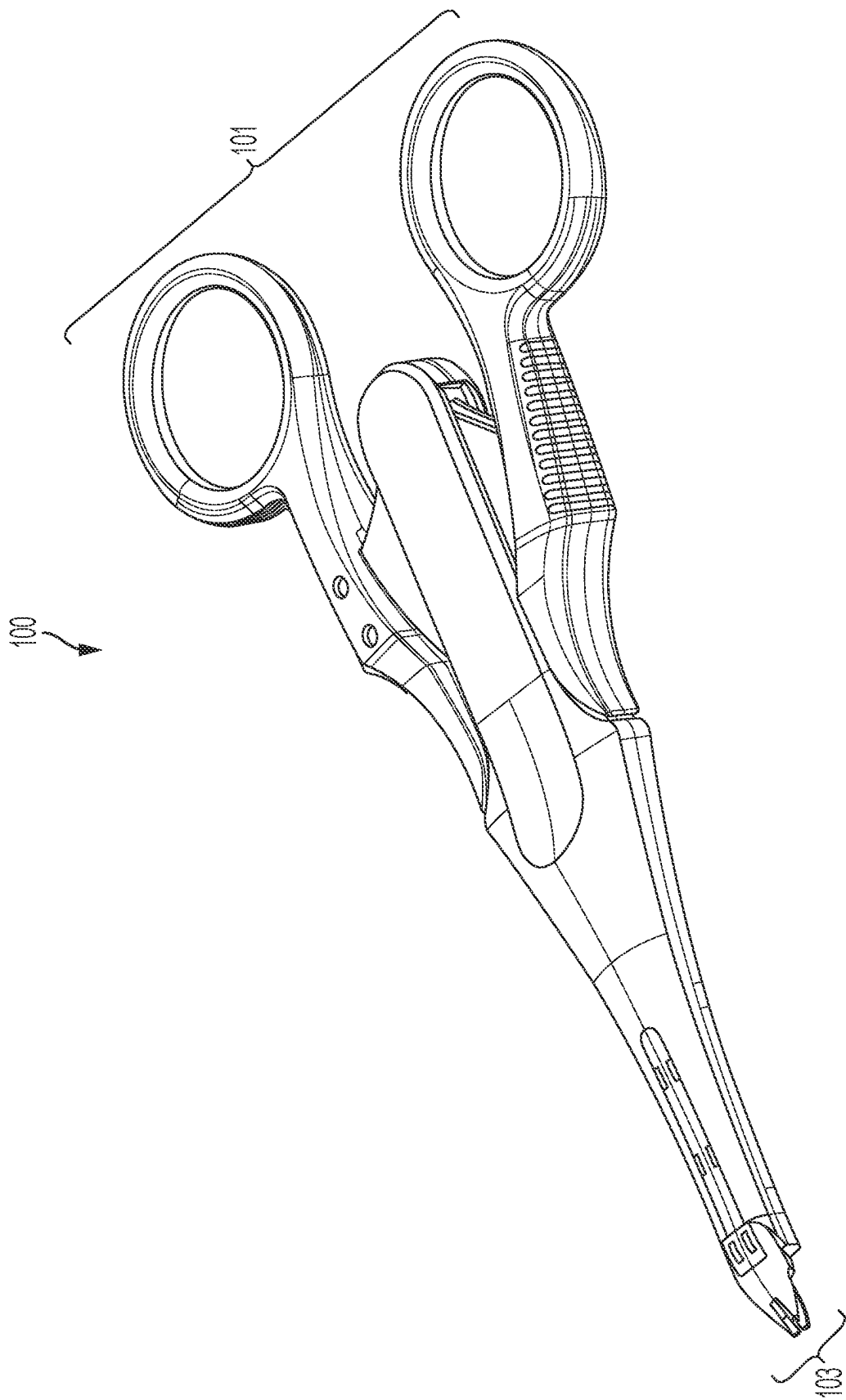


FIG. 1F

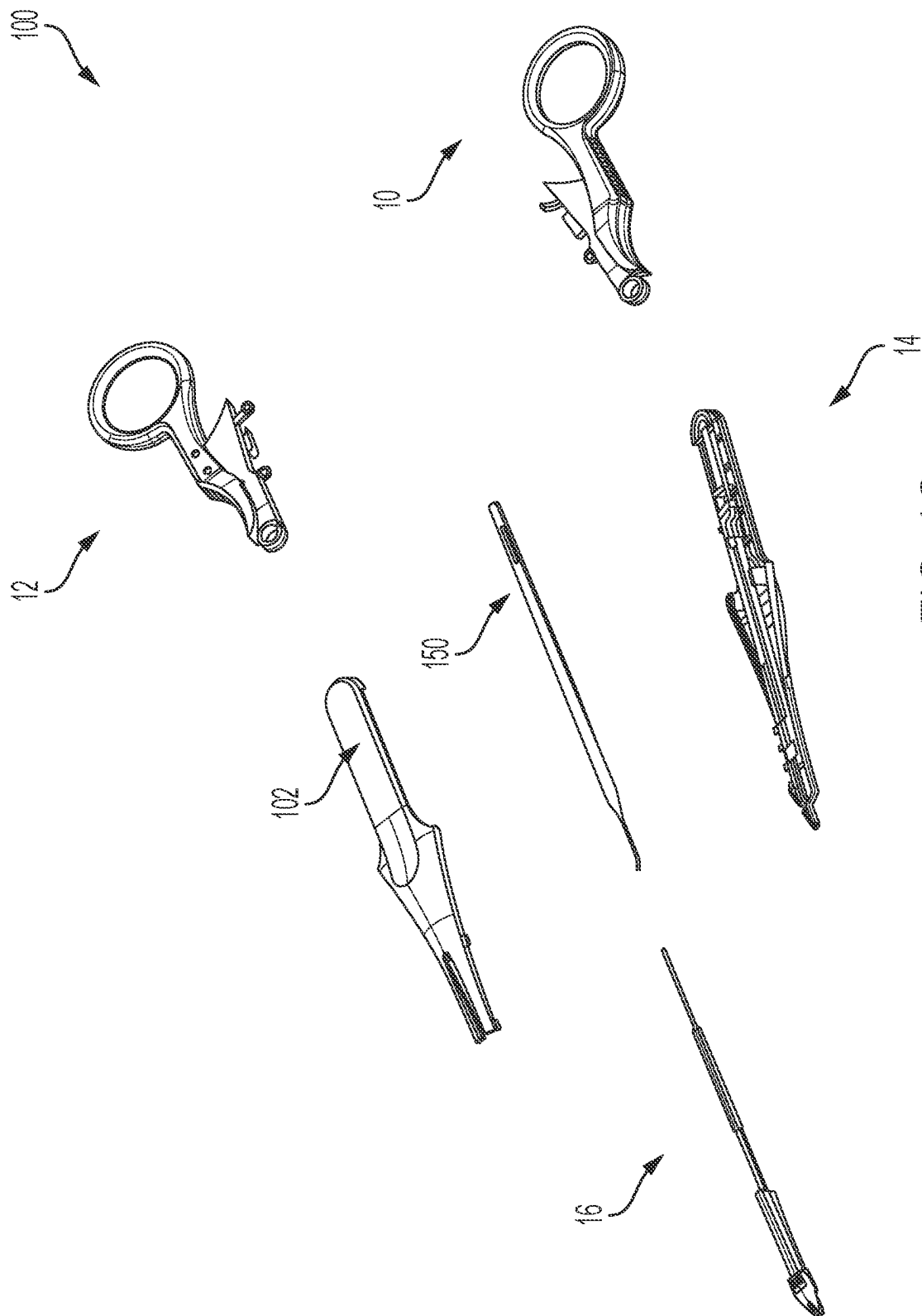


FIG. 1G

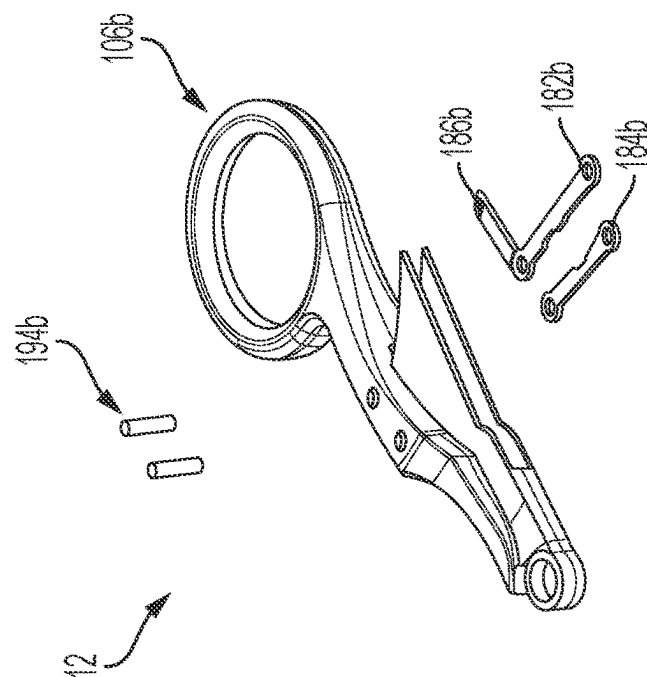


FIG. 1I

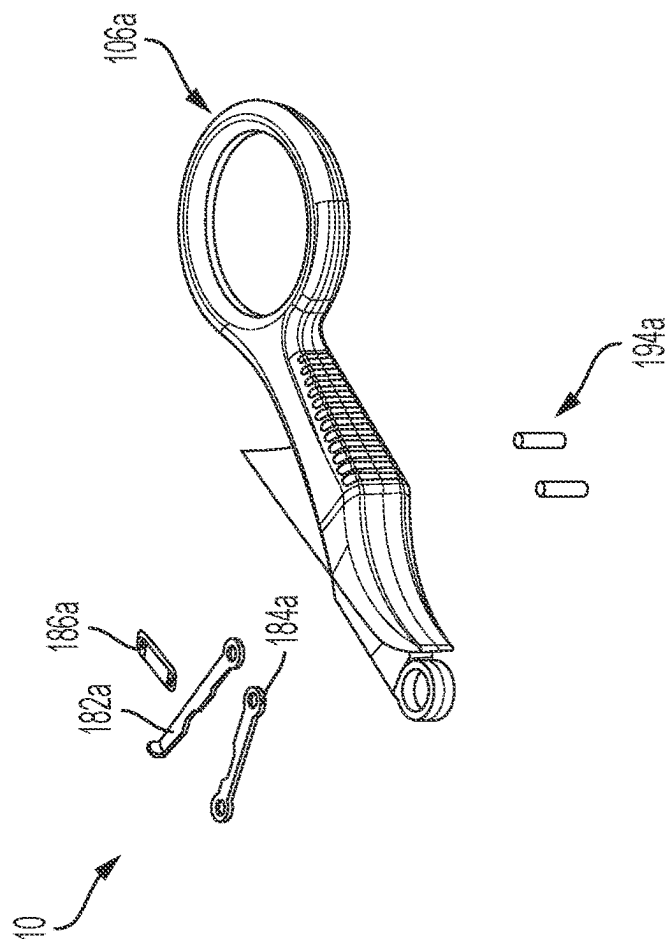


FIG. 1H

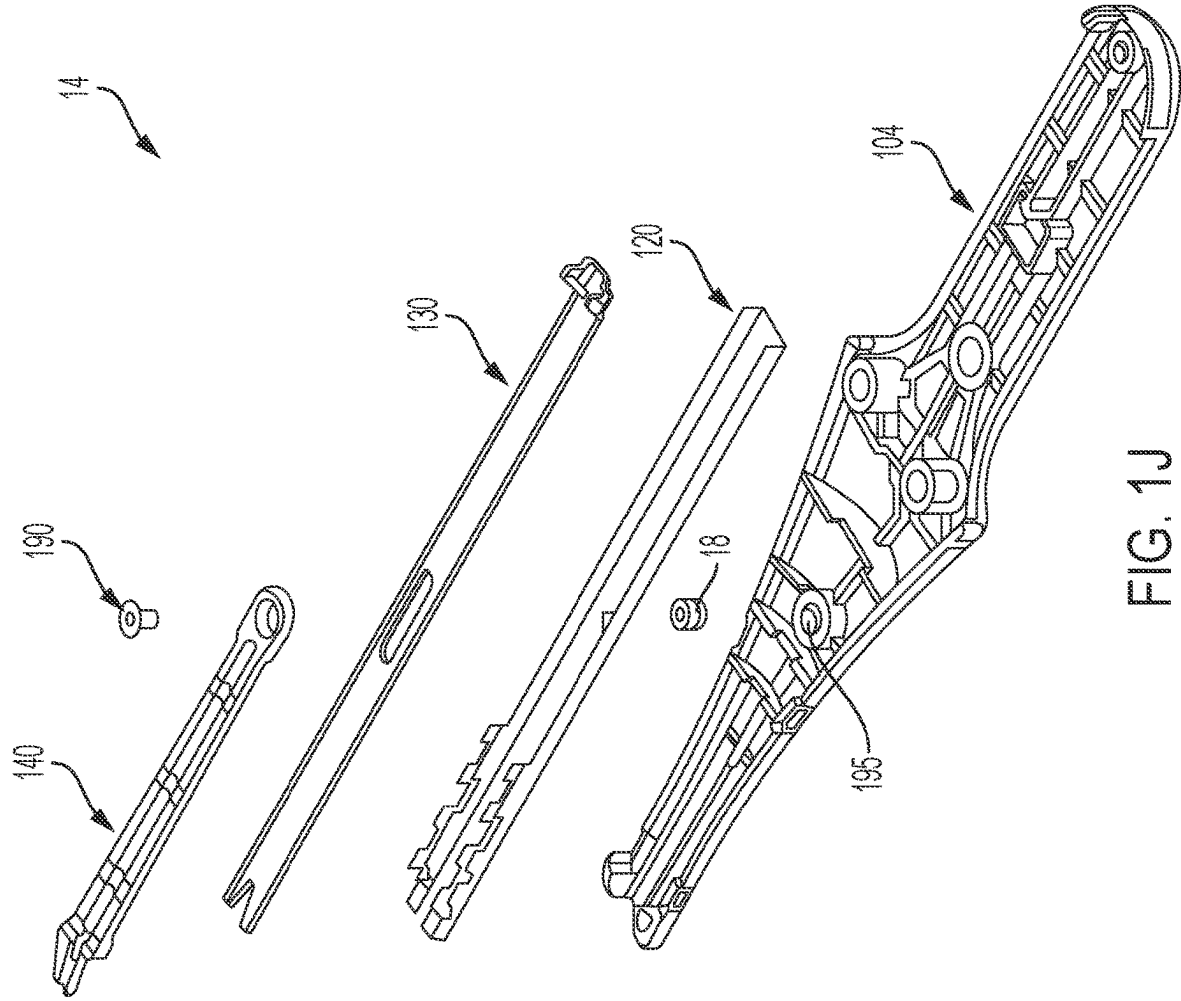


FIG. 1J

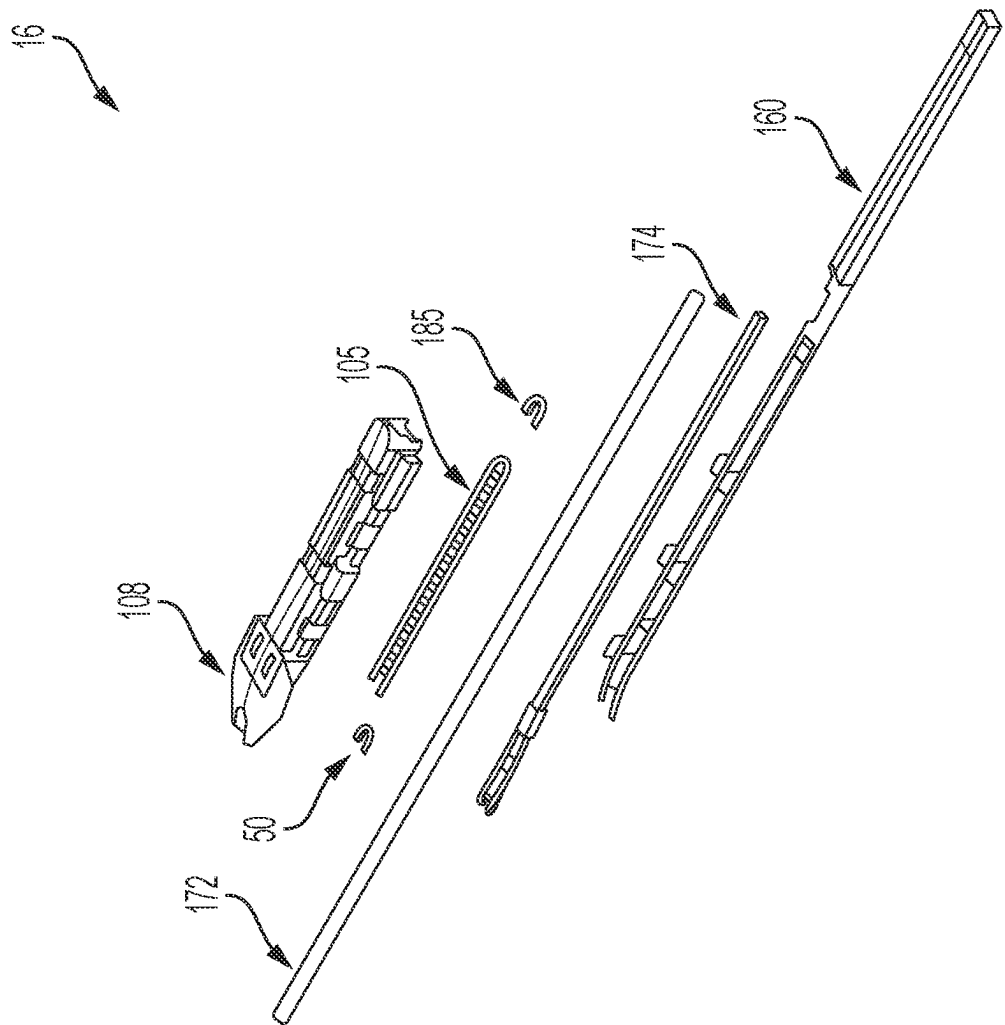


FIG. 1K

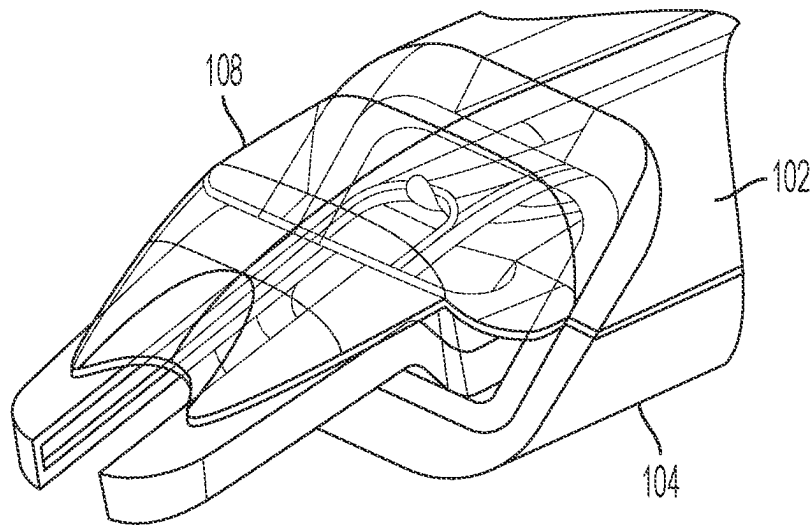


FIG. 2A

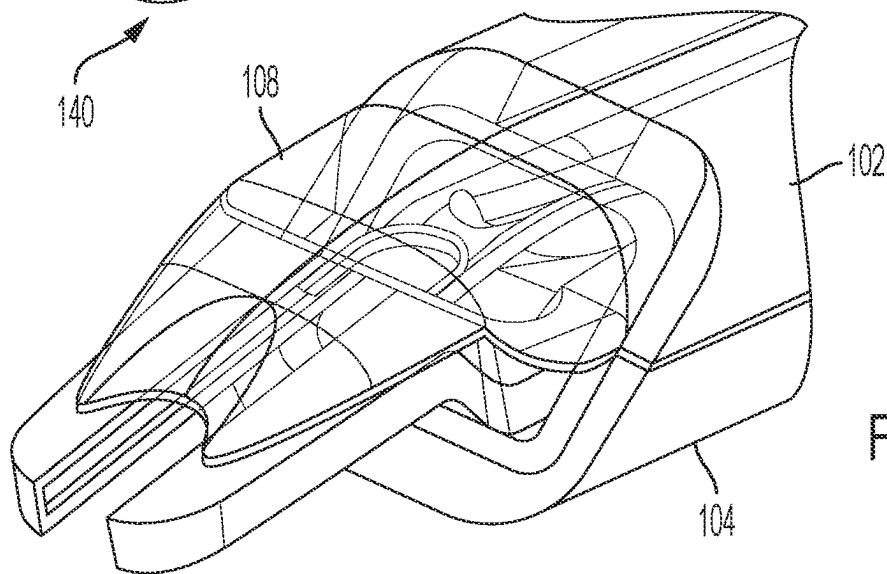


FIG. 2B

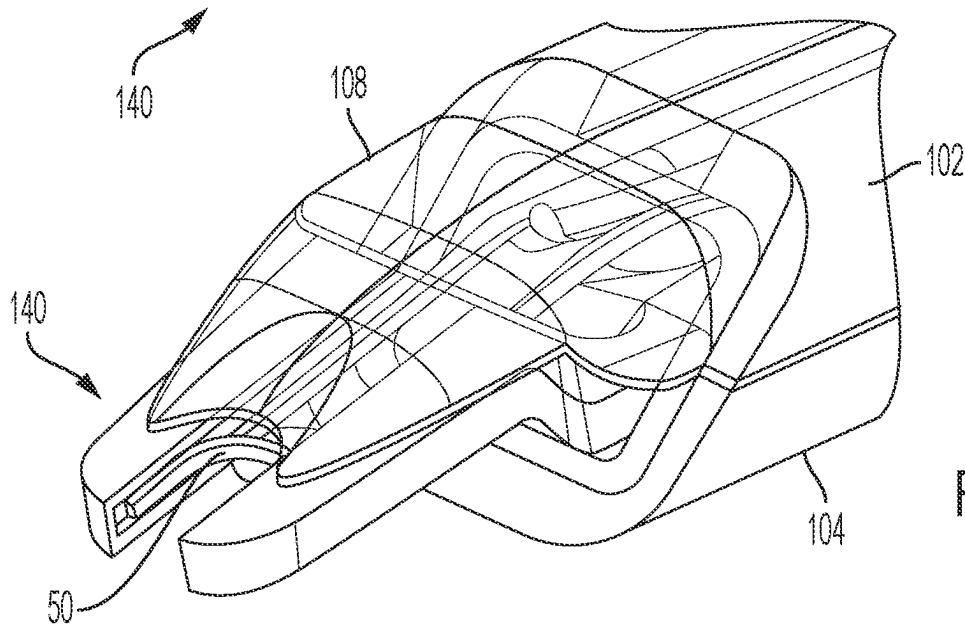


FIG. 2C

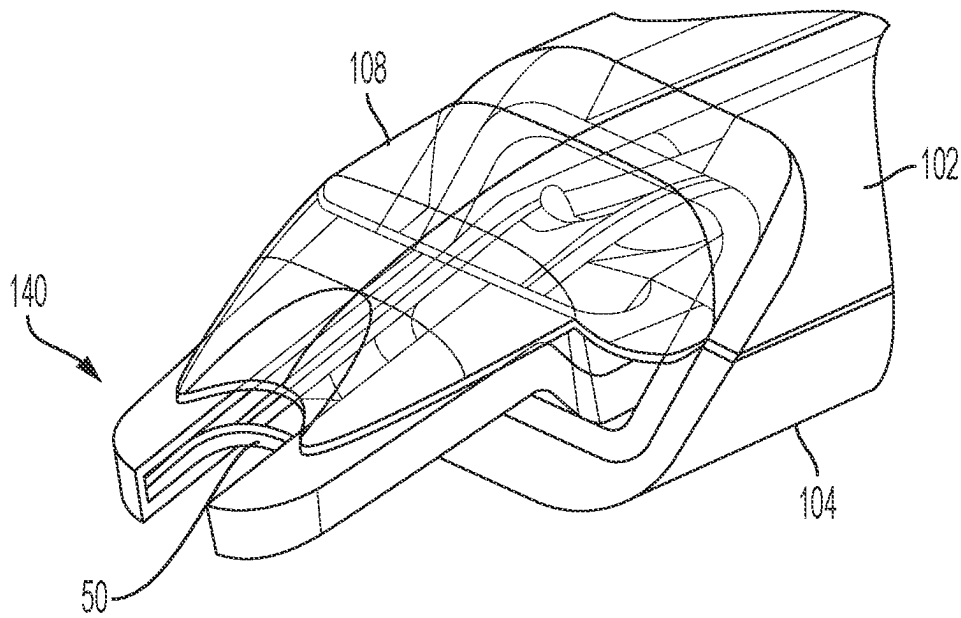


FIG. 2D

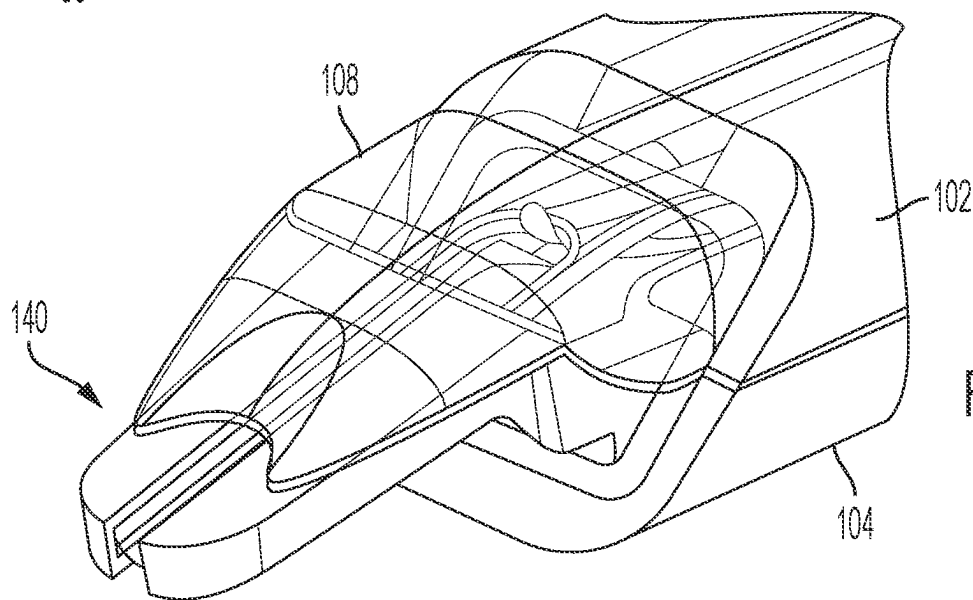


FIG. 2E

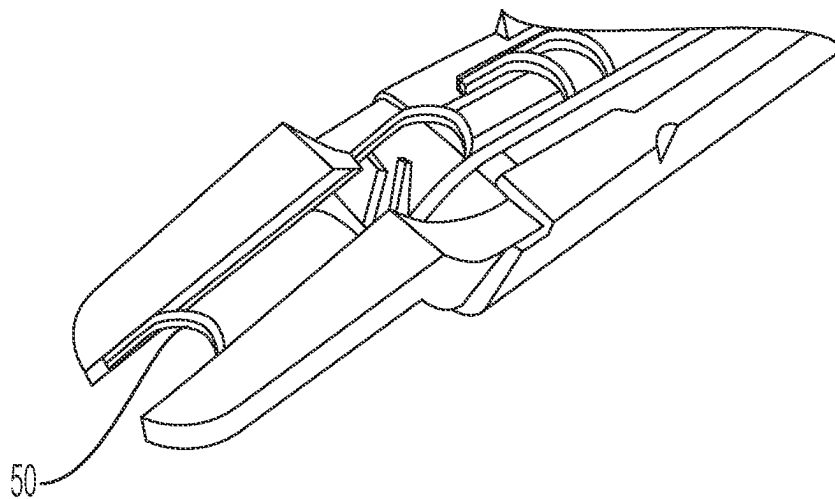


FIG. 2F

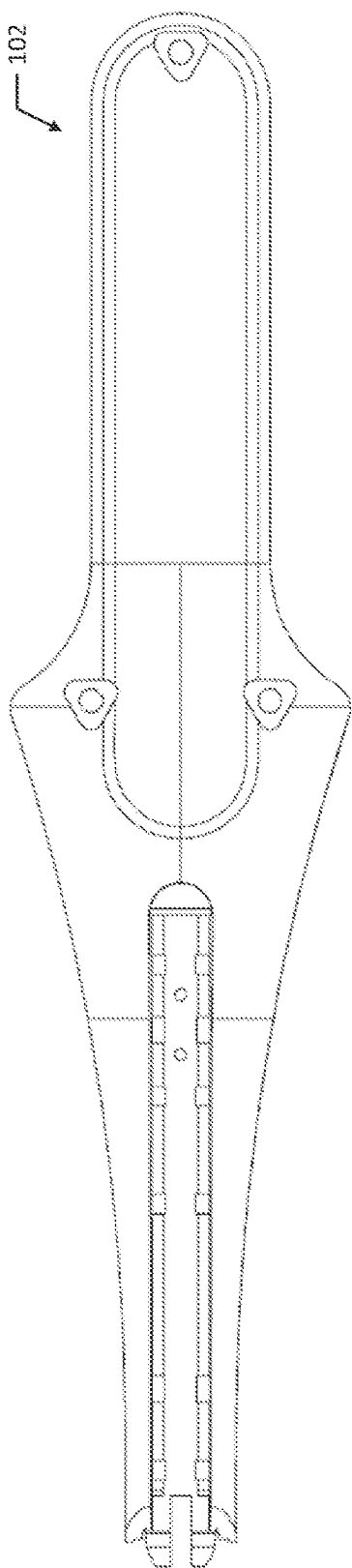


FIG. 3A



FIG. 3B

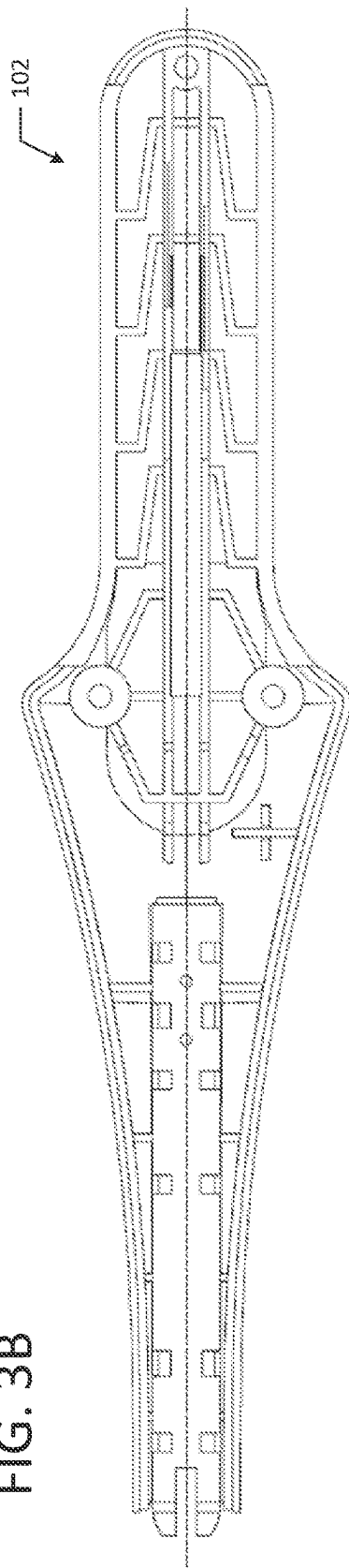


FIG. 3C

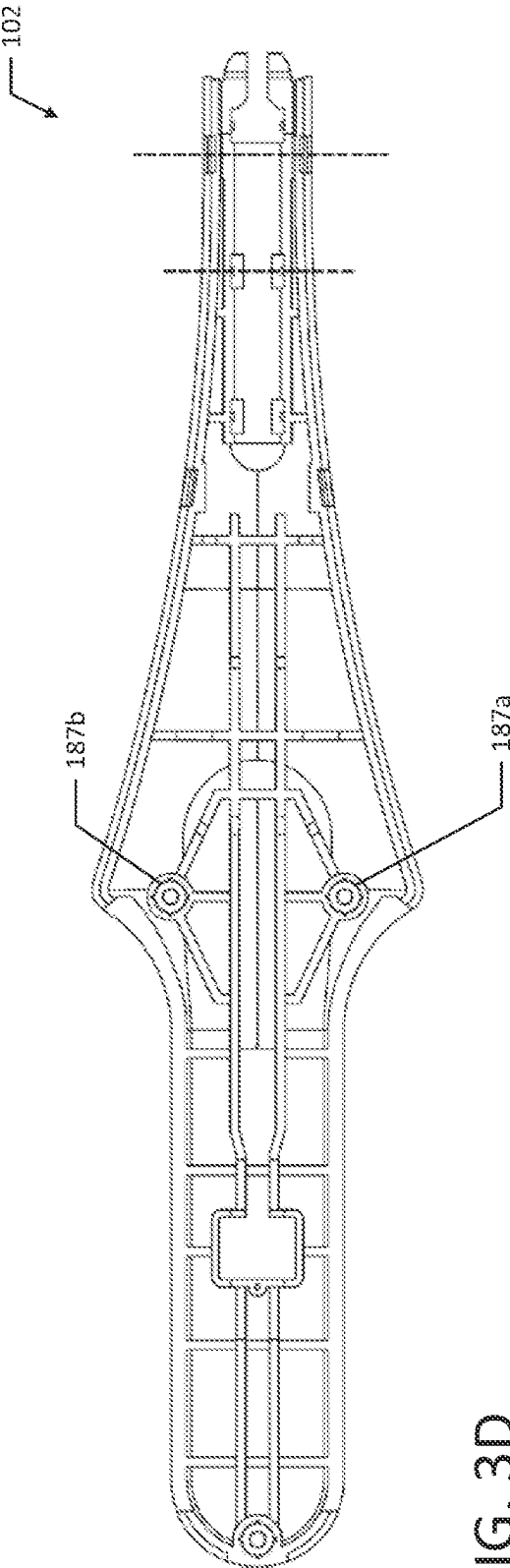


FIG. 3D

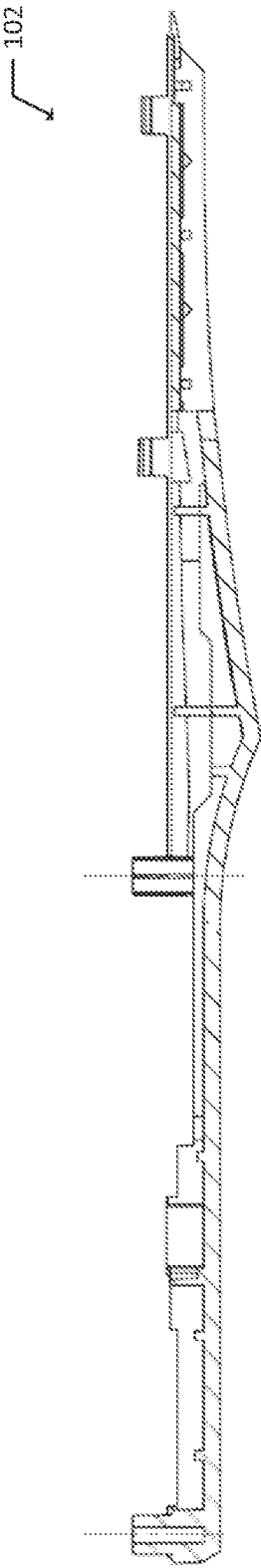


FIG. 3E

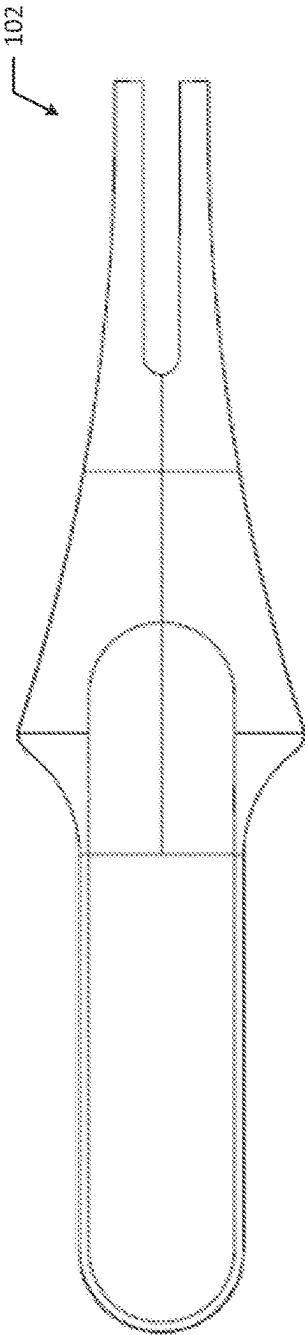


FIG. 3F

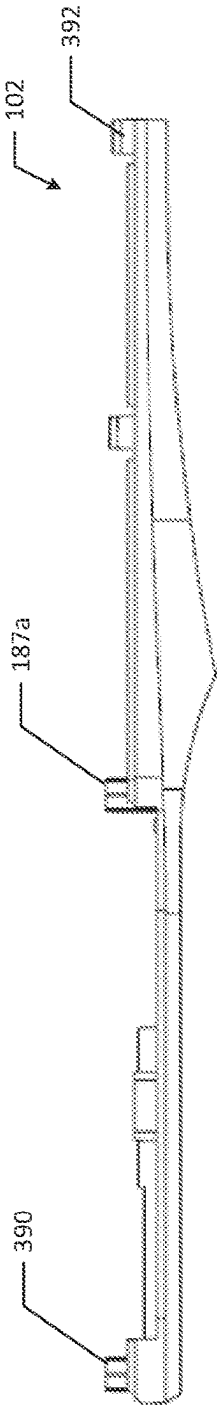


FIG. 3G

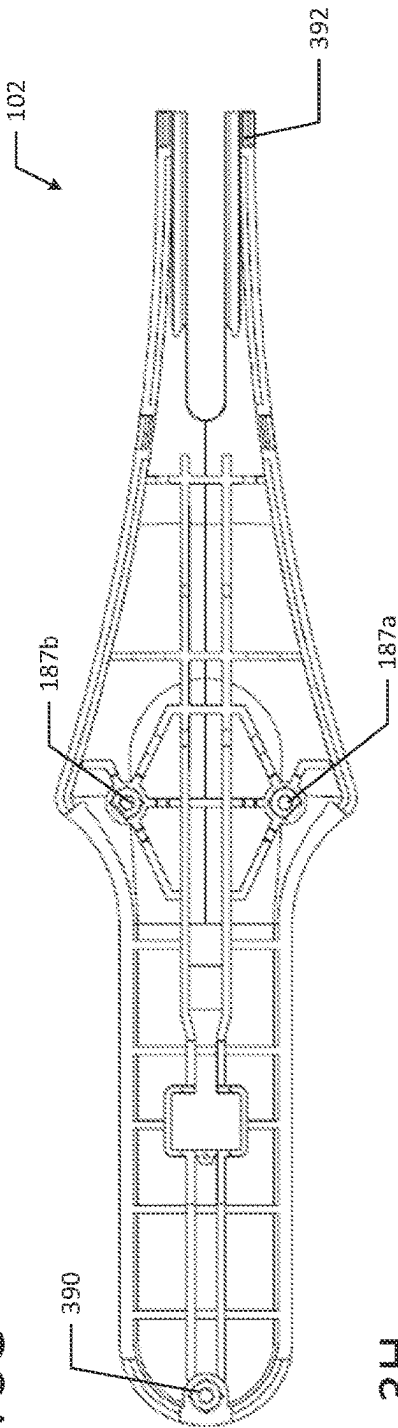


FIG. 3H

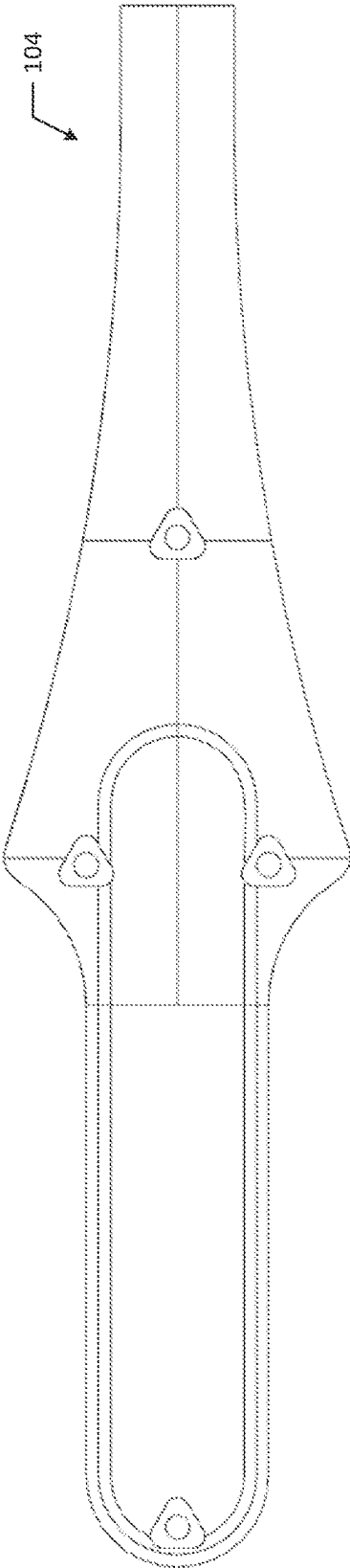


FIG. 4A

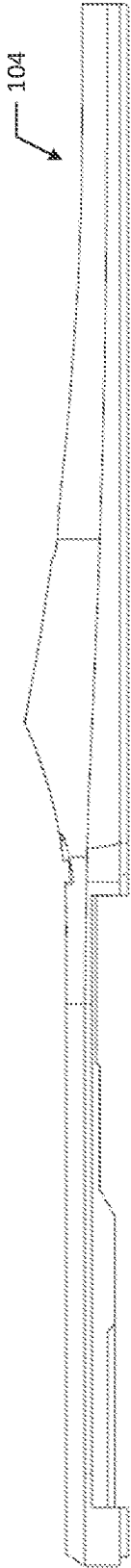


FIG. 4B

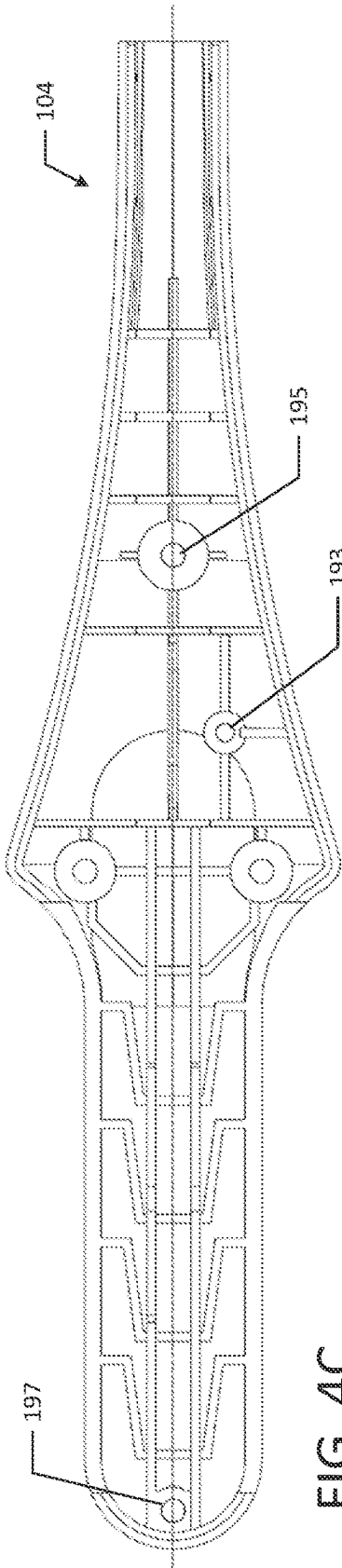


FIG. 4C

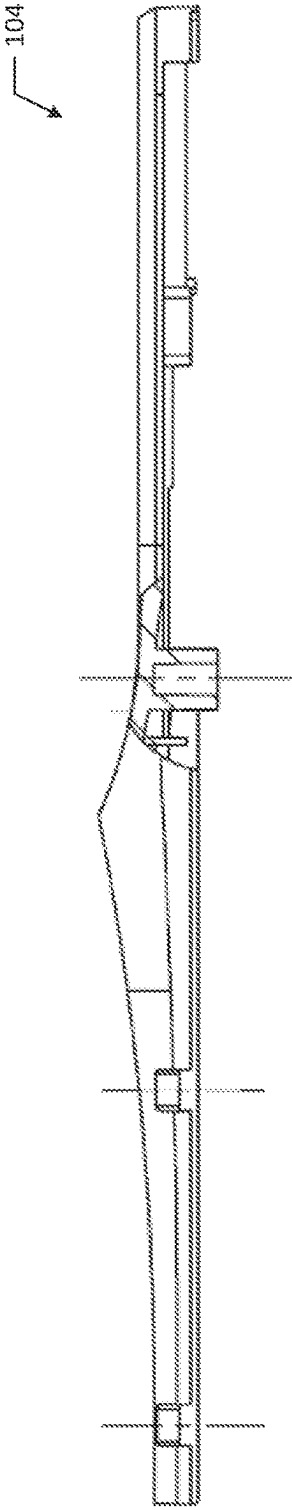


FIG. 4D

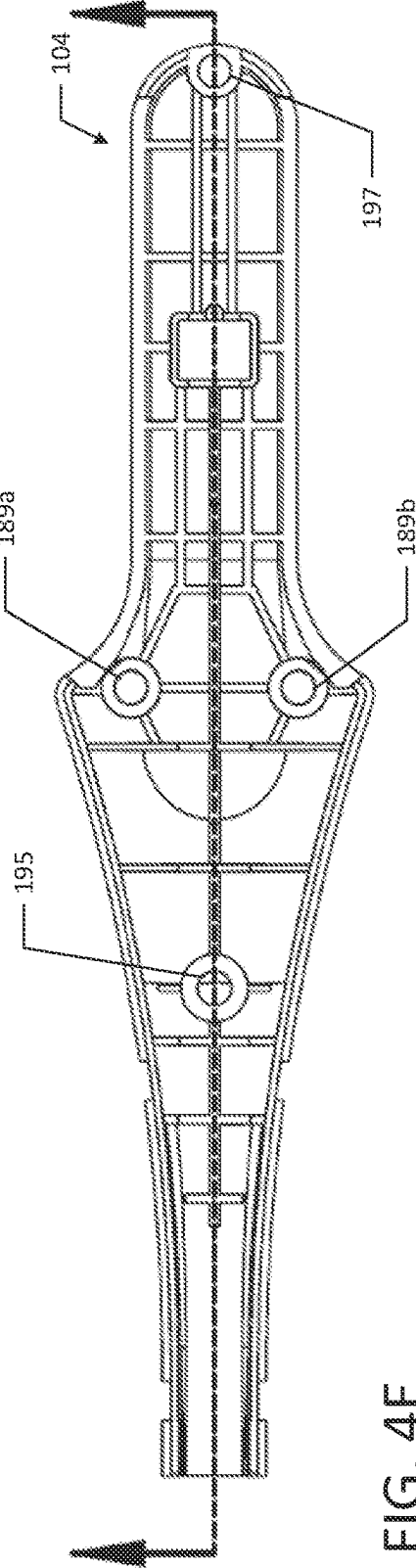


FIG. 4E

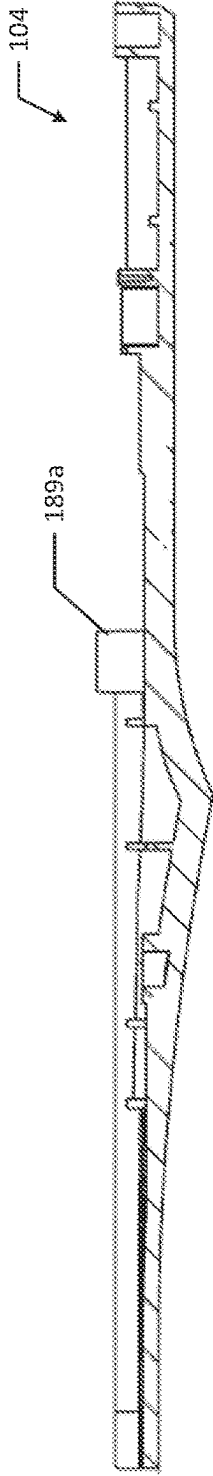


FIG. 4F

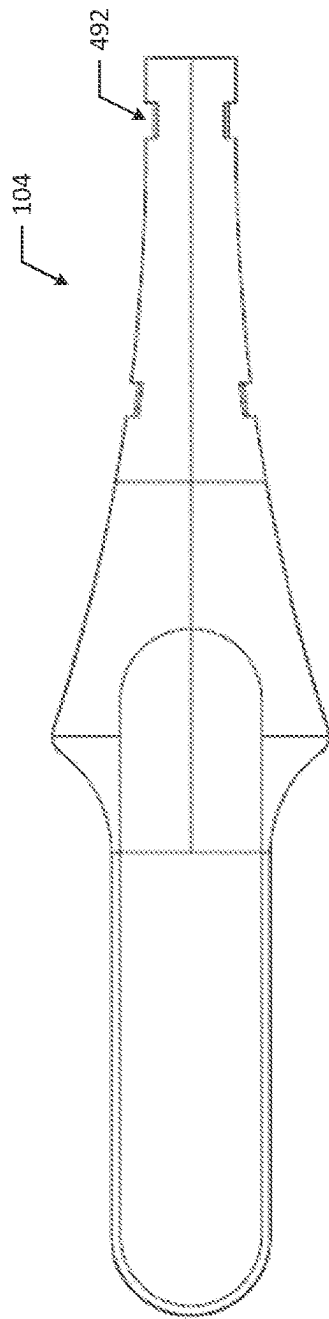


FIG. 4G

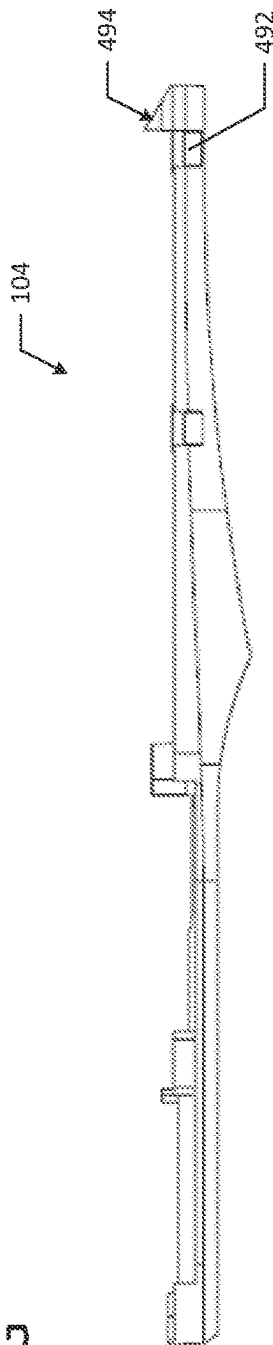


FIG. 4H

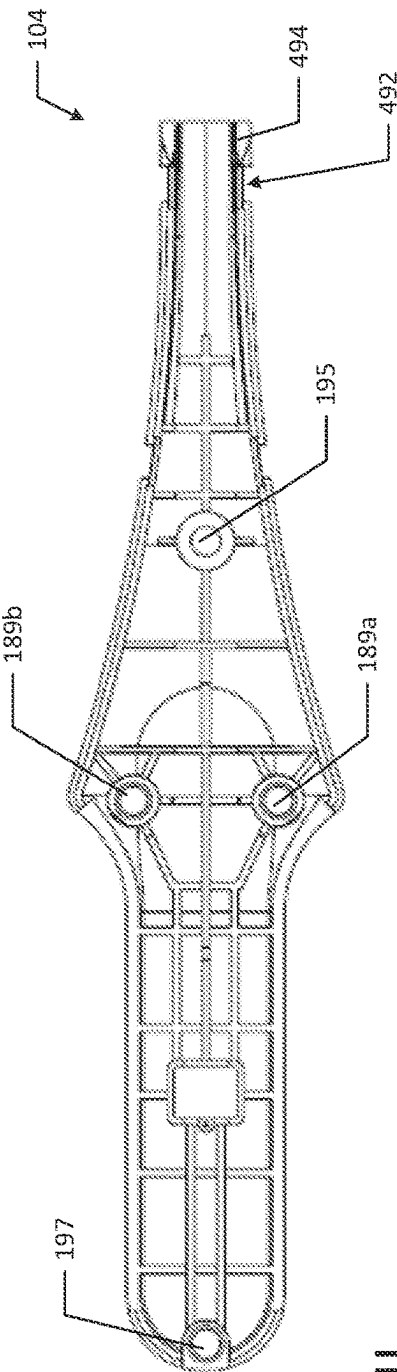


FIG. 4I

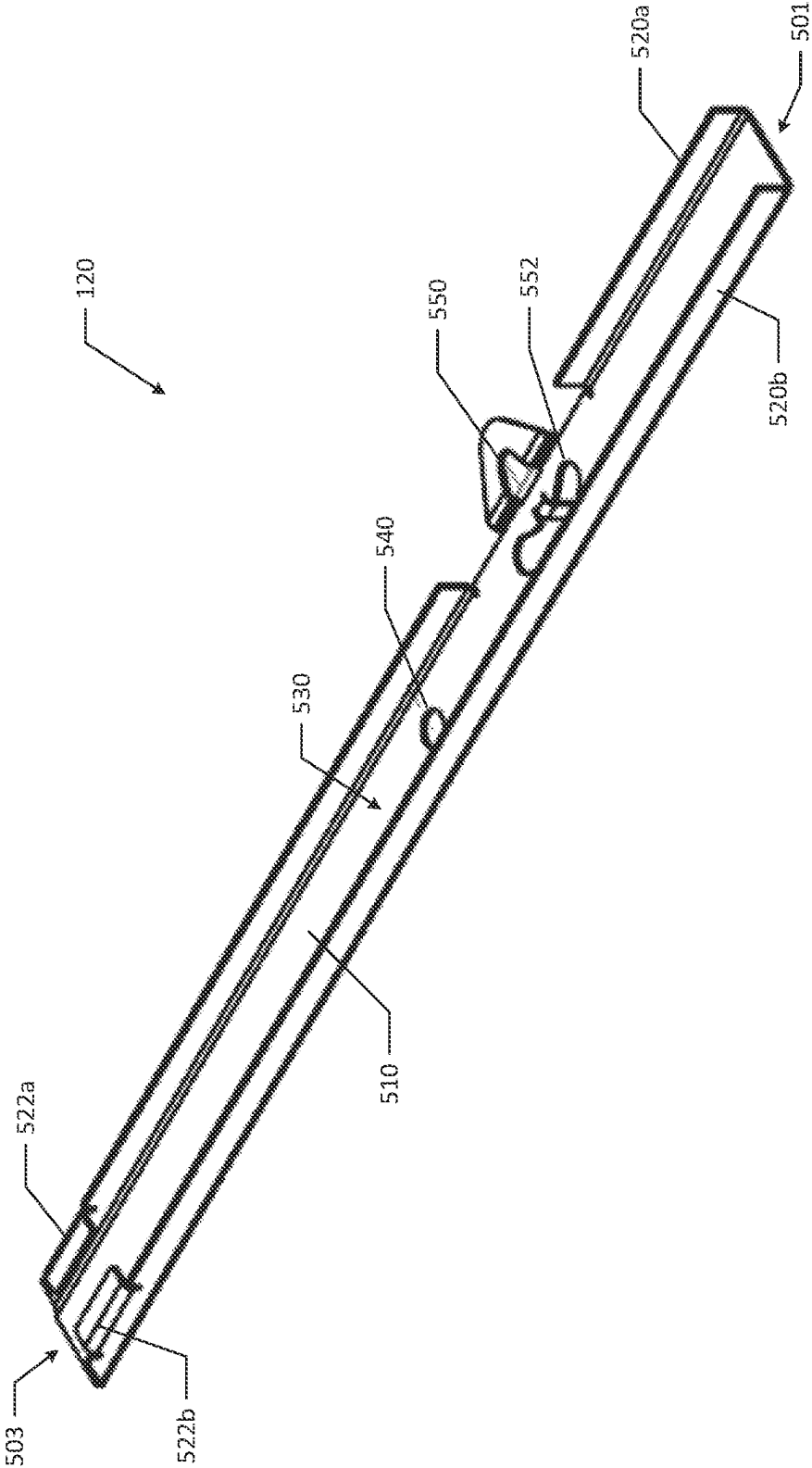


FIG. 5A

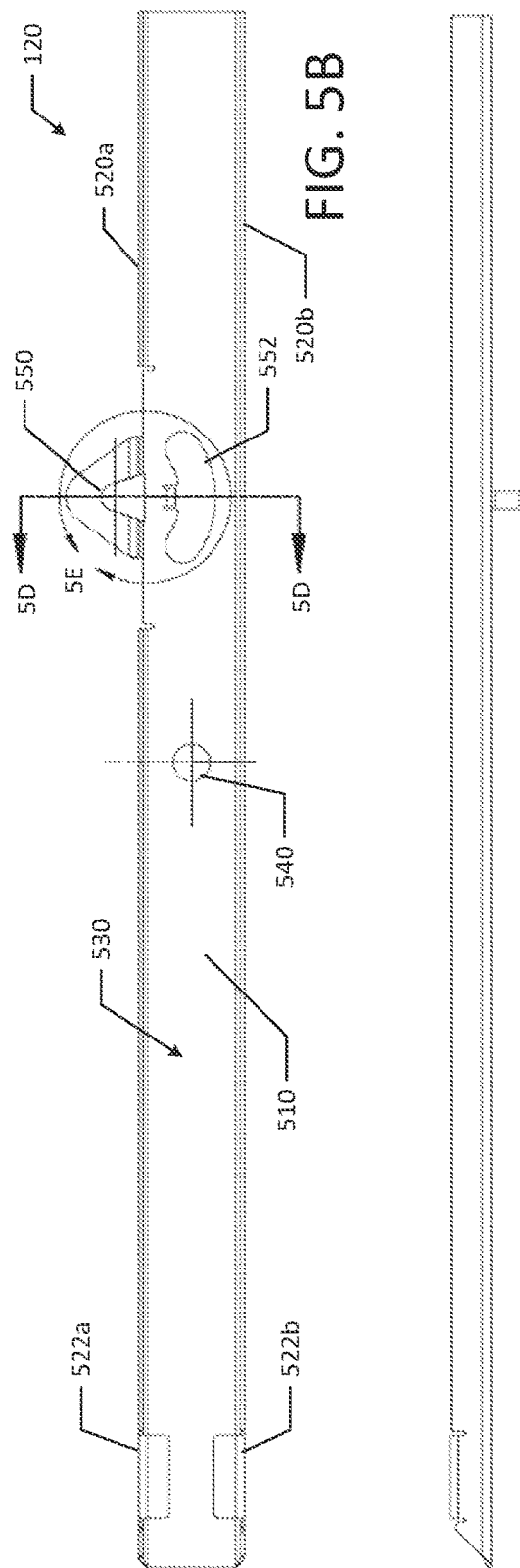
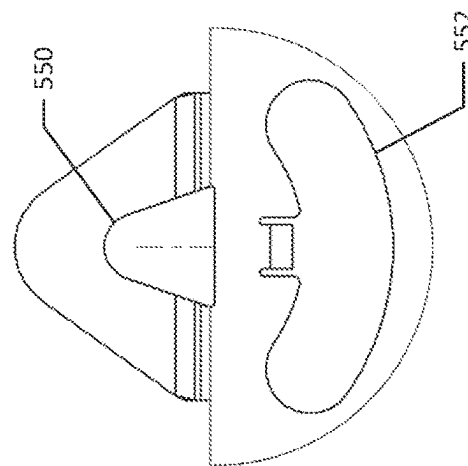
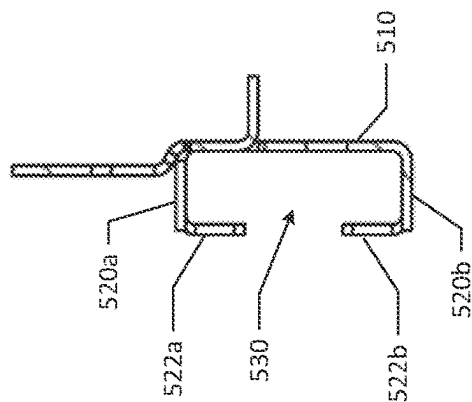


FIG. 5C



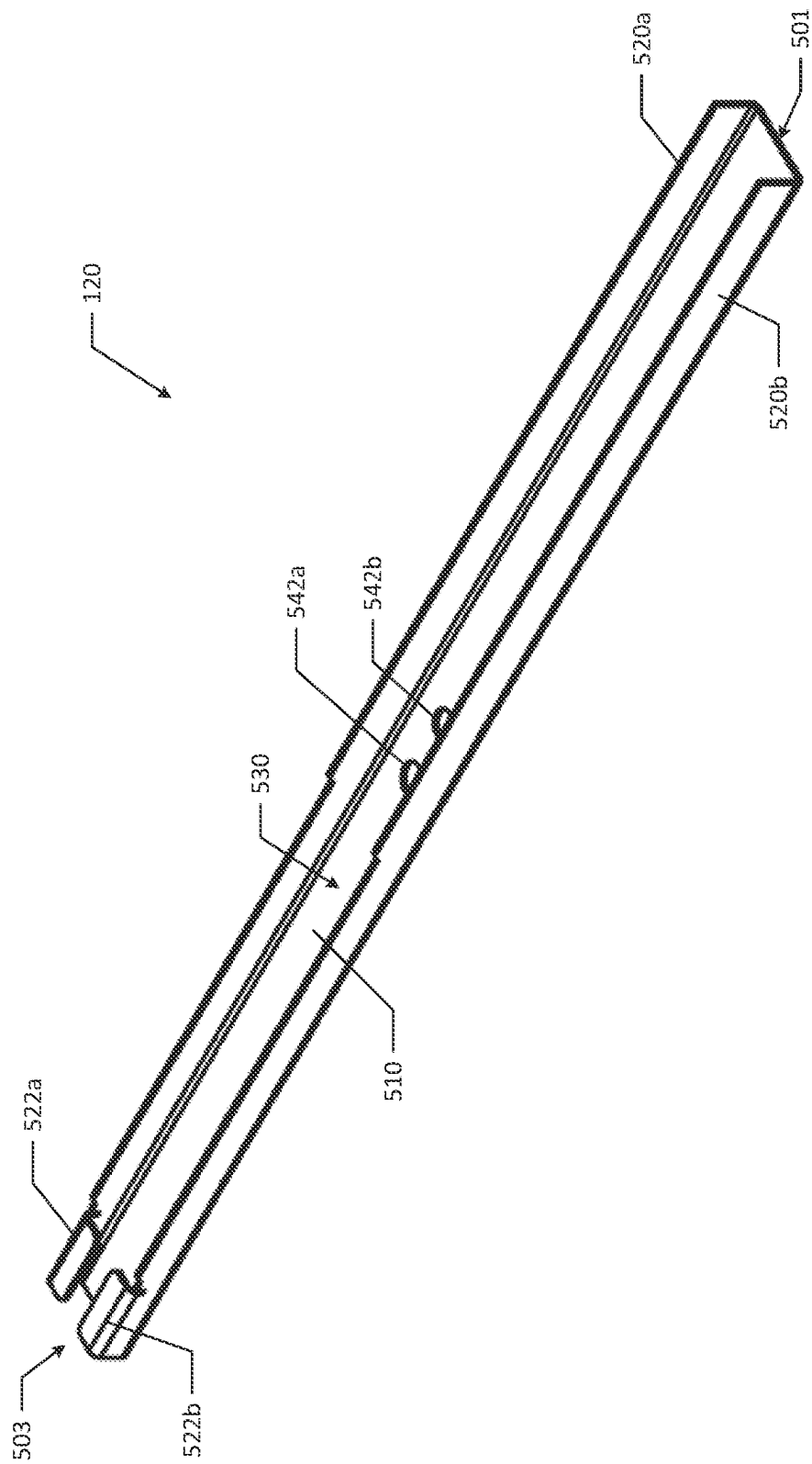


FIG. 5F

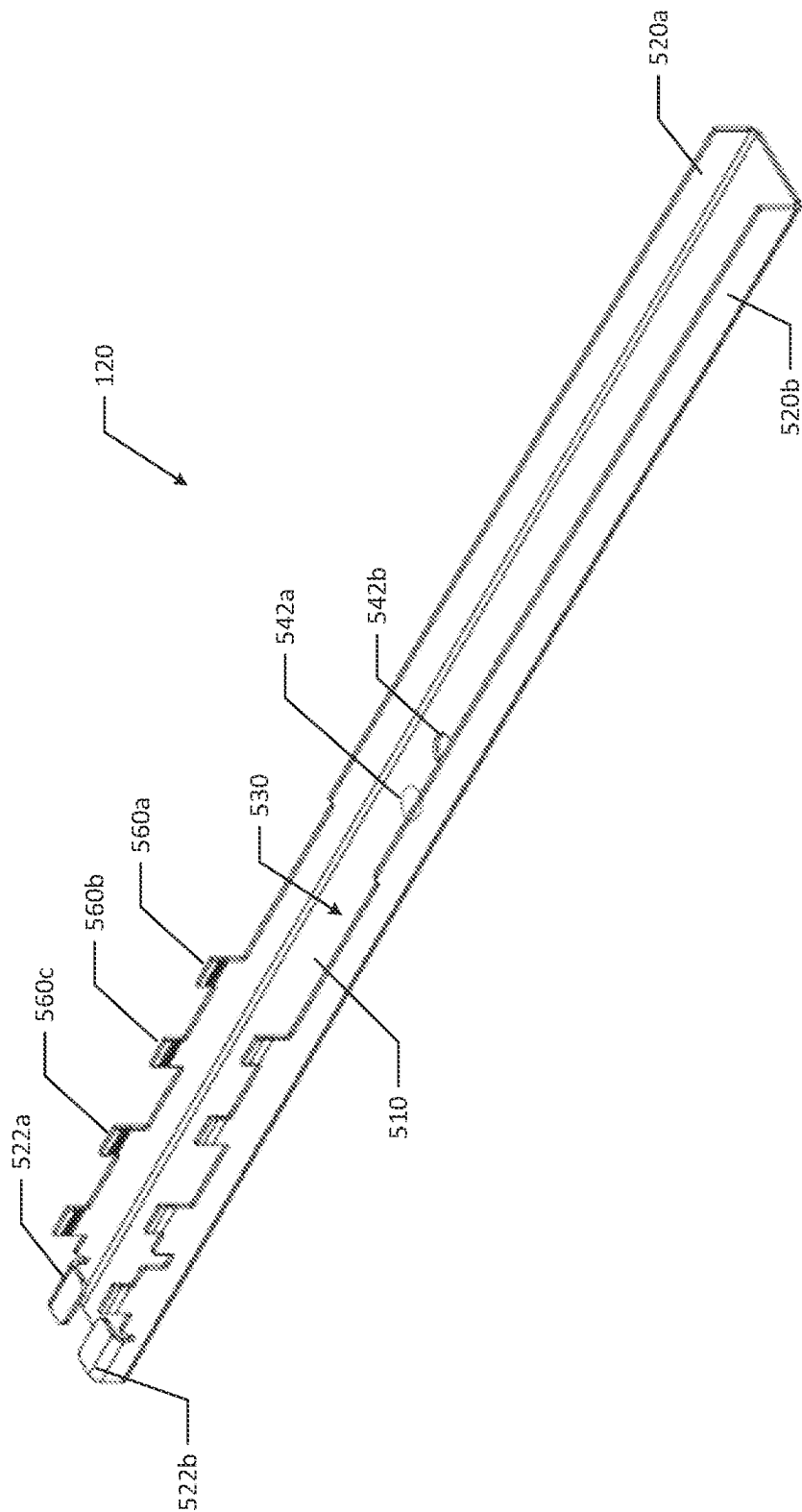
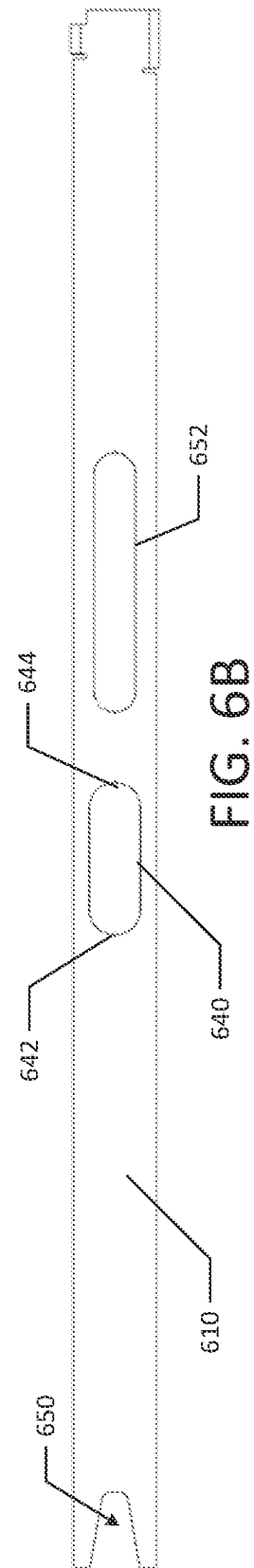
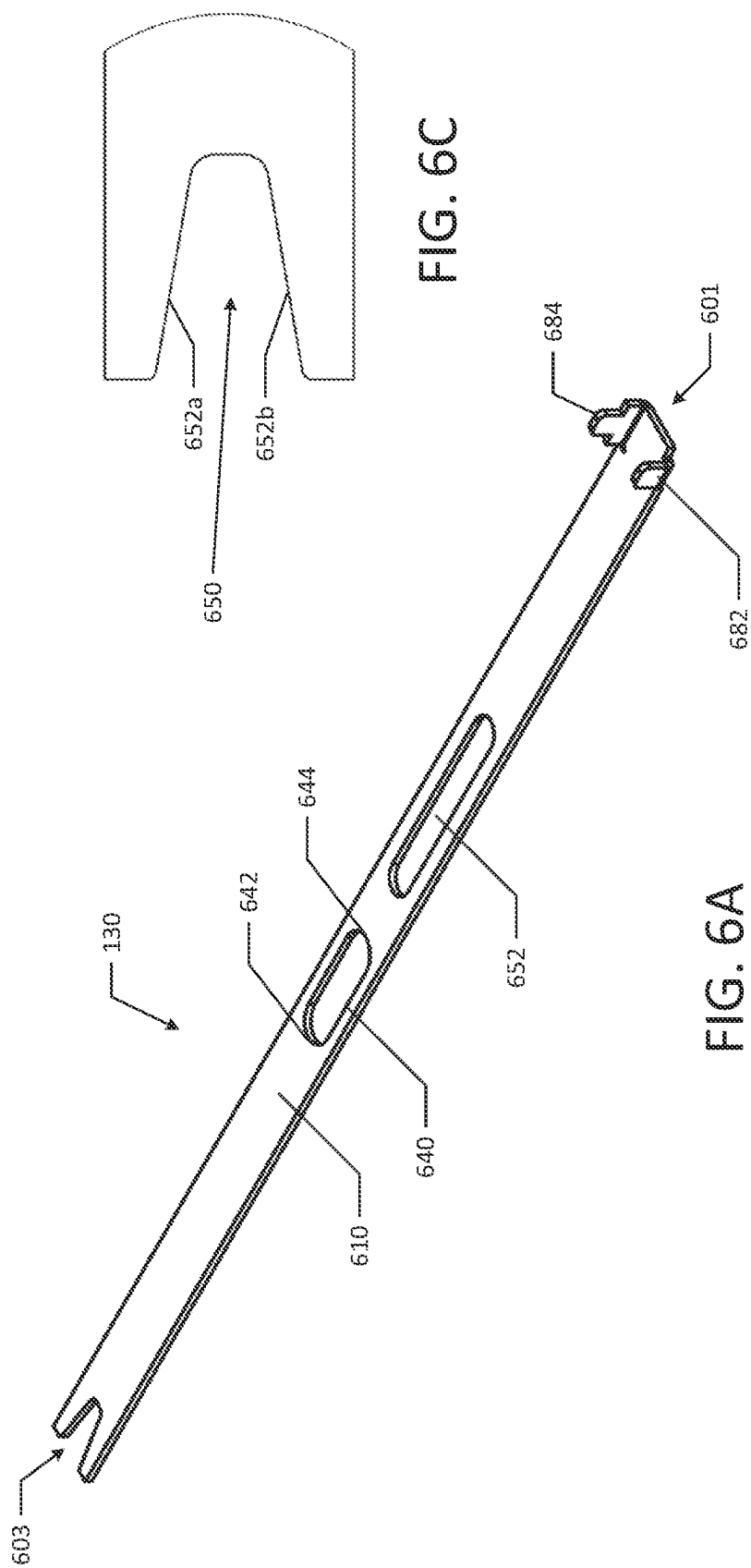
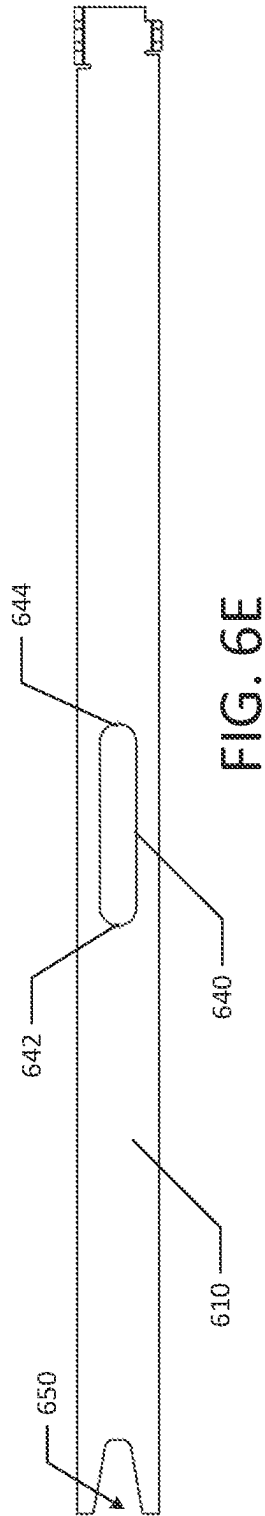
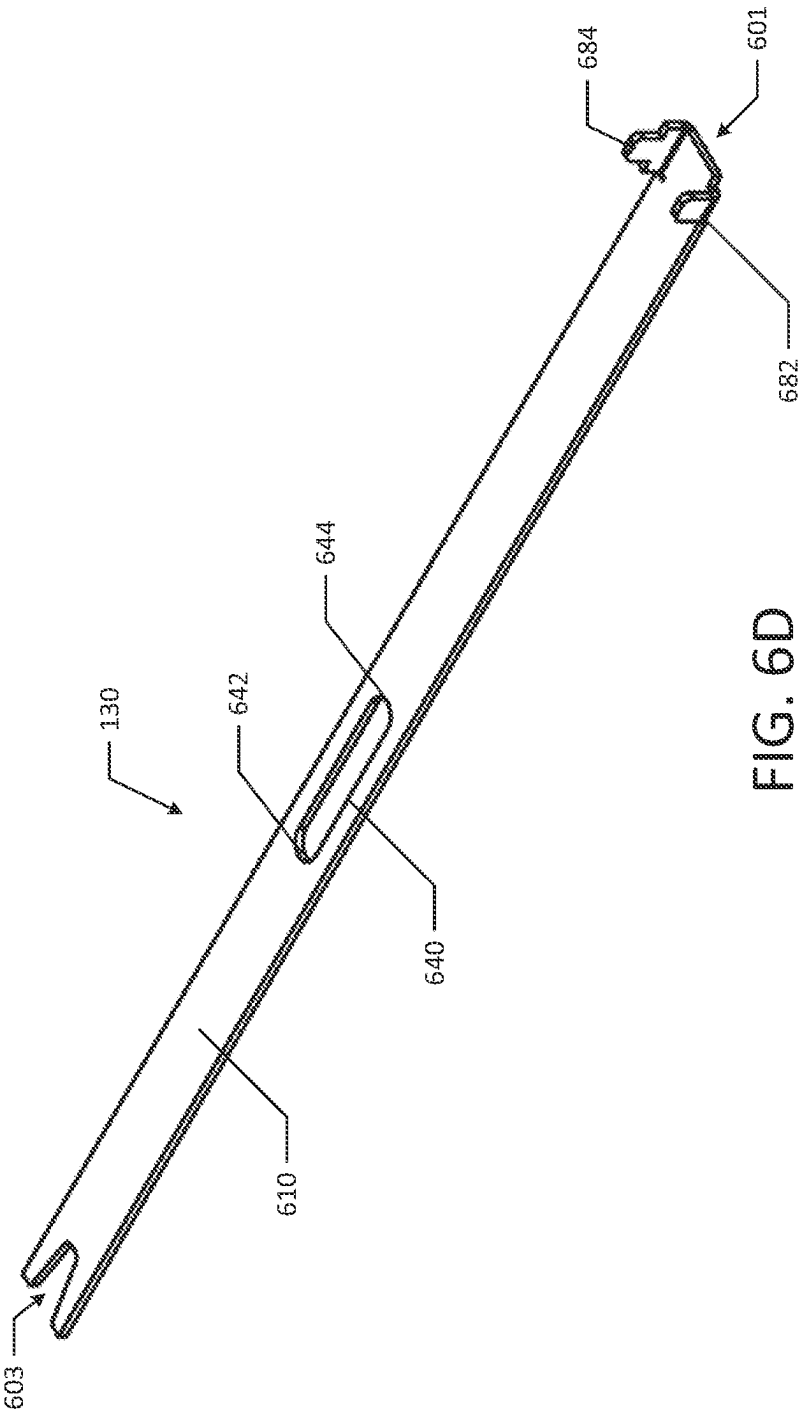


FIG. 5G





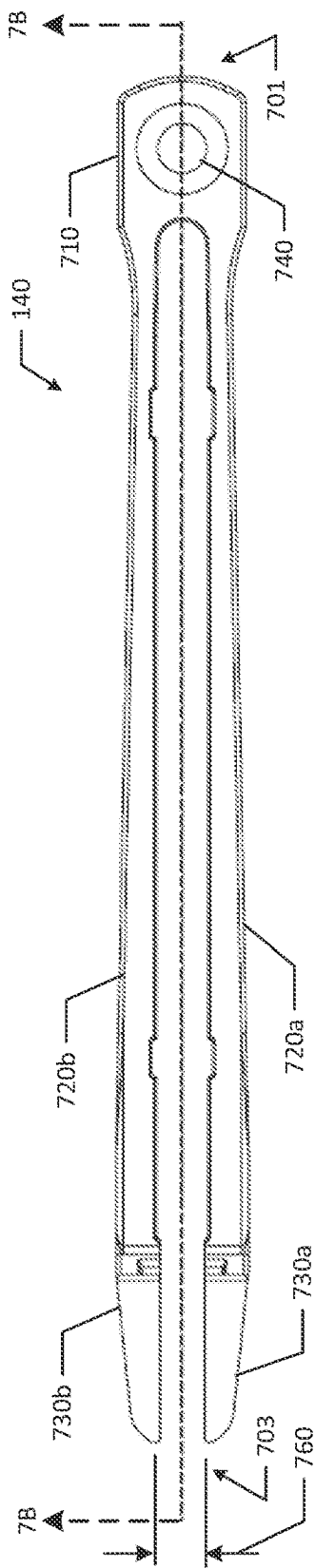


FIG. 7A

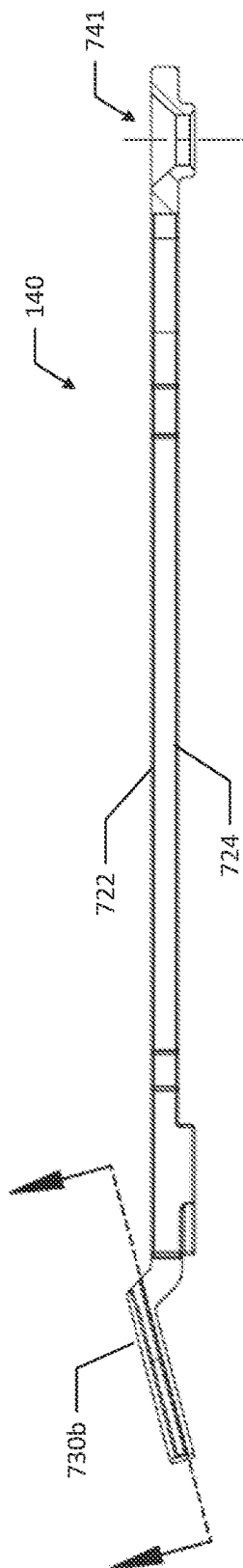


FIG. 7B

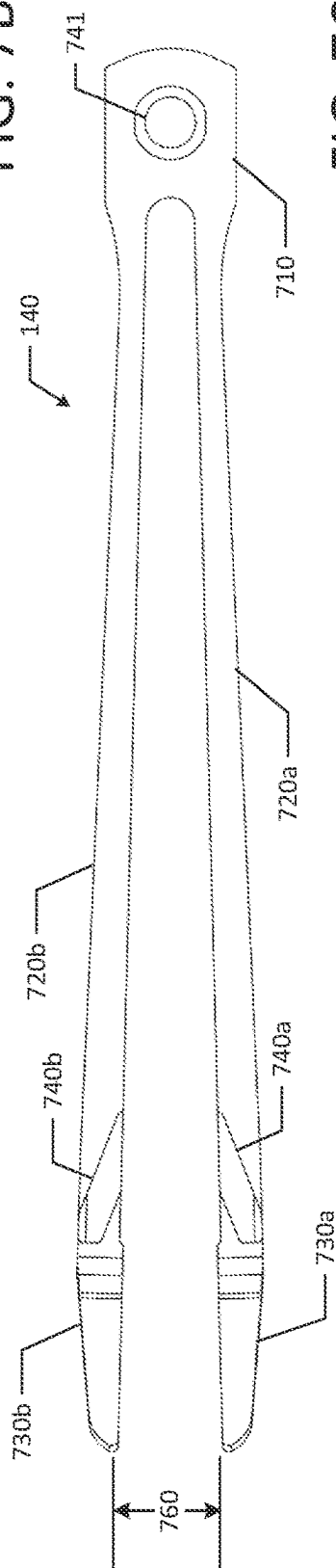


FIG. 7C

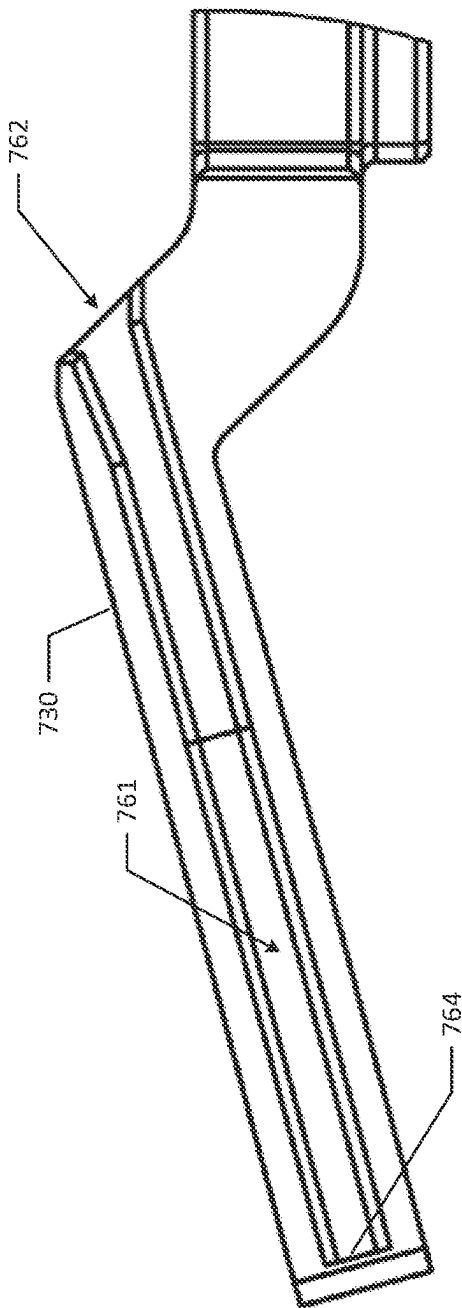
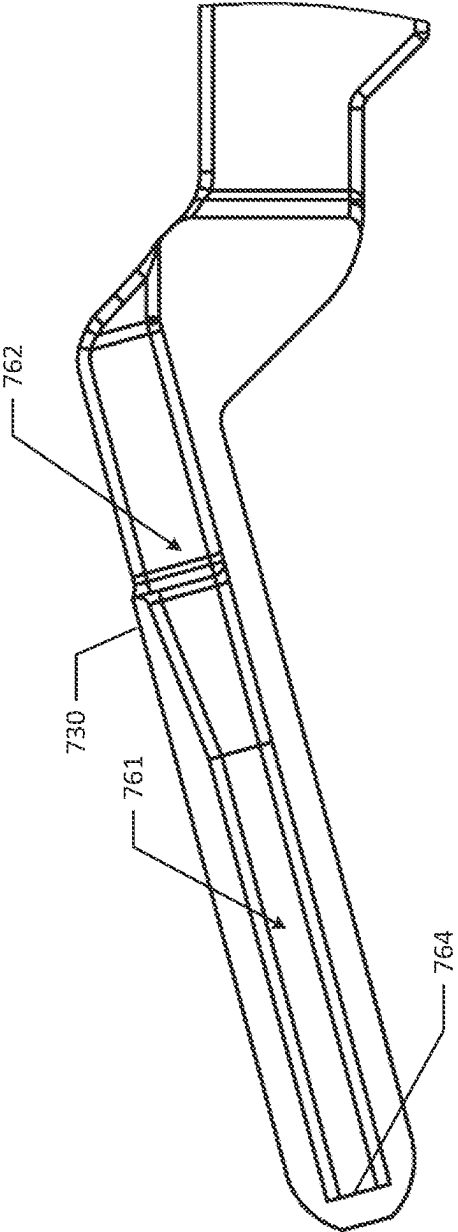
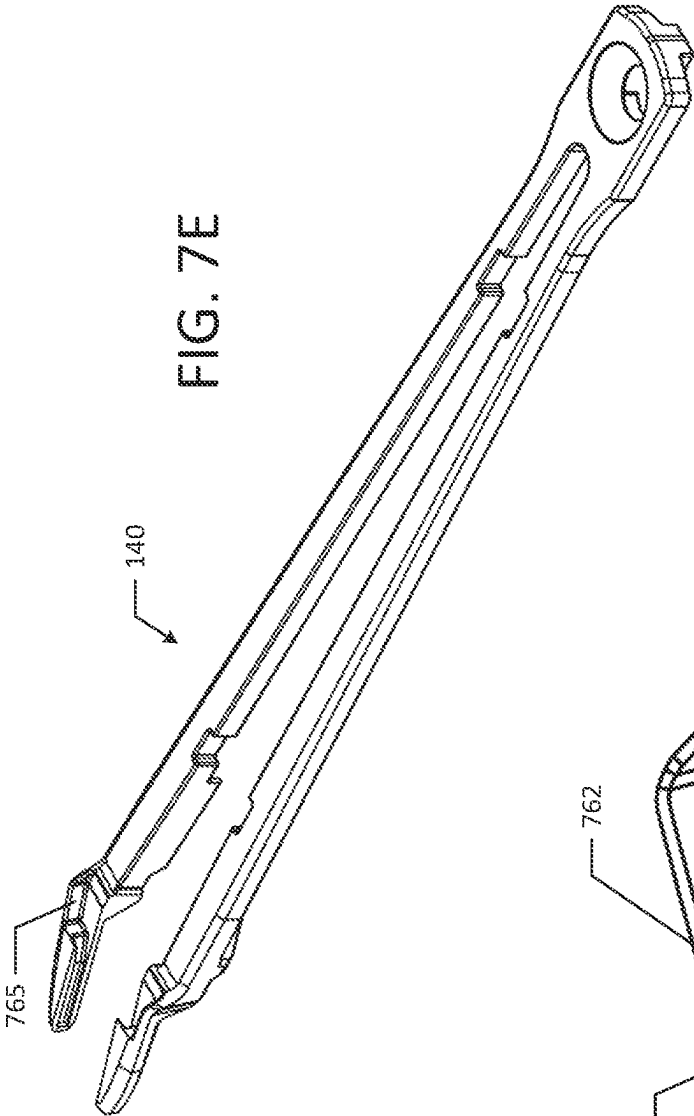


FIG. 7D



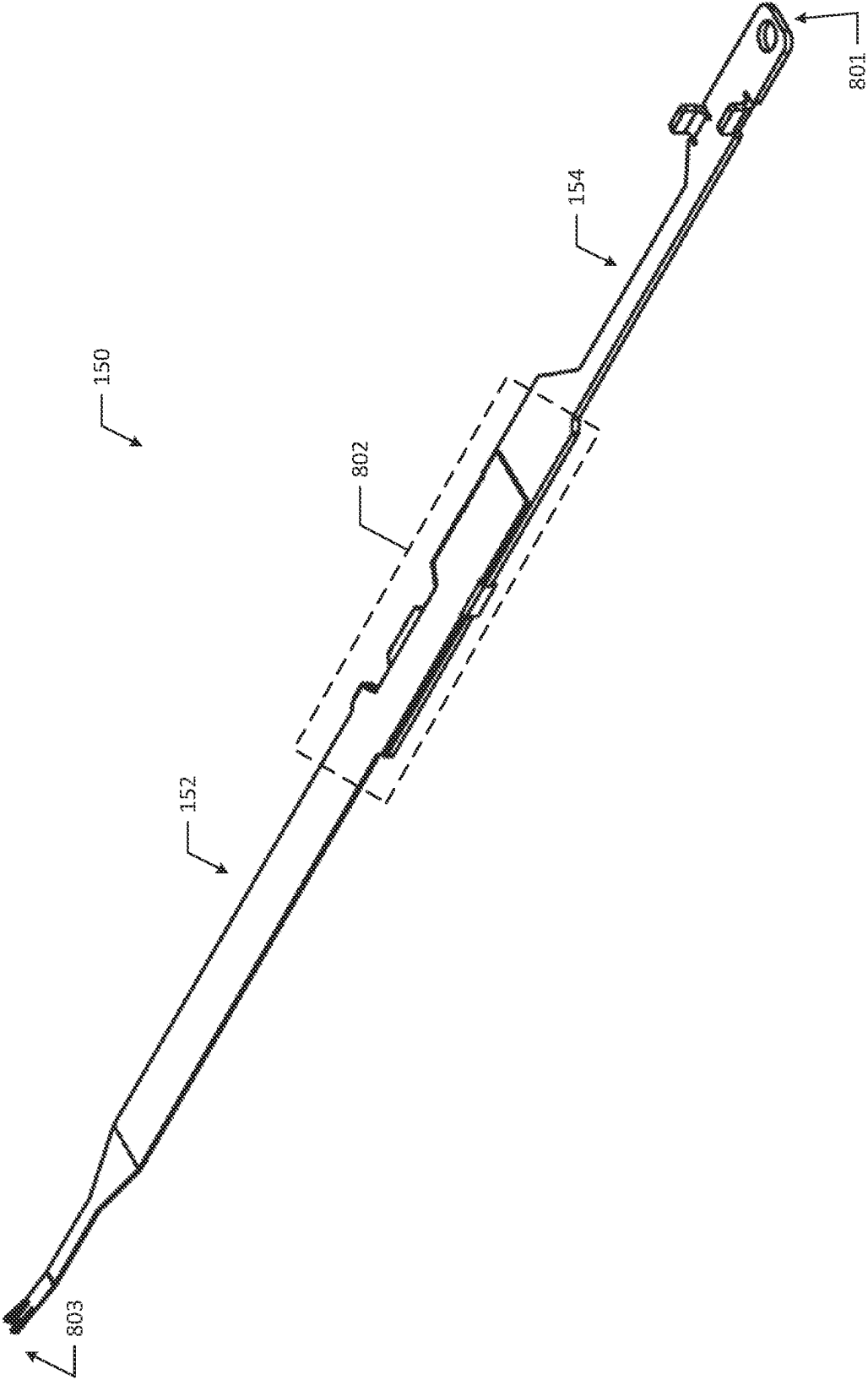
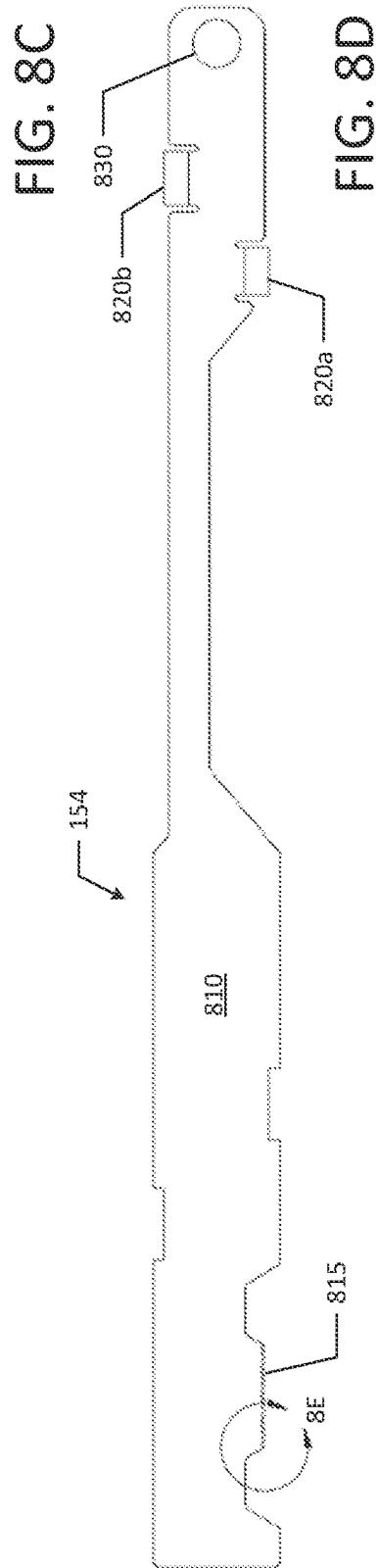
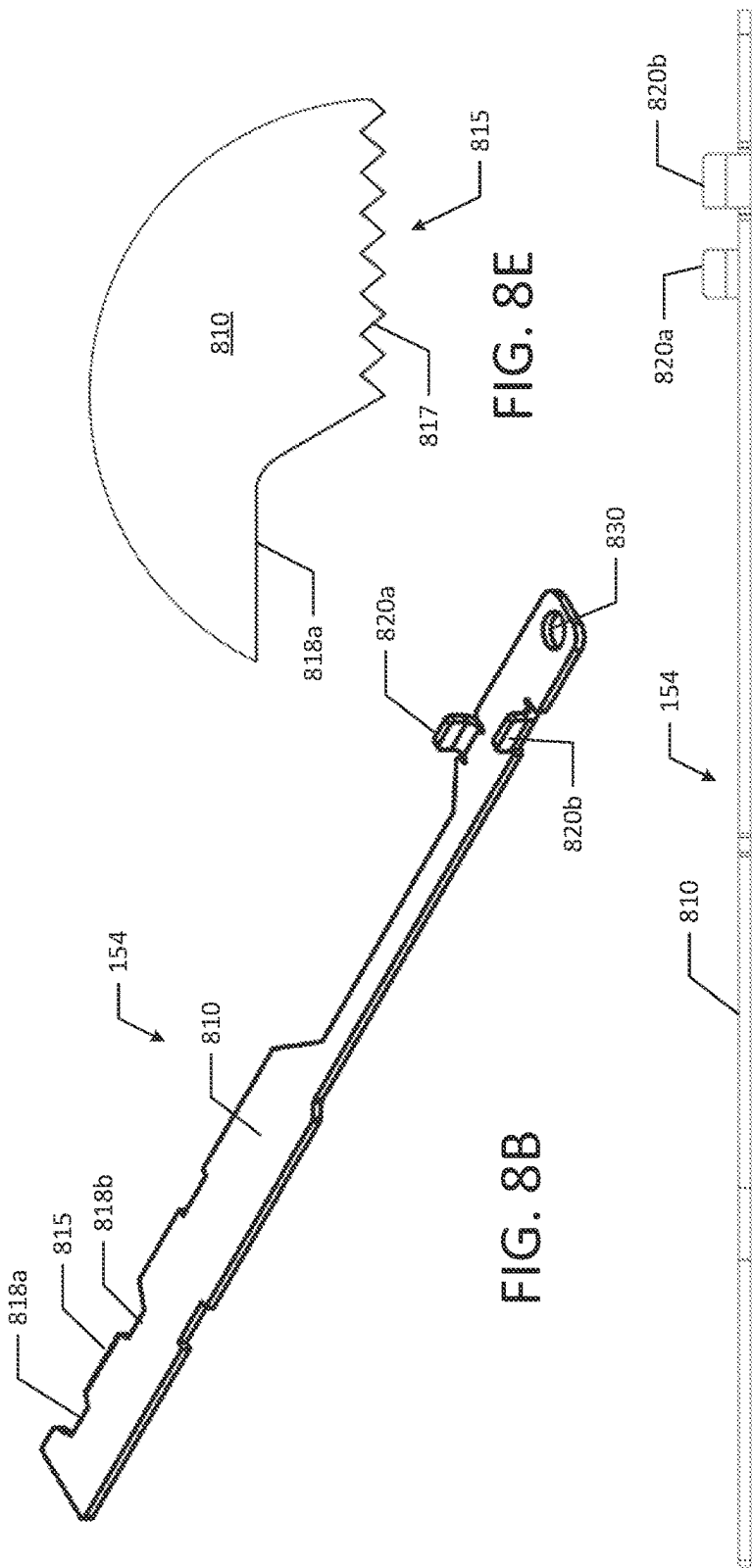
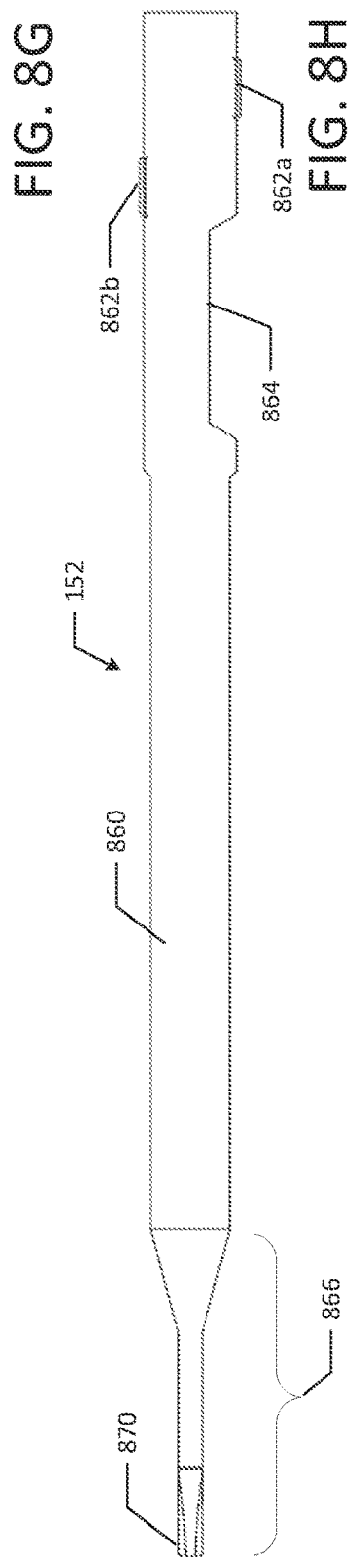
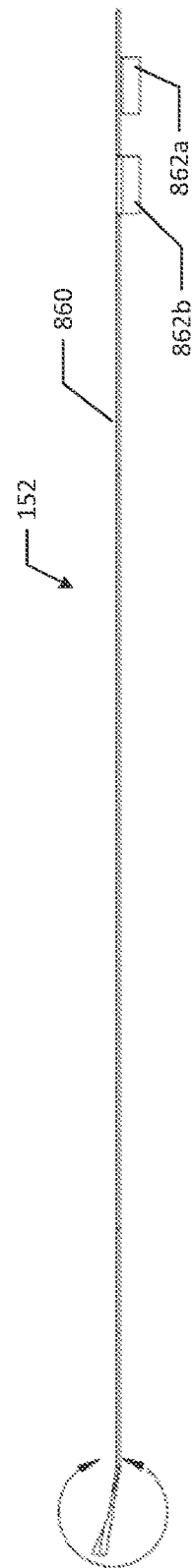
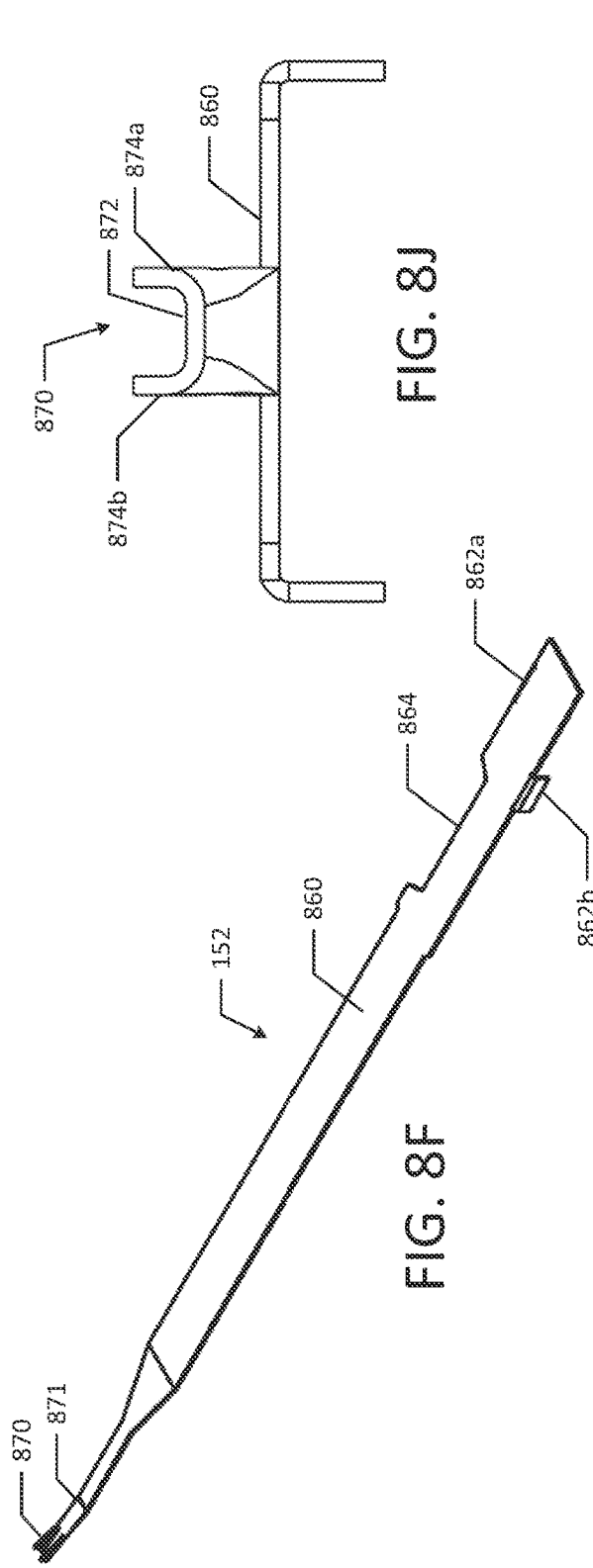


FIG. 8A





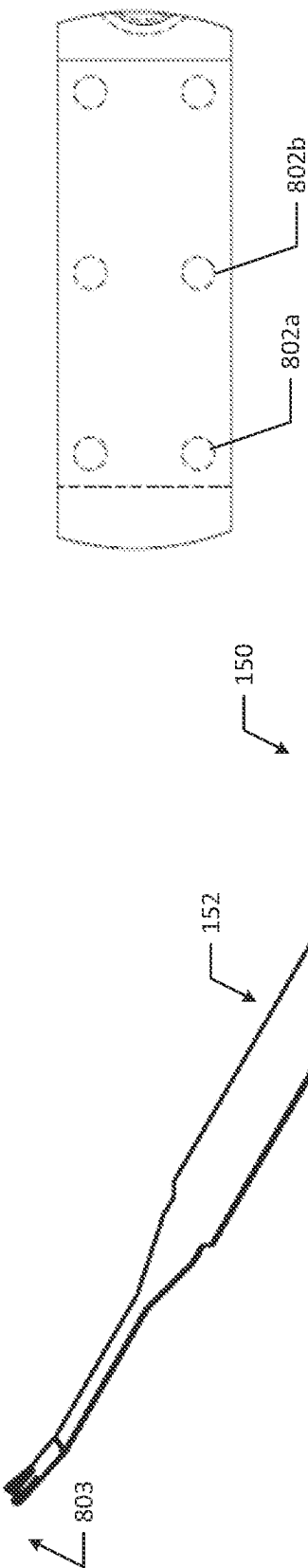


FIG. 8K

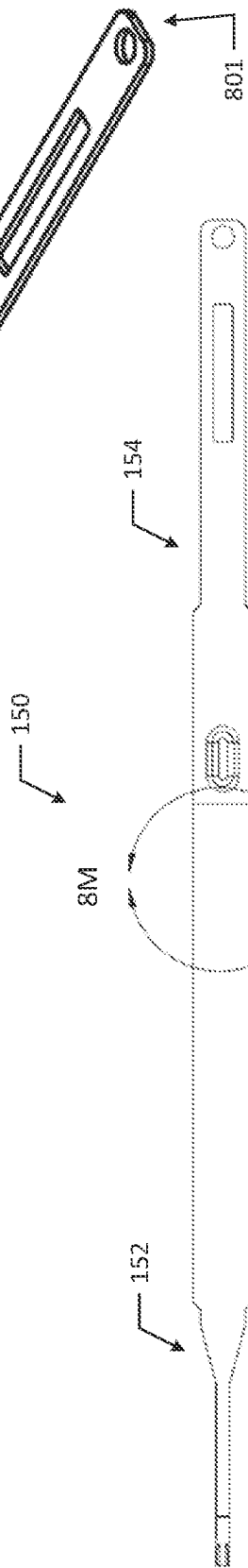
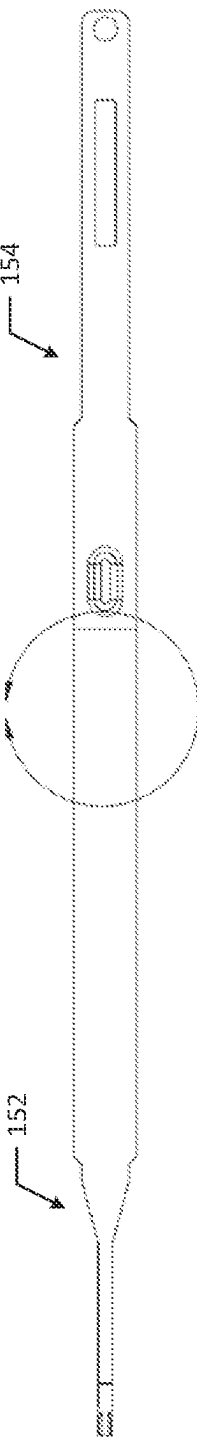
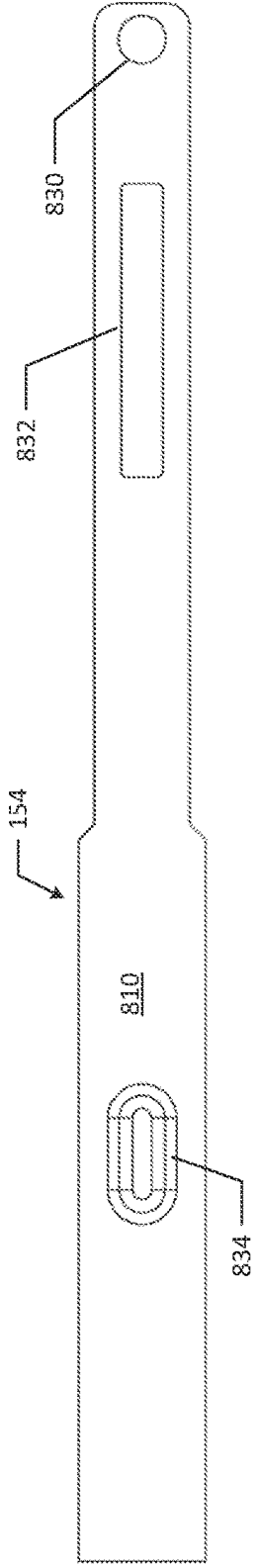
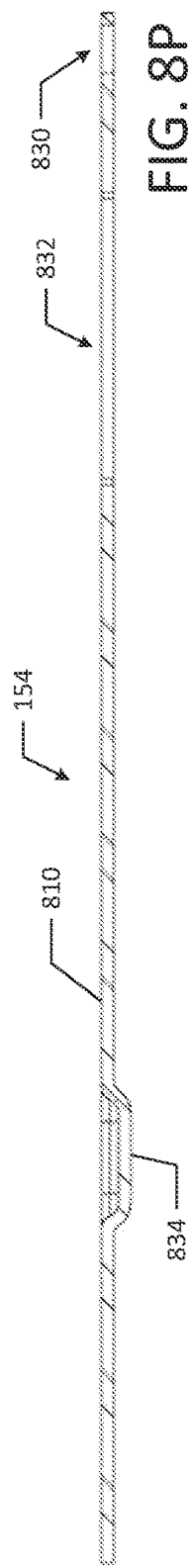
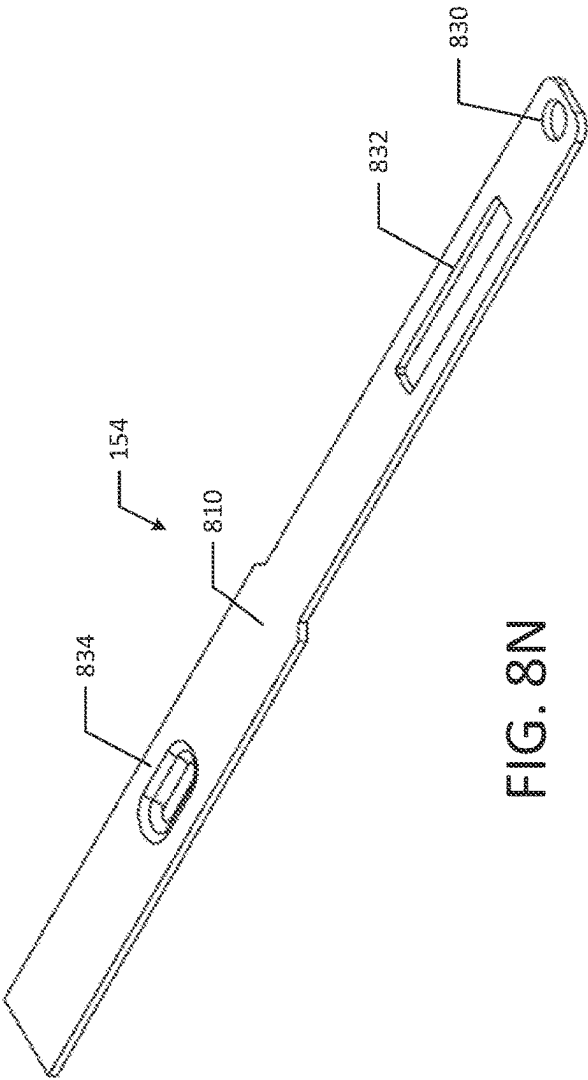


FIG. 8L





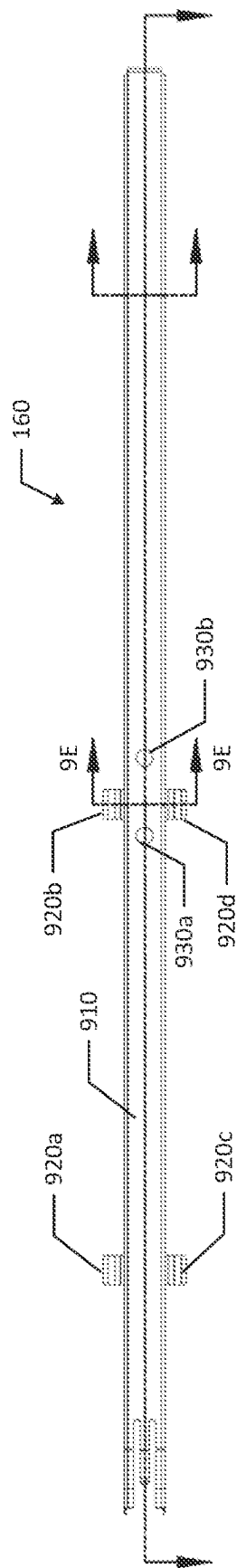


FIG. 9A

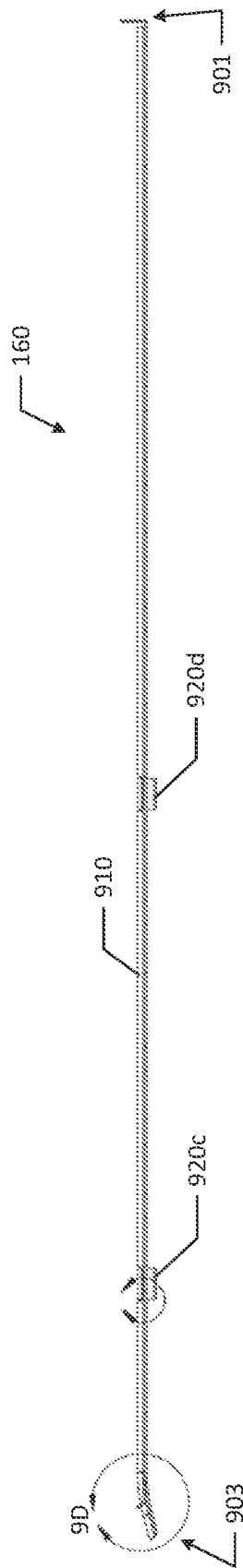


FIG. 9B

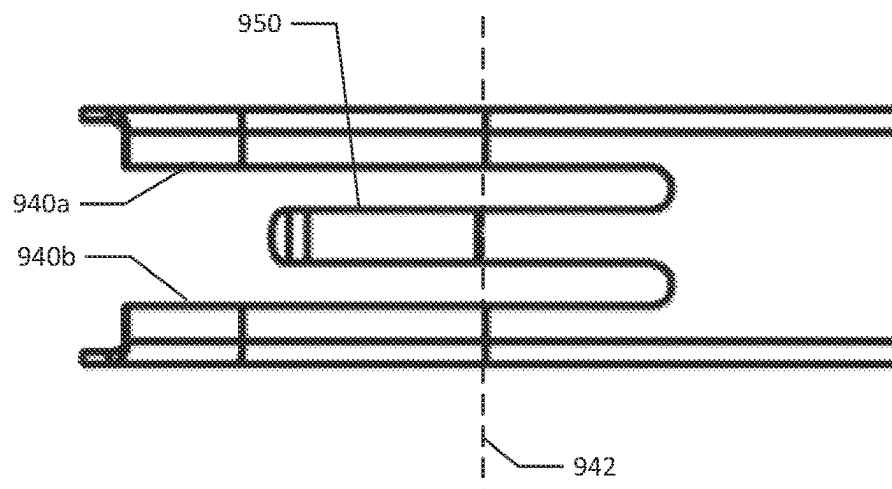


FIG. 9C

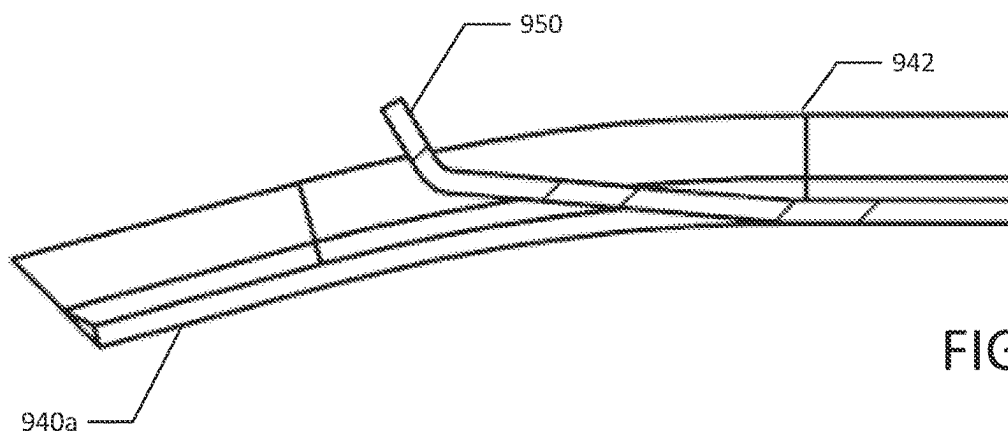


FIG. 9D

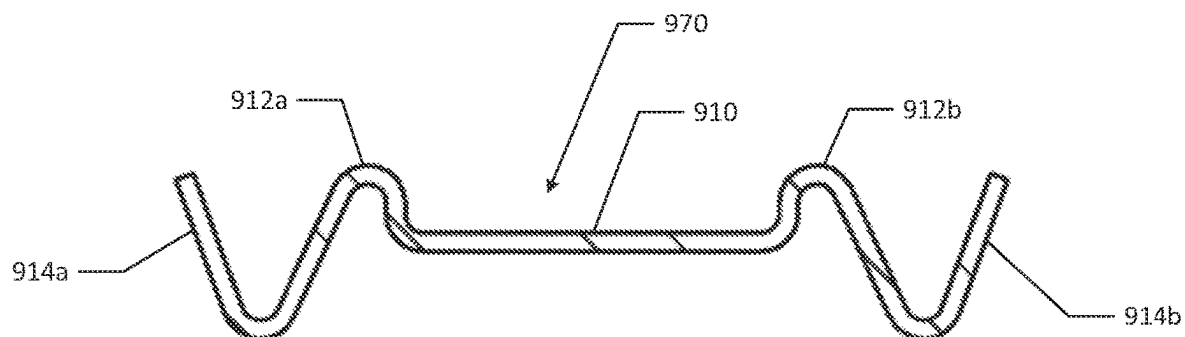


FIG. 9E

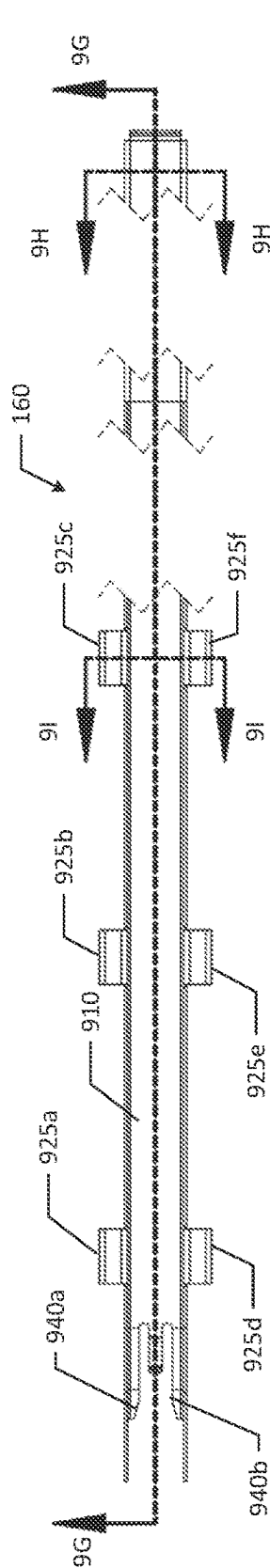


FIG. 9F

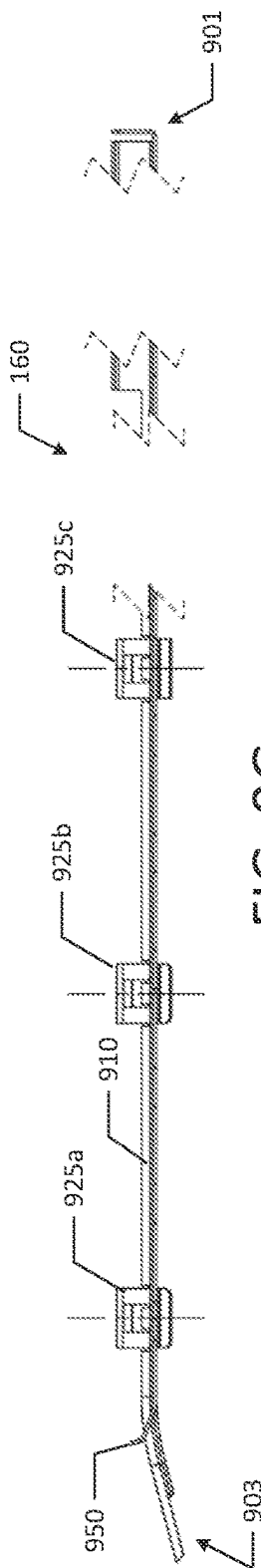


FIG. 9G

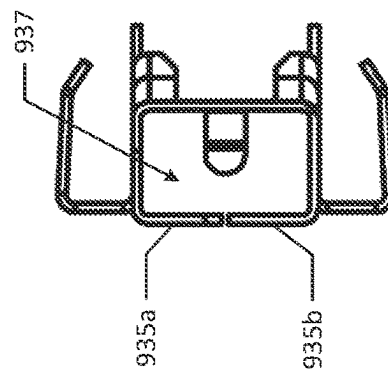


FIG. 9H

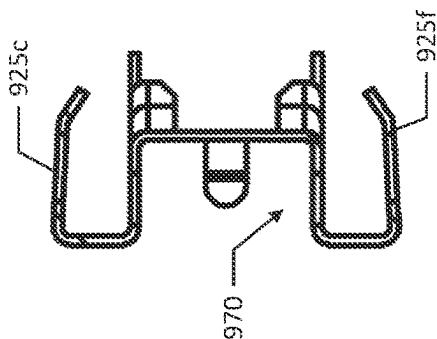
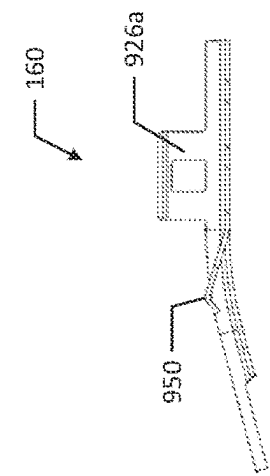
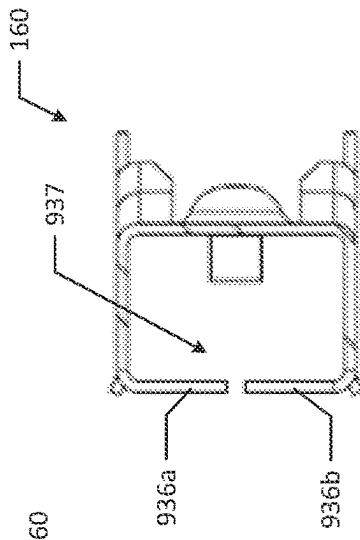
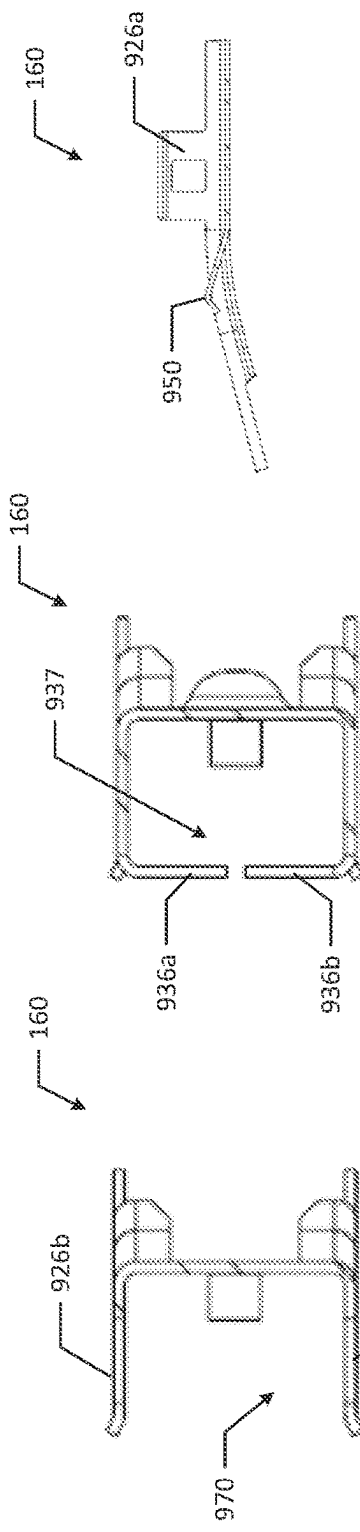
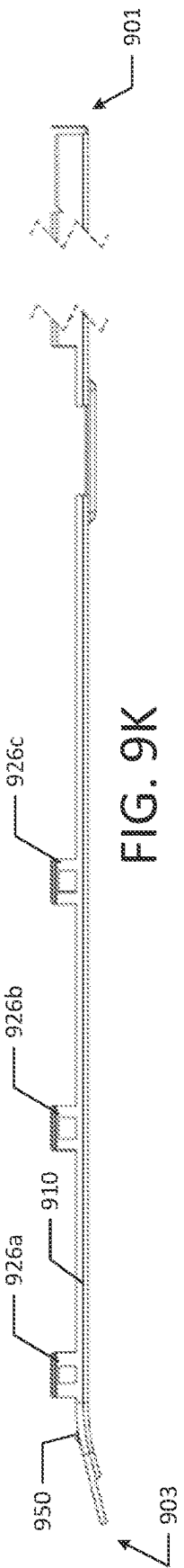
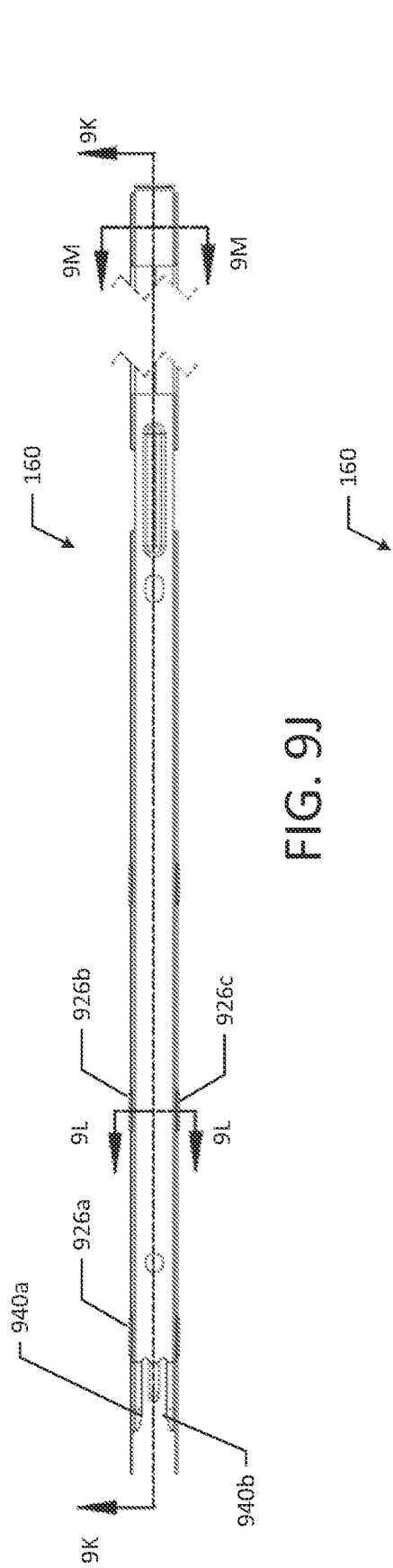
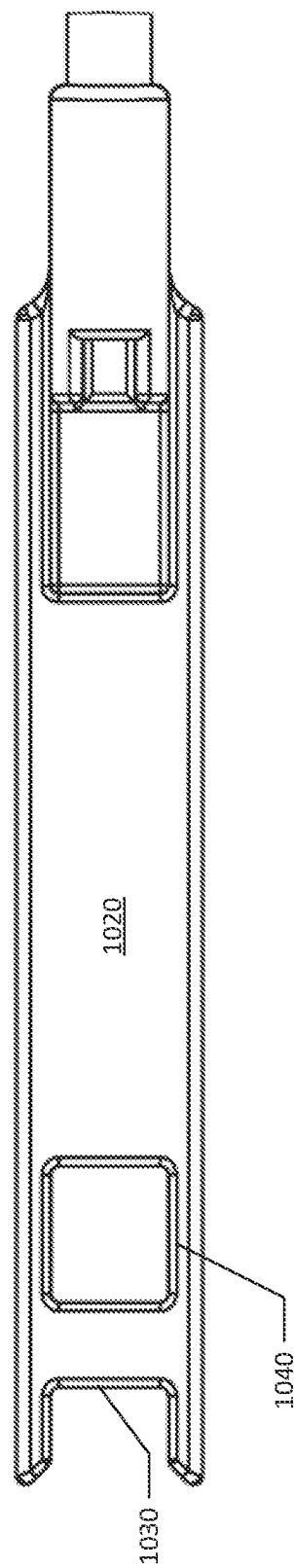
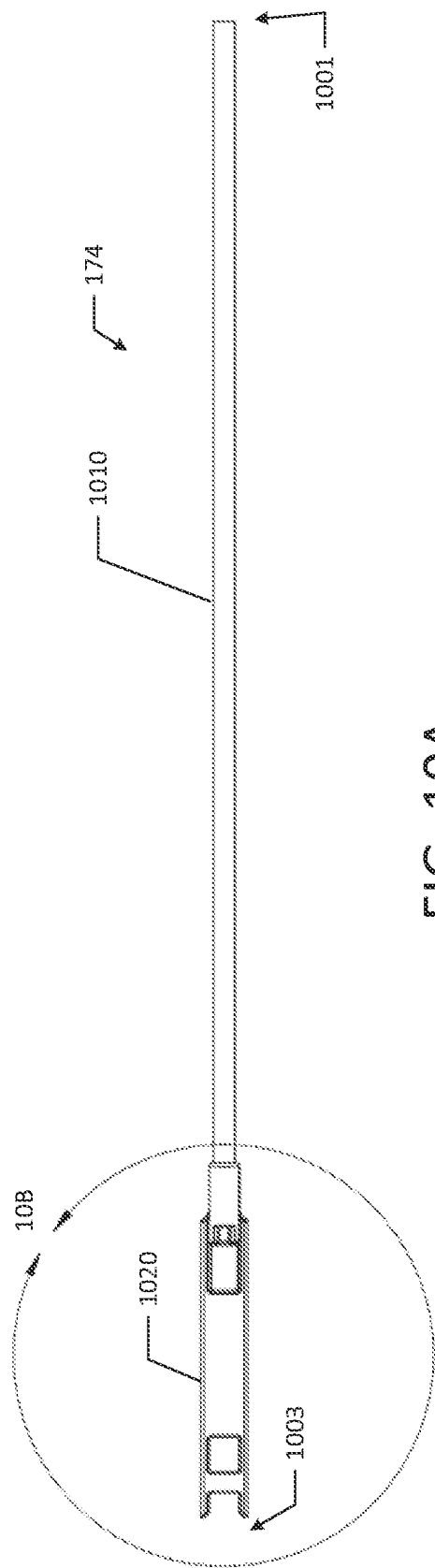


FIG. 9I





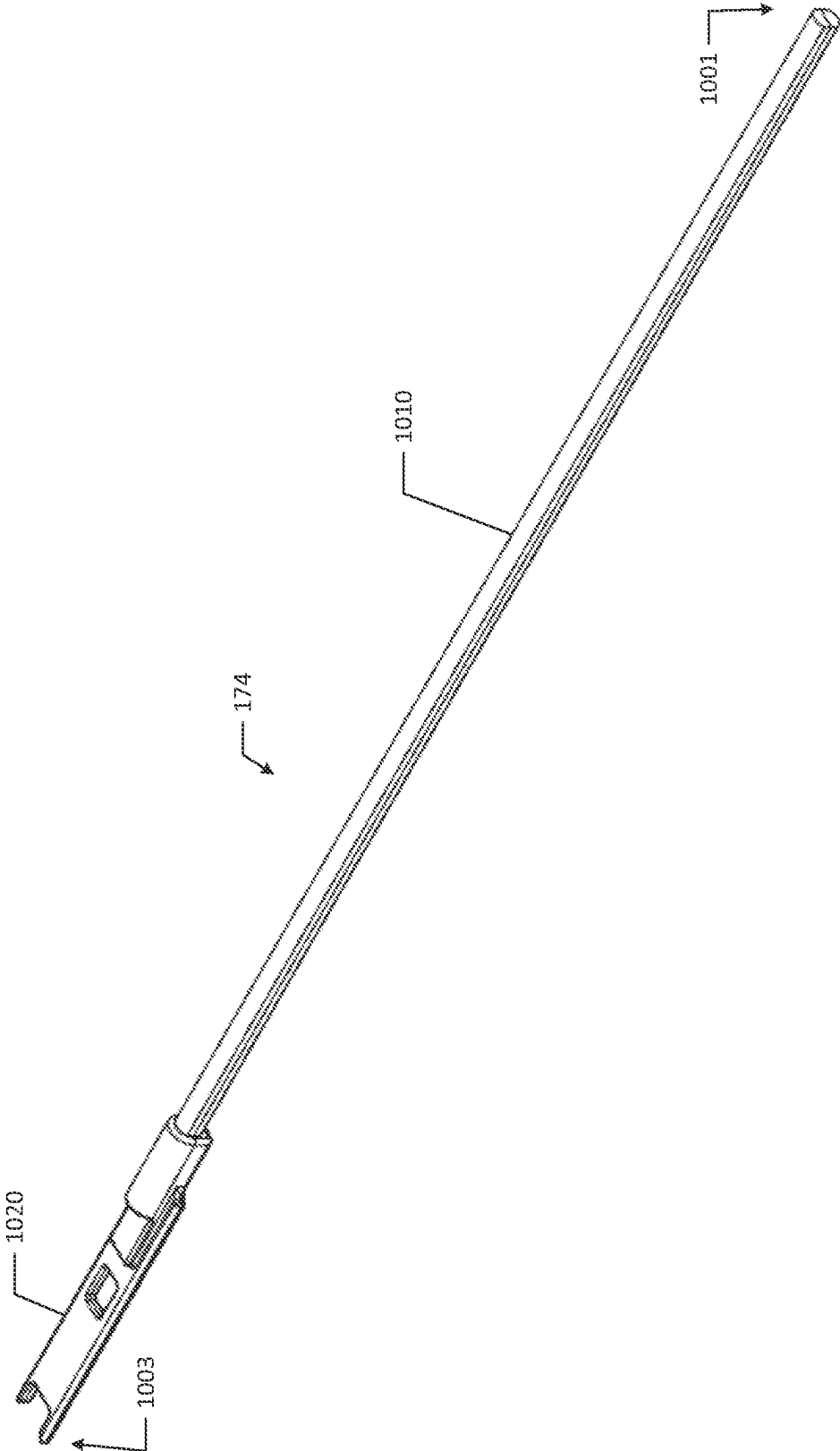
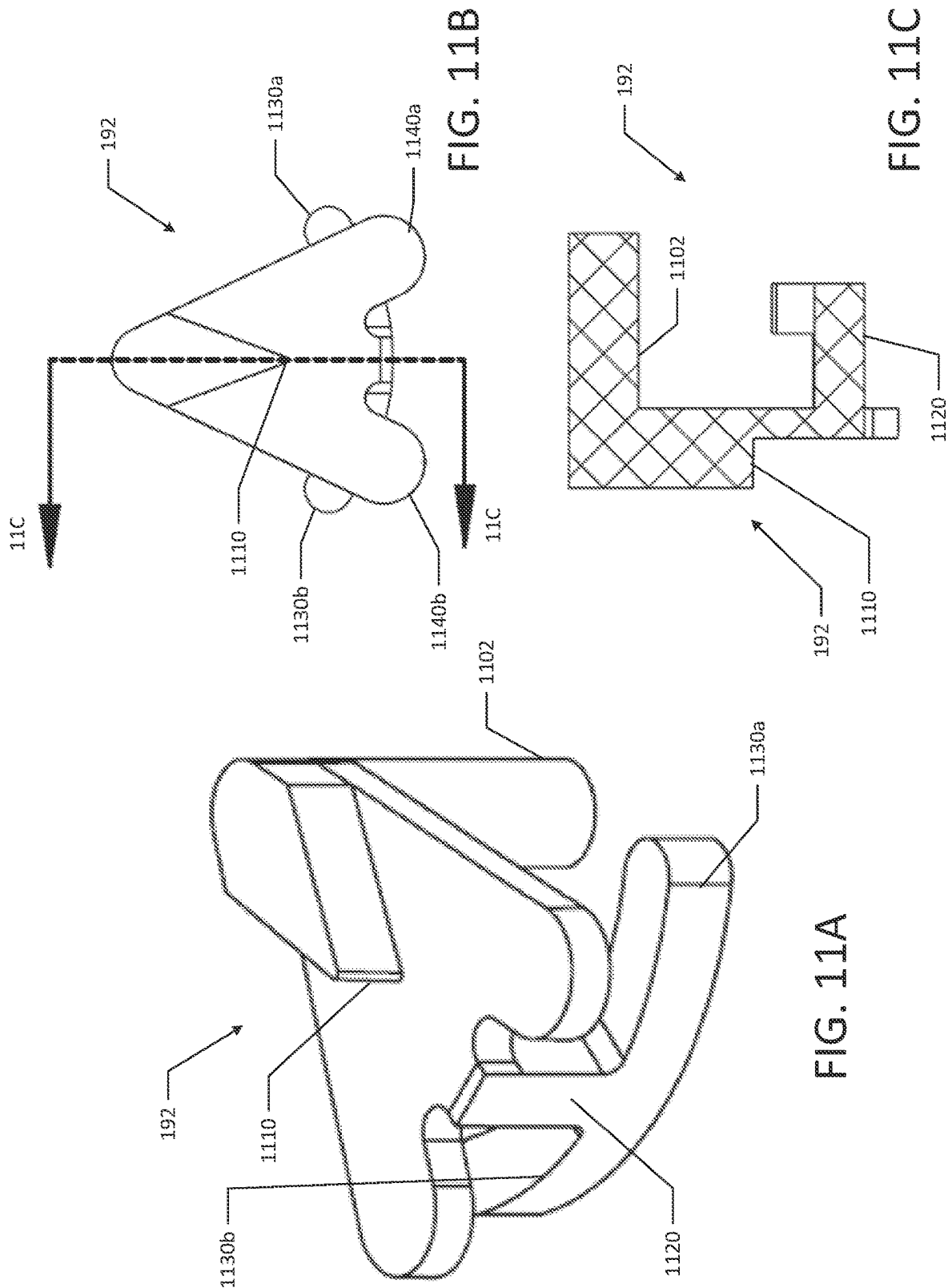


FIG. 10C



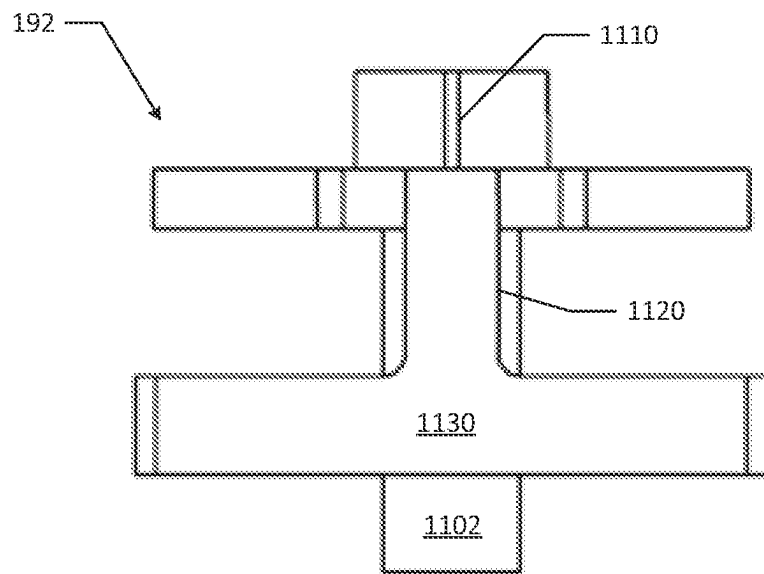


FIG. 11D

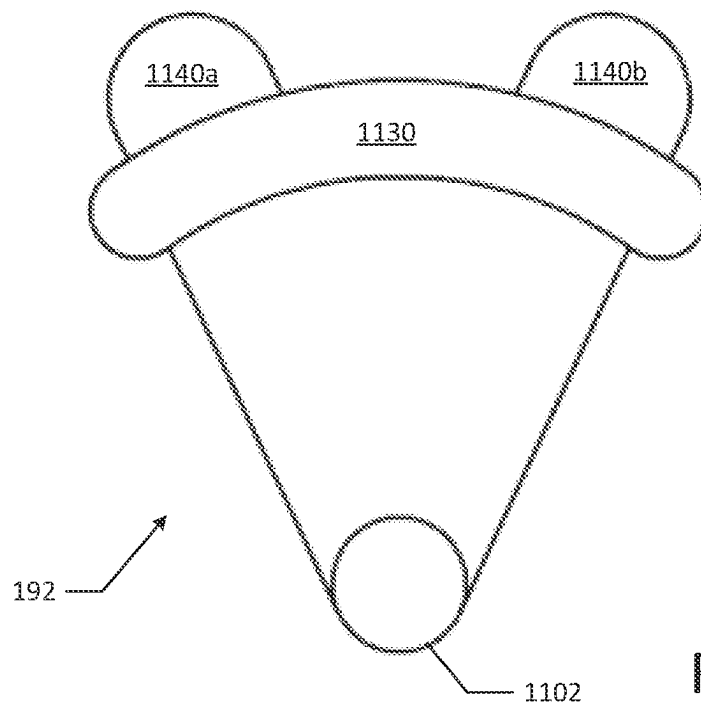


FIG. 11E

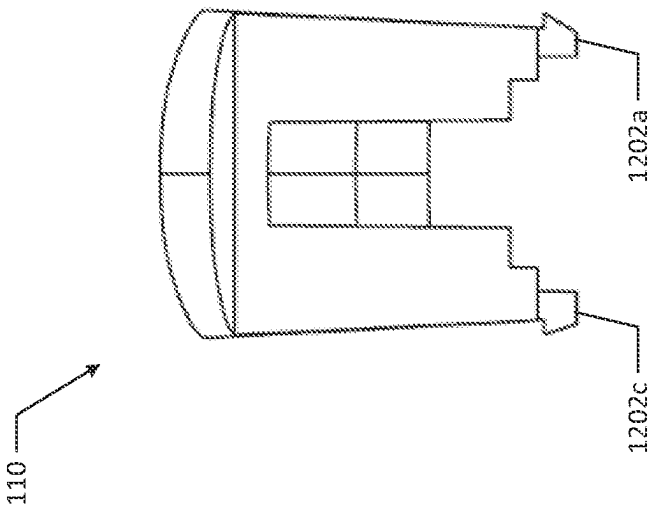


FIG. 12B

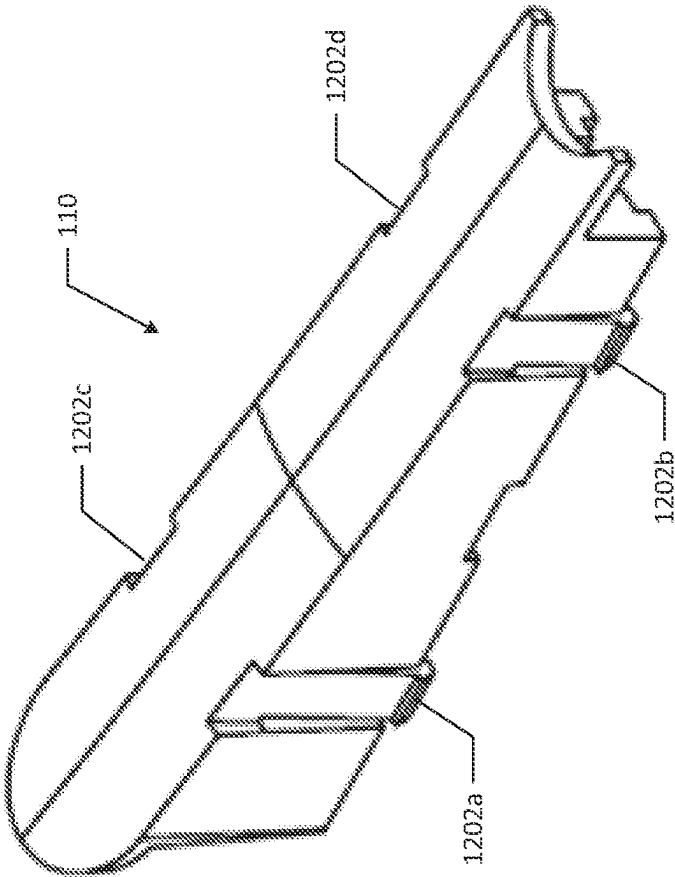


FIG. 12A

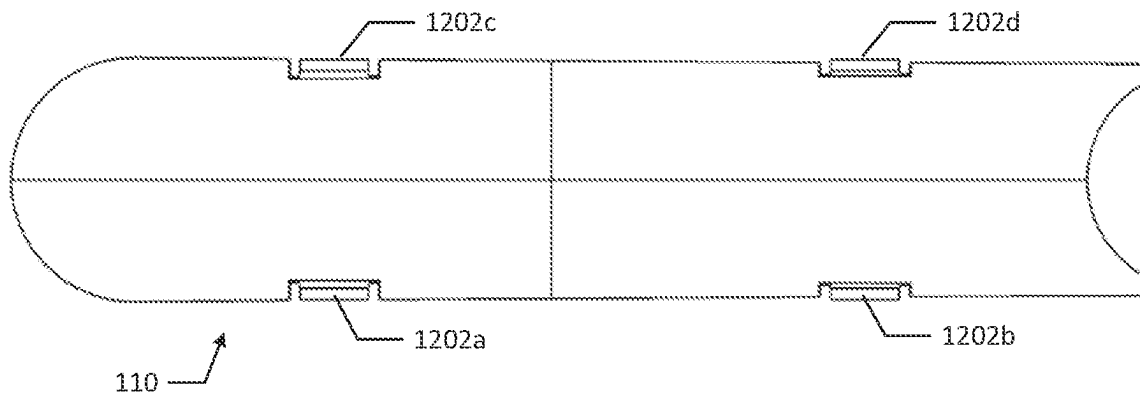


FIG. 12C

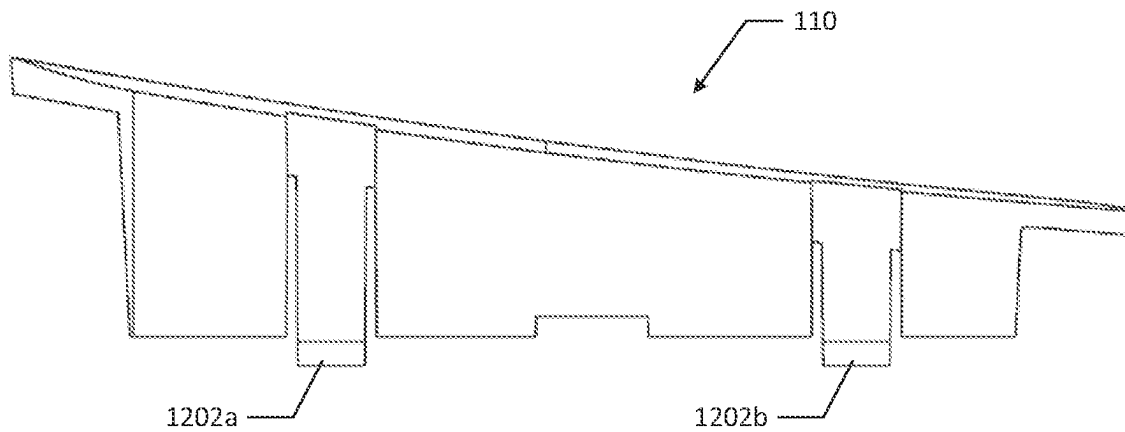


FIG. 12D

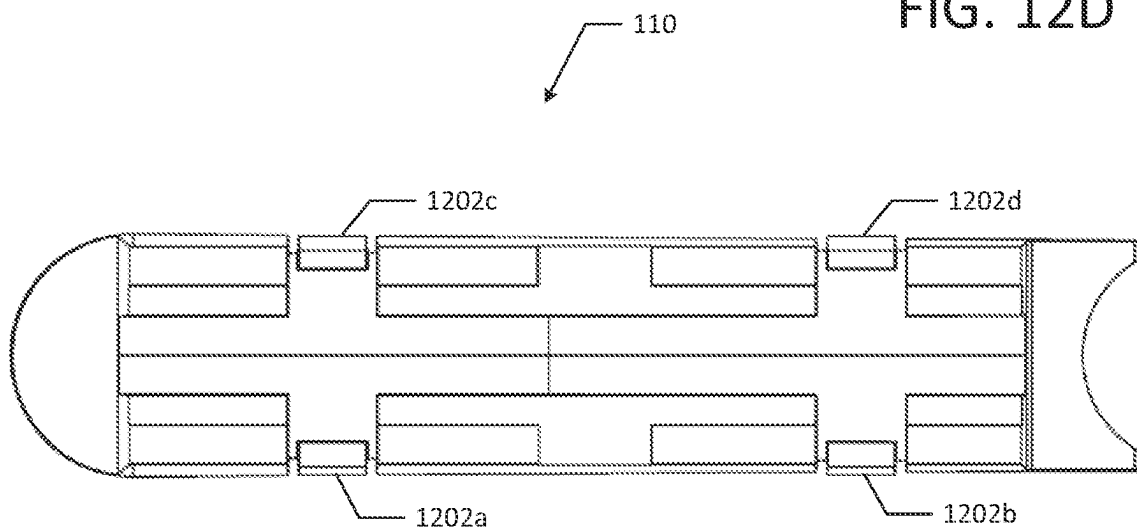


FIG. 12E

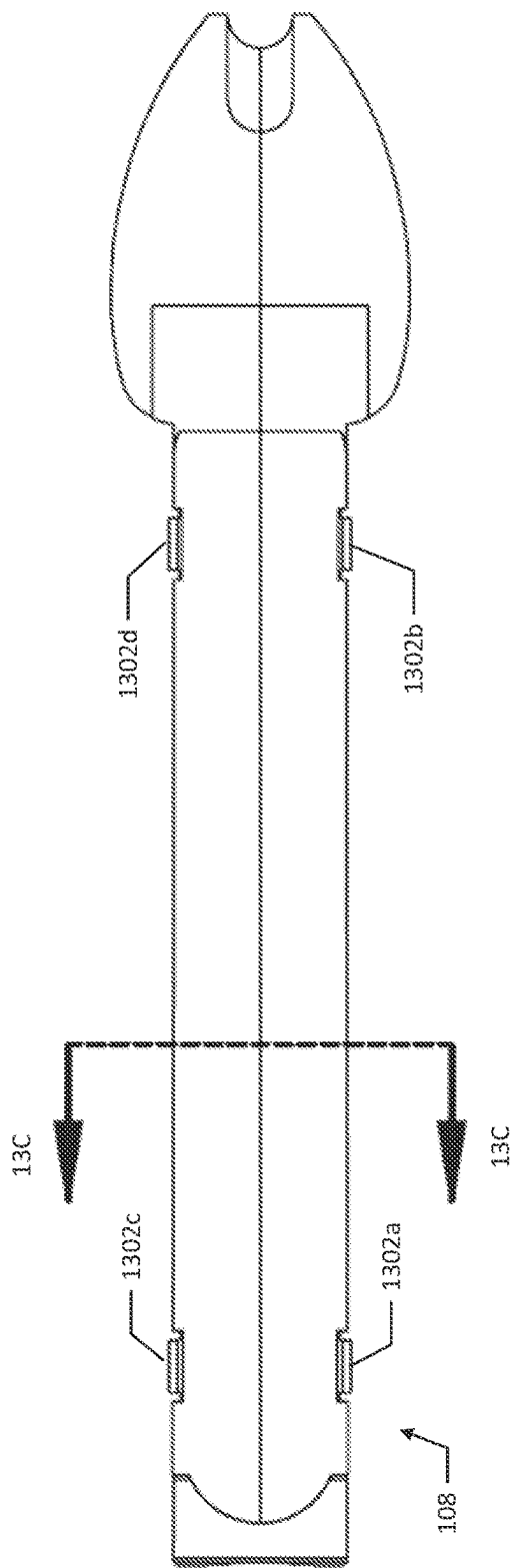


FIG. 13A

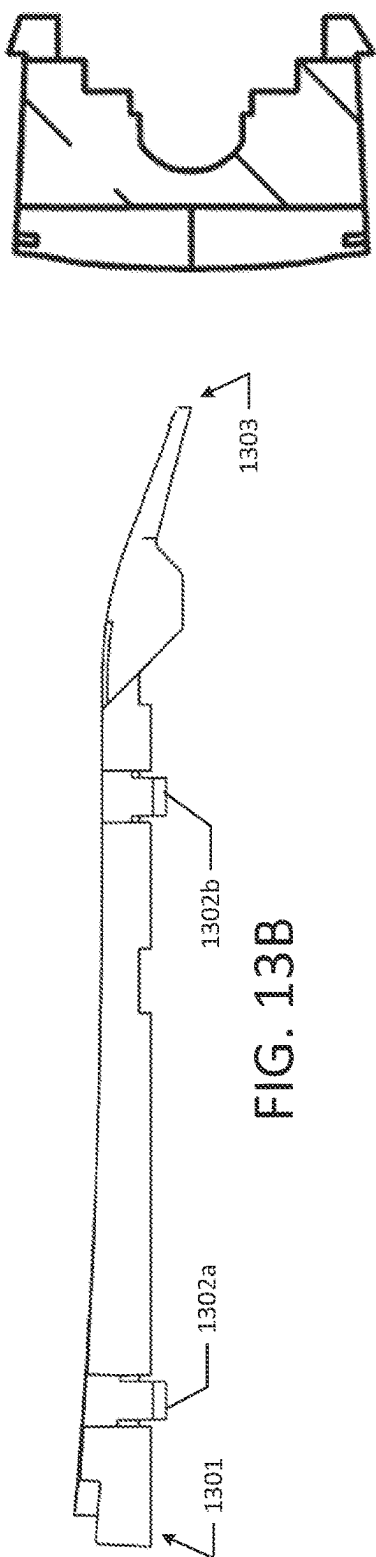
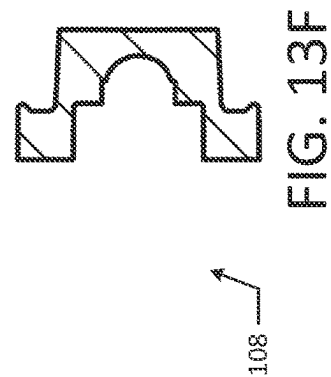
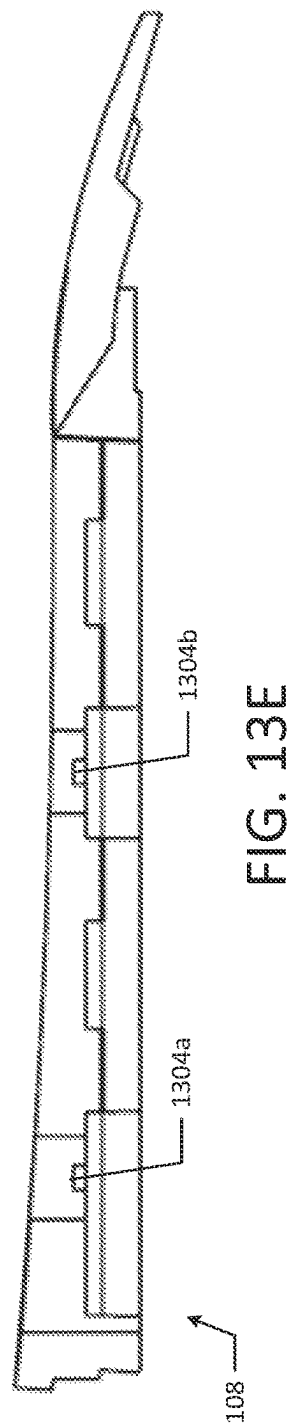
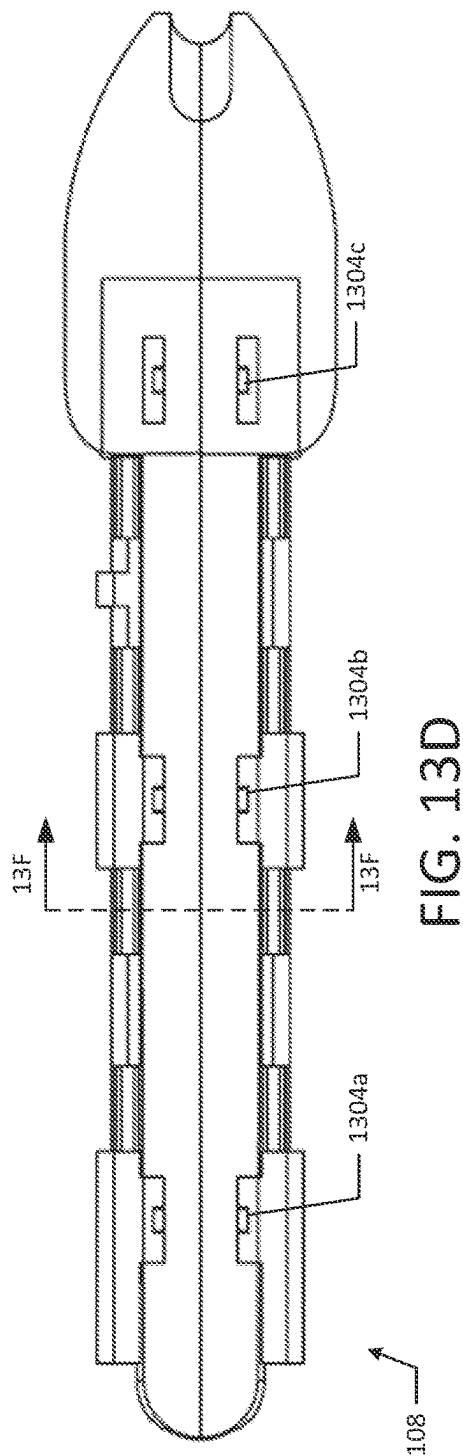


FIG. 13B

FIG. 13C



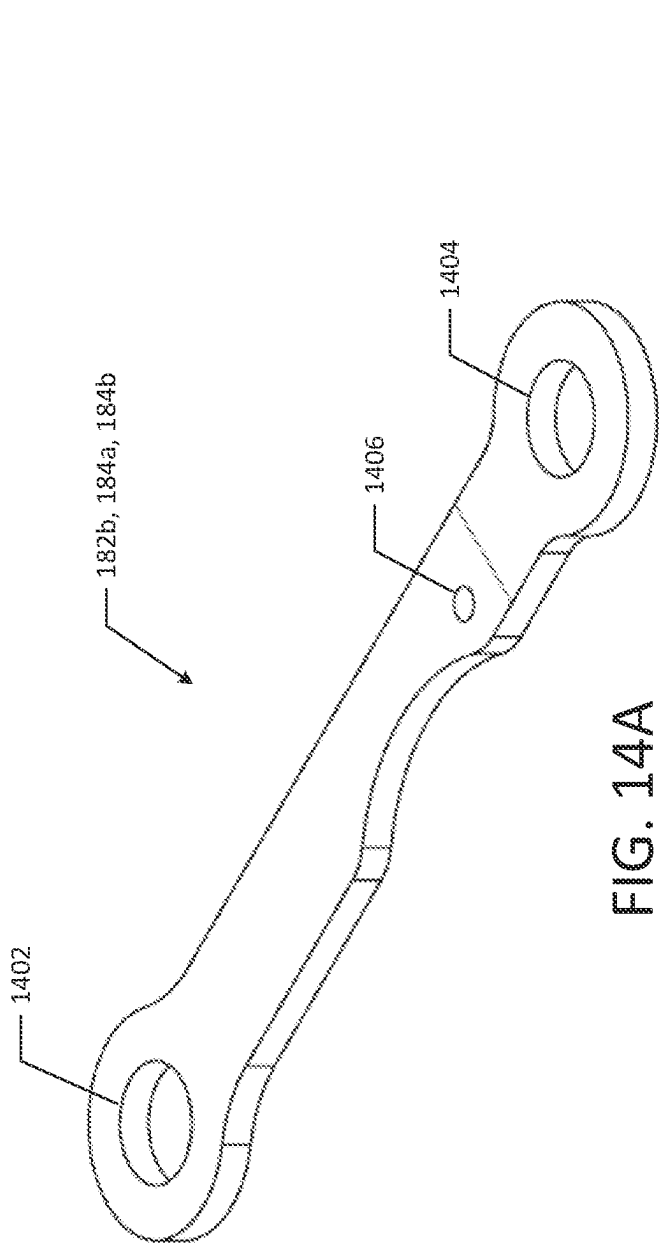


FIG. 14A

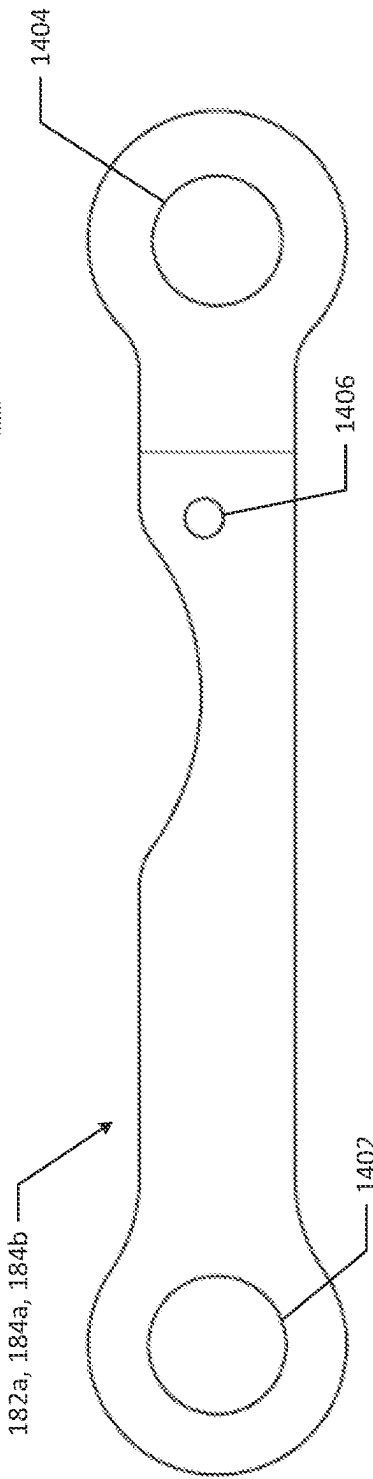
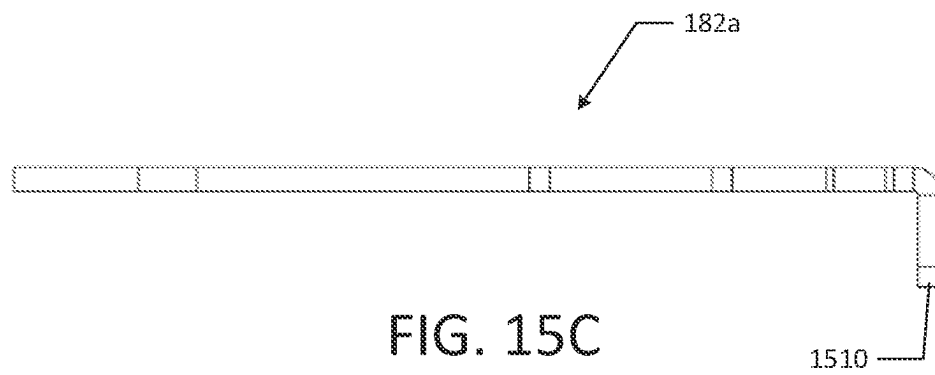
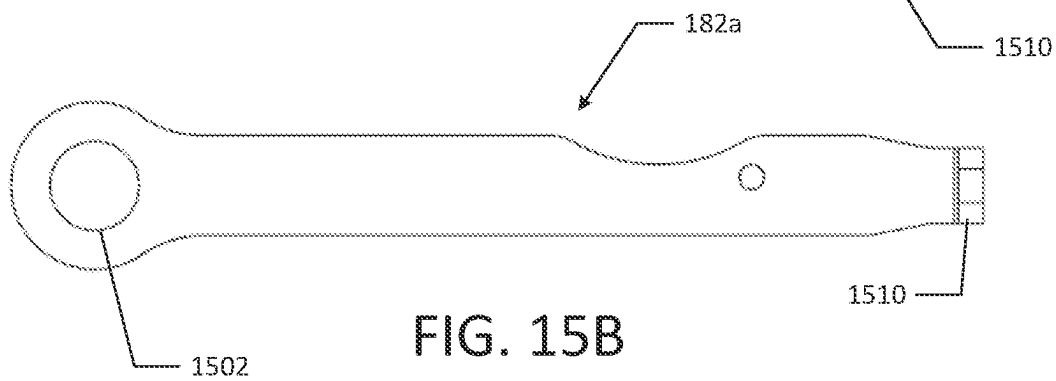
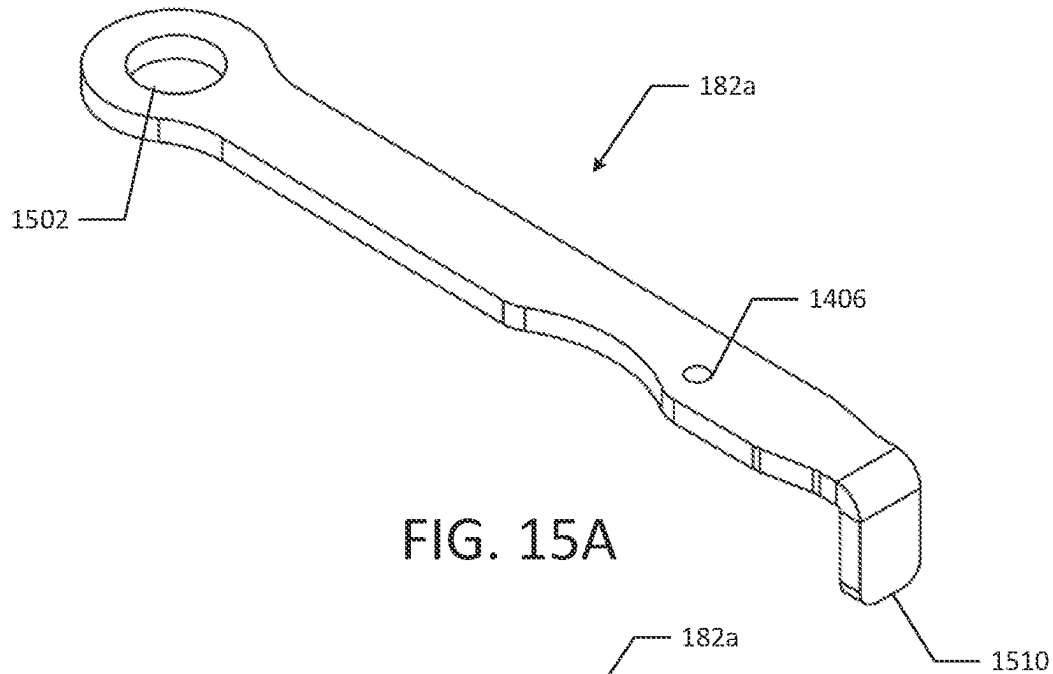


FIG. 14B



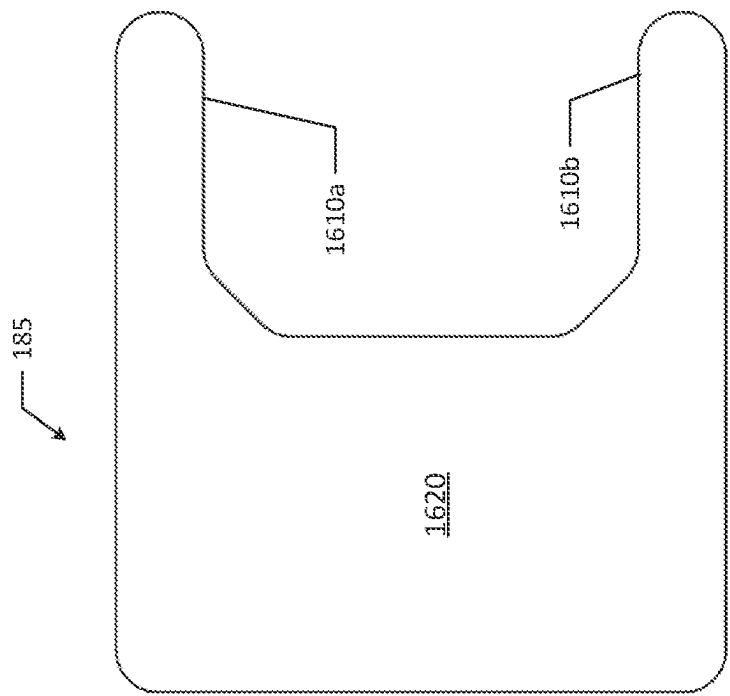


FIG. 16A

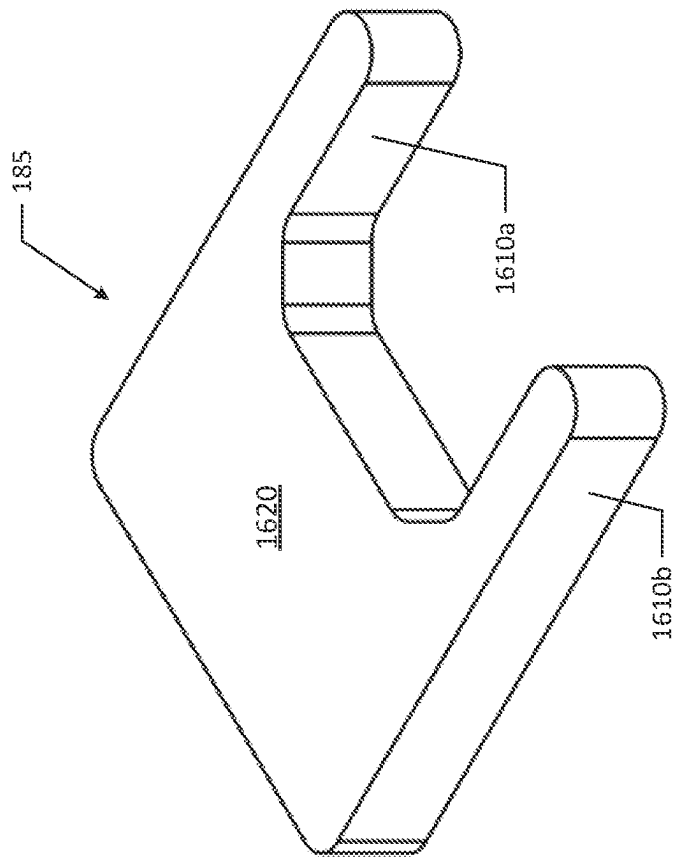


FIG. 16B

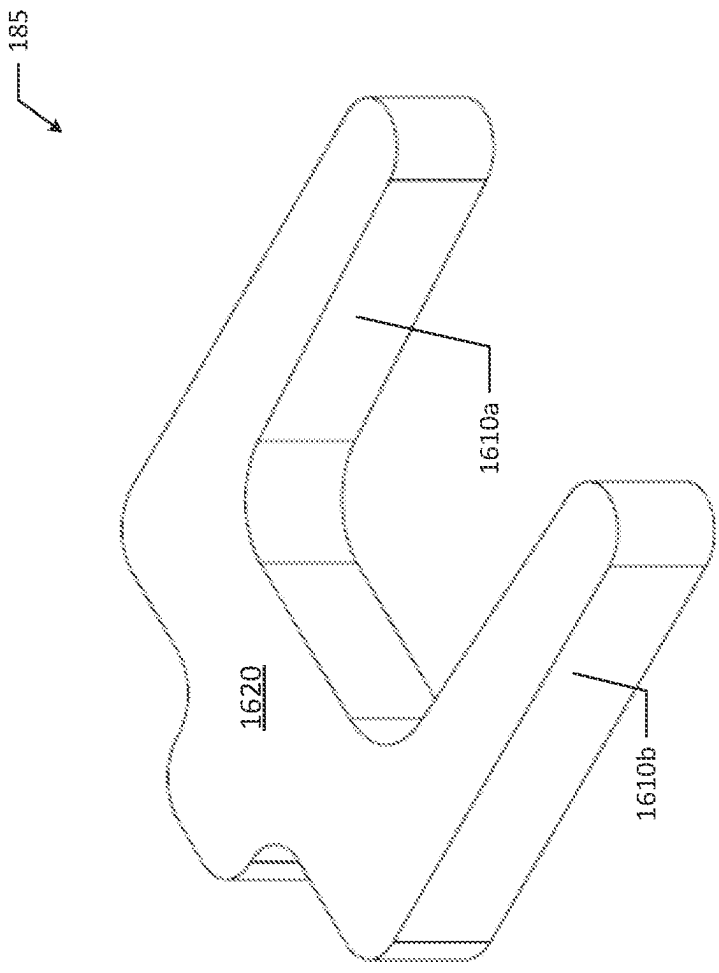


FIG. 16C

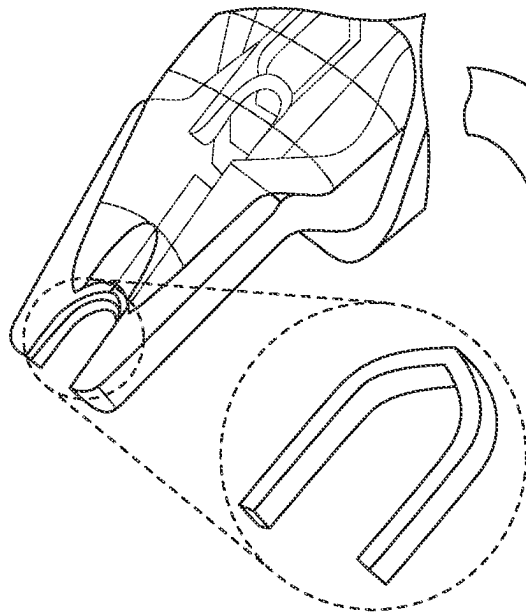


FIG. 17A

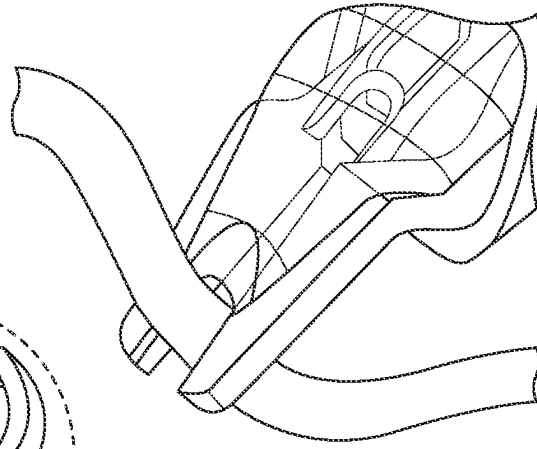


FIG. 17B

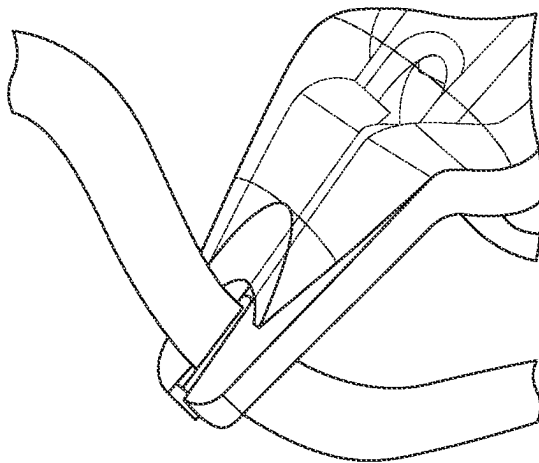


FIG. 17C

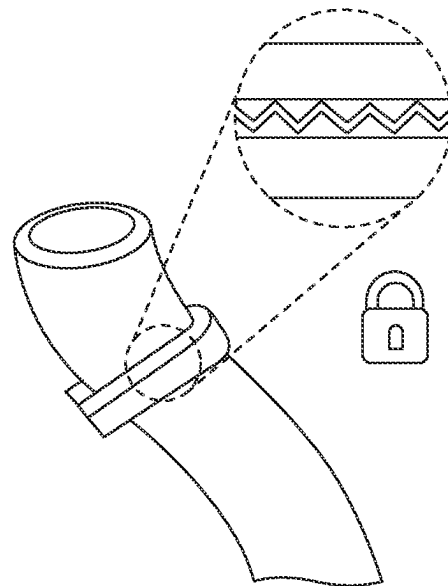


FIG. 17D

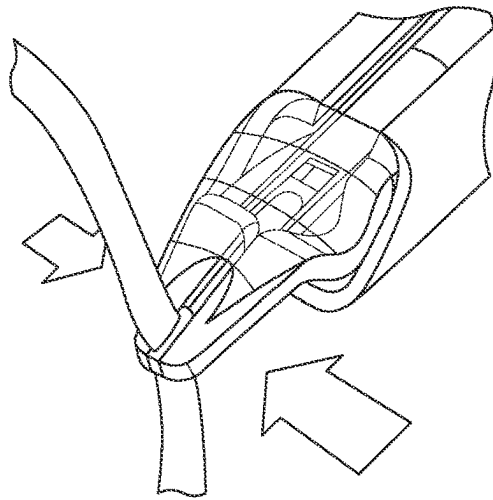


FIG. 17E

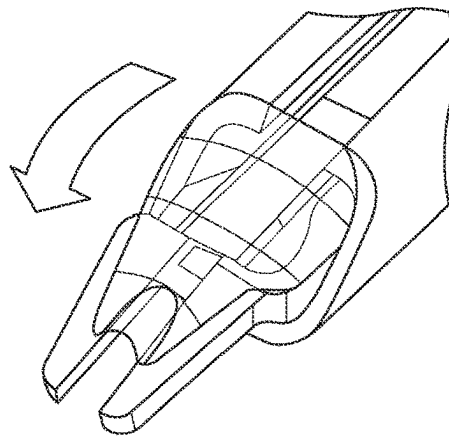


FIG. 17F

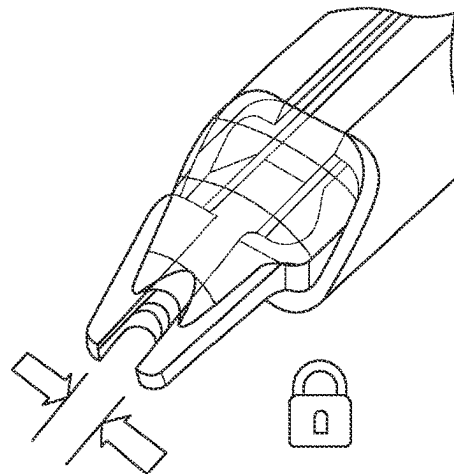


FIG. 17G

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SURGICAL CLIP APPLICATION DEVICE**CROSS-REFERENCE TO RELATED APPLICATIONS**

The present application claims priority to U.S. Patent Application No. 63/241,288, filed on Sep. 7, 2021, the disclosure of which is incorporated herein by reference for all purposes.

BACKGROUND

Clip application devices or clip applicators may be used during microsurgery procedures. Microsurgery covers a variety of procedures using a microscope for operating on successively smaller blood vessels, nerves, etc. Conventional suturing techniques in microsurgery have given way to the use of surgical clips, which are applied at the end of a severed vessel or at a junction of vessels. For example, the surgical clips hold or close the tissue in a similar fashion as conventional sutures. The clips used in microsurgery are very small and are typically called microclips. An example microclip may have a size on the order of 2 mm high and 2 mm wide.

Microclips are commonly applied in surgery by forceps that load and use a single clip at a time. Single load-and-use devices are burdensome to medical professionals, as several clips may be required for a surgical procedure. The numerous reloading actions may cause handling accidents (e.g., dropping a clip on the floor, dropping an instrument, dropping a closed or partially closed clip into a wound), mis-loaded clips, etc. Additionally, using several sets of forceps requires cleaning and otherwise maintaining a stock of several forceps.

The present invention is directed to a surgical microclip applicator for use in microsurgery that provides significant advantages over prior art instruments of the type described above.

SUMMARY

The present disclosure provides a surgical clip application device or clip applicator for applying surgical clips to ligate vessels during surgery. The clip applicator disclosed herein may automatically load clips, which allows a user to ligate multiple vessels during surgery. As a user aligns a vessel within the jaws of the device and squeezes the device handle, a surgical clip is crimped to ligate the vessel aligned within the jaws. Once the handle is released, another clip is automatically loaded and ready for ligating another vessel.

In an example, a surgical clip applying device includes an enclosure formed from a top housing, a bottom housing and a window cover. The clip applying device also includes a pair of handles including a left handle and a right handle, a main rail supporting a jaw closer, and a pair of clip applying jaws fixedly attached to the bottom housing and retained within the main rail. The pair of clip applying jaws has arms terminating with a pair of jaw heads. Additionally, the clip applying device includes a clip loader assembly with a clip loading tip at the clip loader assembly's distal end and a dispenser positioned above the clip loader assembly. The dispenser includes a pair of clip forks and a retention prong positioned between the pair of clip forks at the dispenser's distal end. The clip loading tip is configured to push a surgical clip supported by the pair of clip forks over the retention prong. The clip applying device also includes a clip pusher assembly configured to advance a plurality of clips

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towards the pair of jaw heads and a drive mechanism including a plurality of levers and at least one spring. The drive mechanism is configured to translate an actuation of the pair of handles to linear motion of the jaw closer and the clip loader assembly.

The surgical clip application device or clip applicator disclosed herein is expected to offer convenience compared to devices and systems that require manually loading individual clips.

It is another advantage of the present disclosure to provide a surgical clip application device (e.g., clip applicator) with automatic surgical clip reloading.

Additionally, another advantage of the present disclosure is to provide a surgical clip application device (e.g., clip applicator) with a transparent window thereby allowing a user to easily ascertain a remaining clip count for surgical clips housed within the device.

It is a further advantage of the present disclosure to provide a surgical clip application device (e.g., clip applicator) with multiple touch points, finger loops, and gripping surfaces for ambidextrous surgical clip application.

Additional features and advantages of the disclosed surgical clip application device (e.g., clip applicator), systems, and methods are described in, and will be apparent from, the following Detailed Description and the Figures. The features and advantages described herein are not all-inclusive and, in particular, many additional features and advantages will be apparent to one of ordinary skill in the art in view of the figures and description. Also, any particular embodiment does not have to have all of the advantages listed herein. Moreover, it should be noted that the language used in the specification has been principally selected for readability and instructional purposes, and not to limit the scope of the inventive subject matter.

BRIEF DESCRIPTION OF THE FIGURES

FIG. 1A is a perspective view of an example clip application device according to the present disclosure.

FIG. 1B is an exploded perspective view of the example clip application device of FIG. 1A.

FIG. 1C is an exploded perspective view of an alternate embodiment of an example clip application device according to the present disclosure.

FIG. 1D illustrates an example clip application device in an open configuration according to the present disclosure.

FIG. 1E illustrates an example clip application device in a closed configuration according to the present disclosure.

FIGS. 1F, 1G, 1H, 1I, 1J, and 1K illustrate another alternate embodiment of an example clip application device according to the present disclosure.

FIGS. 2A, 2B, 2C, 2D, 2E and 2F illustrate a clip advancing to a distal end of the clip application device.

FIGS. 3A, 3B and 3C illustrate an example top housing according to the present disclosure.

FIGS. 3D and 3E illustrate another example top housing according to the present disclosure.

FIGS. 3F, 3G, and 3H illustrate yet another example top housing according to the present disclosure.

FIGS. 4A, 4B and 4C illustrate an example bottom housing according to the present disclosure.

FIGS. 4D, 4E and 4F illustrate another example bottom housing according to the present disclosure.

FIGS. 4G, 4H, and 4I illustrate yet another example bottom housing according to the present disclosure.

FIGS. 5A, 5B, 5C, 5D and 5E illustrate an example main rail according to the present disclosure.

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FIG. 5F illustrates another example main rail according to the present disclosure.

FIG. 5G illustrates yet another example main rail according to the present disclosure.

FIGS. 6A, 6B and 6C illustrate an example jaw closer according to the present disclosure.

FIGS. 6D and 6E illustrate another example jaw closer according to the present disclosure.

FIGS. 7A, 7B, 7C and 7D illustrate an example pair of clip applying jaws according to the present disclosure.

FIGS. 7E and 7F illustrate another example pair of clip applying jaws according to the present disclosure.

FIG. 8A illustrates an example clip loader assembly according to the present disclosure.

FIGS. 8B, 8C, 8D and 8E illustrate an example proximal clip loader according to the present disclosure.

FIGS. 8F, 8G, 8H and 8J illustrate an example distal clip loader according to the present disclosure.

FIGS. 8K, 8L and 8M illustrate another example clip loader assembly according to the present disclosure.

FIGS. 8N, 8P and 8Q illustrate another example proximal clip loader according to the present disclosure.

FIGS. 9A, 9B, 9C, 9D and 9E illustrate an example dispenser according to the present disclosure.

FIGS. 9F, 9G, 9H and 9I illustrate another example dispenser according to the present disclosure.

FIGS. 9J, 9K, 9L, 9M, and 9N illustrate yet another example dispenser according to the present disclosure.

FIGS. 10A and 10B illustrate an example clip pusher bar according to the present disclosure.

FIG. 10C illustrates another example clip pusher bar according to the present disclosure.

FIGS. 11A, 11B, 11C, 11D and 11E illustrate an example ratchet pawl according to the present disclosure.

FIGS. 12A, 12B, 12C, 12D and 12E illustrate an example trough of the present disclosure.

FIGS. 13A, 13B and 13C illustrate an example window cover of the present disclosure.

FIGS. 13D, 13E, and 13F illustrate another example window cover of the present disclosure.

FIGS. 14A and 14B illustrate an example lever of the present disclosure.

FIGS. 15A, 15B and 15C illustrate an example lever of the present disclosure.

FIGS. 16A and 16B illustrate an example lock-out clip of the present disclosure.

FIG. 16C illustrates another example lock-out clip of the present disclosure.

FIGS. 17A, 17B, 17C, 17D, 17E, 17F and 17G illustrate the clip applier in various orientations while applying a clip according to examples of the present disclosure.

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

The surgical clip application device (e.g., clip applier) for ligating vessels described herein provides improved surgical clip application, automatic surgical clip reloading, and safety lock-out features.

FIGS. 1A and 1B illustrate an example embodiment of a clip applier 100. The clip applier 100 is configured to apply clips to a surgical site. The clip applier 100 includes a top housing 102, a bottom housing 104, a left handle 106a, and a right handle 106b that together form an enclosure for the clip applier 100. Each of the left handle 106a and right handle 106b, hereinafter referred to generally as handles 106, are pivotally mounted in relation to the rest of the

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enclosure. The enclosure for the clip applier 100 may be secured together by fasteners or other attachment means. Each of the top housing 102, bottom housing 104, left handle 106a and right handle 106b may be fabricated from molded plastic. As illustrated in FIG. 1A, the clip applier 100 has a proximal end 101 and a distal end 103 (e.g., clip applying end). Specifically, the distal end 103 corresponds to the portion of the clip applier 100 where clips are crimped and applied.

The handles 106 cooperate to impart linear reciprocating movement to the clip applying components housed within the enclosure. In an example, the handles 106 are biased to an open position. As illustrated in FIGS. 1A and 1B, the handles 106 include looped bodies with finger rings, similar to a pair of scissors. In another example, the handles 106 may instead include loop-less bodies, similar to a pair of pliers. In either case, the finger rings of the looped bodies or the corresponding gripping surfaces of the loop-less bodies may be made from or over-molded with a rubber-like material to improve grip and comfort.

A window cover 108 and a trough 110 sit atop the top housing 102. The enclosure of the clip applier 100 houses a main rail 120, a jaw closer 130, clip applying jaws 140, and a clip loader assembly 150 that includes a proximal clip loader 154 and a distal clip loader 152. The clip loader assembly 150 cooperates with handles 106 and various other internal components, such that the distal clip loader 152 moves in a linear reciprocating motion for loading clips into the clip applying jaws 140.

The enclosure of the clip applier 100 also houses a dispenser 160 and a clip pusher assembly 170. The clip pusher assembly 170 includes a clip pusher spring 172 and a clip pusher bar 174. Additionally, the clip applier 100 includes a right lever assembly 180a and a left lever assembly 180b. The right lever assembly 180a includes a proximal lever 182a, a distal lever 184a and a spring 186a. The left lever assembly 180b includes a proximal lever 182b, a distal lever 184b and a spring 186b.

As discussed in more detail below, right lever assembly 180a and left lever assembly 180b, hereinafter referred to generally as lever assemblies 180, move in conjunction with actuation of handles 106 to control the motion of the jaw closer 130 and the clip loader assembly 150. In the open position, the proximal levers 182 and the distal levers 184 are nearly parallel with each other (see FIG. 1D) with the clip loader assembly 150 fully advanced. When the handles are transitioned from the open position to the closed position, the proximal levers 182 and the distal levers 184 create a diamond shape, pulling the clip loader assembly 150 back to a retracted position to grab the next surgical clip. Additionally, when the handles are transitioned from the open position to the closed position, the distal levers 184 push the jaw closer 130 forward to close the jaw heads and crimp the surgical clip that was advanced to the end of the clip applying jaws 140. As the handles are again transitioned from the closed position to the open position, the jaw closer 130 retreats to a fully retracted position.

A jaw anchor 190, such as a pin or screw (e.g., flat head cap screw) couples the clip applying jaws 140 to the jaw closer 130 and the main rail 120. Additionally, the anchor 190 fixes the clip applying jaws 140 and the main rail 120 to the bottom housing 104. As discussed in more detail below, the anchor 190 limits the range of motion of the jaw closer 130. In another example, the jaw anchor 190 may instead be a post that is molded as part of the bottom housing 104. As illustrated in FIG. 1B, the jaw anchor 190 is received in a corresponding slot 195 in the lower housing 104.

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A handle anchor **191**, such as a pin or screw (e.g., button head cap screw) couples the top housing **102** to the bottom housing **104** near the proximal end of the clip applier **100**. As illustrated in FIG. **1B**, the handle anchor **191** is received in a corresponding slot **197** in the lower housing **104**.

The clip applier **100** also includes a ratchet pawl **192** that serves as an anti-backup mechanism that cooperates with the other clip handling components housed within the enclosure for the clip applier **100**. As illustrated in FIG. **1B**, the ratchet pawl **192** cooperates with the proximal clip loader **154**, such that the proximal clip loader **154** moves in a linear reciprocating motion. The ratchet pawl **192** includes a pawl pin that is positioned through corresponding openings in the jaw closer **130** and the main rail **120** before being received in a corresponding slot **193** in the lower housing **104**.

The clip applier **100** may also include various attachment mechanisms, such as a set of right side pins **194a** and a set of left side pins **194b** that fixedly attach one end of the levers to their corresponding handle. For example, the set of pins **194a** fixedly attach one end of each of the proximal lever **182a** and the distal lever **184a** to the left handle **106a**. Similarly, the set of pins **194b** fixedly attach one end of each of the proximal lever **182b** and the distal lever **184b** to the right handle **106b**. The clip applier **100** may also include a set of screws **196** that connect the top housing **102** to the bottom housing **104**. The pins **194a**, **194b** (hereinafter generally referred to as pins **193**) and the screws **196** are example attachment mechanisms illustrated in FIG. **1B**. It should be appreciated that the clip applier **100** may include various other attachment means, including other types of fasteners, press-fit connections, adhesives, welding (e.g., electronic welding), etc.

FIG. **1C** illustrates another example embodiment of a clip applier **100**. Many of the components illustrated in FIG. **1C** may be the same or have similar features to the components illustrated in FIG. **1B**. In the illustrated example, the alternate embodiment includes variations of the main rail **120**, jaw closer **130**, clip applying jaws **140**, clip loader assembly **150** (e.g., distal clip loader **152** and proximal clip loader **154**), dispenser **160**, etc. These variations are described in more detail and illustrated in some of the following component diagrams. The exploded view illustrated in FIG. **1C** also shows a stack **105** of surgical clips (not pictured in FIG. **1B**). Furthermore, the alternate embodiment of the clip applier **100** shown in FIG. **1C** also includes a lock-out clip **185**.

FIG. **1D** illustrates the clip applier **100** in the open position and FIG. **1E** illustrates the clip applier **100** in the closed position.

FIGS. **1F**, **1G**, **1H**, **1I**, **1J**, and **1K** illustrate yet another example embodiment of a clip applier **100**. Some of the components of the example embodiment of the clip applier **100** shown in FIGS. **1F**-**1K** may be the same or have similar features as corresponding components illustrated in FIGS. **1B** and/or **1C**. The alternate embodiment of the clip applier **100** illustrated in FIGS. **1F**-**1K** includes variations of the top housing **102**, the bottom housing **104**, the window cover **108**, the main rail **120**, the dispenser **160**, and the lock-out clip **185**. These variations are described and/or illustrated in more detail in within other illustrative examples of the present disclosure.

FIG. **1F** illustrates a perspective view of an example clip applier **100**. FIG. **1G** illustrates an exploded view of the example clip applier **100** of FIG. **1F**. In the illustrated example of FIG. **1G**, the clip applier **100** includes a left handle assembly **10**, a right handle assembly **12**, a bottom enclosure assembly **14**, a clip dispenser assembly **16**, the top

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housing **102**, and the clip loader assembly **150**. More generally, in some examples, one or more portions of the clip applier **100** are implemented as separate sub-assemblies (e.g., the left handle assembly **10**, the right handle assembly **12**, the bottom enclosure assembly **14**, the clip dispenser assembly **150**, etc.), which are then combined to assemble the clip applier **100**.

FIG. **1H** illustrates an exploded view of the left handle assembly **10**. As best shown in FIG. **1H**, the left handle assembly **10** includes the left handle **106a**, the proximal lever **182a**, the distal lever **184a**, the spring **186a**, and the pins **194a**. In some examples, a length of the distal lever **184a** (e.g., "short link") is less than a length of the proximal lever **182a** (e.g., "long link," "proximal support long link," etc.). In some examples, the left handle assembly **10** can be assembled by sliding the levers **182a** and **184a** into the left handle **106a**, and then pressing the pins **194a** through respective holes in the left handle **106a** and/or the levers **182a**, **184a** to attach the levers **182a**, **184a** to the left handle **106a**. Respective ends of the spring **186a** can then be connected to the levers **182a** and **184a**.

FIG. **1I** illustrates an exploded view of the right handle assembly **12**. As best shown in FIG. **1I**, the right handle assembly **12** includes the right handle **106b**, the proximal lever **182b**, the distal lever **184b**, the spring **186b**, and the pins **194b**. In some examples, a length of the distal lever **184b** (e.g., "short link") is less than a length of the proximal lever **182b** (e.g., "long link"). In some examples, the right handle assembly **12** can be assembled by sliding the levers **182b** and **184b** into the right handle **106b**, and then pressing the pins **194b** through respective holes in the right handle **106b** and/or the levers **182b**, **184b** to attach the levers **182b**, **184b** to the right handle **106b**. The spring **186b** can then be connected to the levers **182b** and **184b**.

FIG. **1J** illustrates an exploded view of the bottom enclosure assembly **14**. As best shown in FIG. **1J**, the bottom enclosure assembly **14** includes an insert **18**, the bottom housing **104** (which includes the slot **195**), the main rail **120**, the jaw closer **130**, the clip applying jaws **140**, and the jaw anchor **190**. The insert **18** may be a threaded insert or any other type of mechanical coupling device received in the slot **195** to facilitate coupling the bottom housing **104** with the jaw anchor **190**. The insert **18** can be formed from any suitable material, such as brass, other metal or metal oxide, plastic, or any other material. In some examples, the jaw anchor **190** is implemented as a screw or a flat head screw. In some examples, the bottom enclosure assembly **14** is assembled by inserting (e.g., sliding) the clip applying jaws **140** and the jaw closer **130** into the main rail **120**. The main rail **120** can then be placed into the bottom housing **104** while aligning the threaded insert **18** with respective holes in the jaws **140**, the jaw closer **130**, and the main rail **120**. As such, in the illustrated example of FIG. **1J** one or more components (i.e., the main rail **120**, the jaw closer **130**, and the jaws **140**) of the bottom enclosure assembly **14** can be attached to the bottom housing **104** (e.g., by coupling or torquing the screw **190** into the insert **18** and the slot **195**). In alternative examples, a different attachment mechanism can be used.

FIG. **1K** illustrates an exploded view of the clip dispenser assembly **16**. As best shown in FIG. **1K**, the clip dispenser assembly **16** includes the stack **105** of surgical clips (exemplified by clip **50**), the window cover **108**, the dispenser **160**, the clip pusher spring **172**, the clip pusher bar **174**, and the lock-out clip **185**. In some examples, the clip dispenser assembly **16** is assembled by connecting the clip pusher spring **172** to the clip pusher bar **174** (e.g., sliding the spring

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172 over the pusher bar 174), then connecting the clip pusher bar 174 to the dispenser 160 (e.g., sliding the combination of the bar 174 and the spring 172 into the dispenser 160), then loading the stack 105 of surgical clips and the lockout clip 185 into the dispenser 160, and then attaching the window cover 108 to the dispenser 160. Other attachment mechanisms and/or processes are possible.

As noted above, in some examples, the clip applier 100 can be assembled by coupling the left handle assembly 10, the right handle assembly 12, the bottom enclosure assembly 14, the clip dispenser assembly 16, the top housing 102, and the clip loader assembly 150 to one another. In one specific example, the clip applier 100 of FIGS. 1F-1K is assembled by placing the left handle assembly 10 into the bottom enclosure assembly 14 and securing the distal lever 184a onto the jaw closer 130. The clip loader assembly 150 is then attached by securing a rear hole of the clip loader assembly 150 over the proximal lever 182a. The right handle assembly 12 is then placed into the assembly of the clip applier 100 by similarly securing the distal lever 184b onto the jaw closer 130. The clip dispenser assembly 16 is then placed into the assembly of the clip applier 100 by aligning the window cover 108 with the main rail 120. In this example, the main rail 120 can then be crimped onto the window cover 108. Then, the top housing 102 can be attached by pressing the top housing 102 onto the assembly of the clip applier 100. Other example attachment mechanisms are possible.

FIGS. 2A, 2B, 2C, 2D, and 2E illustrate the movement of various drive components at the distal end 103 of the clip applier 100 while the device is dispensing and crimping surgical clips, in accordance with at least one example embodiment herein. FIG. 2F illustrates a stack of surgical clips, exemplified by clip 50, which may be provide in a cartridge, at the distal end 103 of the clip applier 100, in accordance with at least one example embodiment herein.

FIGS. 3A, 3B and 3C illustrate top, side and bottom views of the top housing 102.

FIGS. 3D and 3E illustrate another example top housing 102 (e.g., the top housing 102 from FIG. 1C). The top housing 102 may also include handle pegs 187a and 187b that are configured to pass through handle slots (e.g., handle slots 183a and 183b illustrated in FIG. 1C, hereinafter referred to generally as handle slots 183) and couple to corresponding receiving pegs (e.g., receiving pegs 189a and 189b illustrated in FIG. 4E, hereinafter referred to generally as receiving pegs 189). The handle pegs 187a and 187b, hereinafter referred to generally as handle pegs 187, the receiving pegs 189 and the handle slots 183 are configured and arranged such that the left handle 106a and the right handle 106b are capable of pivoting with respect to the enclosure formed by the handles 106, the top housing 102 and the bottom housing 104. In the example illustrated in FIGS. 3D and 3E, the top housing 102 may incorporate a trough portion (e.g., trough 110 of FIGS. 12A to 12E) instead of having a separate trough component.

FIGS. 3F, 3G, and 3H illustrate top, side, and bottom views of yet another example top housing 102 (e.g., the top housing 102 of FIG. 1G). As best shown in FIGS. 3G and 3H, the example top housing 102 includes the handle pegs 187a, 187b, an anchor peg 390, and a plurality of tabs exemplified by tab 392. In this example, the top housing 102 can be attached (e.g., pressed, crimped, etc.) to other components of the clip applier 100 by aligning the pegs 187a, 187b, 390, and/or the tabs 392, etc. with corresponding receiving features in the bottom housing 104 and/or in other components of the clip applier 100. For example, the handle pegs 187a and 187b can be received by corresponding

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receiving pegs (e.g., receiving pegs 189a and 189b illustrated in FIG. 4I), the anchor peg 390 can be received by a corresponding receiving slot (e.g., slot 197 illustrated in FIG. 4I), and the plurality of tabs (exemplified by tab 392) can be aligned and/or received at corresponding recesses (e.g., recesses 492, etc. illustrated in FIG. 4I).

FIGS. 4A, 4B and 4C illustrate top, side and bottom views of the bottom housing 104. As discussed with relation to FIG. 1B, the bottom housing 104 includes slots 193, 195 and 197. Slot 193 is adapted to receive and retain a pawl pin (e.g., pawl pin 1102 of FIG. 11A) of the ratchet pawl 192 after the ratchet pawl pin passes through corresponding openings in the jaw closer 130 and the main rail 120. Slot 195 is adapted to receive and retain the jaw anchor 190 after the jaw anchor 190 passes through corresponding openings in the clip applying jaws 140, the jaw closer 130 and the main rail 120. Slot 197 is adapted to receive and retain the handle anchor 191.

FIGS. 4D, 4E and 4F illustrate another example bottom housing 104, which may include many of the same or similar features as the bottom housing 104 illustrated in FIGS. 4A, 4B and 4C. As mentioned above, the bottom housing 104 may include receiving pegs 189a and 189b. The receiving pegs 189 may be sized and shaped to receive and couple to the corresponding handle pegs 187 of the top housing 102. Specifically, handle slots 183 may be positioned through handle pegs 187 before the handle pegs 187 are positioned within (e.g., press-fit in) receiving pegs 189, which creates a pivot point for handles 106. In an example, the handle pegs 187 and the receiving pegs 189 may be snap-fit gripper pins that form axes of rotation or pivot points for the handles 106. In another example, the handle pegs 187 and the receiving pegs 189 may be dowel pins and bosses. Snap-fit gripper pins may advantageously provide a rotation or pivot point with fewer components.

FIGS. 4G, 4H, and 4I illustrate bottom, side, and top views of yet another example bottom housing 104 (e.g., the bottom housing 104 of FIG. 1J). In this illustrated example, the bottom housing 104 includes the receiving pegs 189a, 189b, the slot 195, the slot 197, a plurality of recesses exemplified by tab 492, and a plurality of protruding edges exemplified by edge 494. In this example, the bottom housing 104 can be attached (e.g., pressed, crimped, etc.) to other components of the clip applier 100 by aligning the pegs 189a, 189b, the slot 197, the recesses 492, etc., and/or the edges 494, etc., with corresponding features in the top housing 102 and/or in other components of the clip applier 100. For example, the receive pegs 189a and 189b can receive corresponding handle pegs (e.g., handle pegs 187a and 187b of FIG. 3H), the slot 197 can receive a corresponding anchor peg (e.g., anchor peg 390 of FIG. 3H), and the plurality of recesses (exemplified by tab 492) can be aligned with and/or receive corresponding tabs (e.g., tabs 392, etc. of FIG. 3H). Further, in this example, the edges 494, etc., can be shaped to align and/or receive corresponding edge(s) of the top housing 102 of FIG. 3H.

FIGS. 5A, 5B, 5C, 5D and 5E illustrate various views of an example main rail 120. In this example, the main rail 120 includes an elongate base 510 and side walls 520a and 520b that form a channel 530 having a proximal end 501 and a distal end 503. FIG. 5D illustrates a cross-sectional view of the main rail 120 along line A-A of FIG. 5B, which illustrates the channel 530 formed from the base 510 and sidewalls 520a, 520b. Near the distal end 503, the side walls 520a and 520b, hereinafter referred to generally as side walls 520, are folded over forming flanges 522a and 522b. The flanges, which are referred to generally as flanges 522

are adapted to constrain the interaction of the clip applying jaws **140** and the jaw closer **130** thereby preventing the clip applying jaws **140** and the jaw closer **130** from disengaging.

Additionally, in this example, the main rail **120** includes an opening or thru-hole **540** that accommodates jaw anchor **190**. Additionally, in this example, the main rail **120** includes an opening or thru-hole **550** that accommodates a pawl pin of the ratchet pawl **192**. In this example, the main rail **120** also includes a pawl slot **552** to accommodate a pawl flange (see pawl flange **1130** of FIG. 11E) of the ratchet pawl **192**. The pawl slot **552** is sized and shaped to allow the ratchet pawl **192** to pass through the main rail **120** (e.g., flanges **1130a** and **1130b** of the ratchet pawl **192** of FIG. 11A may pass through slot **552**) while the main rail **120** remains fixedly coupled to the bottom housing **104**.

The main rail **120** may be fabricated from plastic or metal. In an example, the main rail **120** is fabricated as a stamped piece(s) of metal. As illustrated in the detail view of the example of FIG. 5E, the pawl slot **552** is a curved oval slot or track that allows the ratchet pawl **192** to rotate within the slot **552**.

FIG. 5F illustrates another example of the main rail **120**. Similar to the main rail **120** illustrated in FIGS. 5A-5E, the main rail **120** illustrated in FIG. 5F includes a base **510** and sidewalls **520a** and **520b** that form channel **530**. Additionally, the main rail **120** includes flanges **522a** and **522b**. Main rail **120** also includes thru-holes **542a** and **542b** that may be adapted for positioning, alignment and/or securing the main rail **120**. Unlike the main rail illustrated in FIGS. 5A-5E, the main rail **120** illustrated in FIG. 5F may be adapted for use without a ratchet pawl **192**.

In this example, after the main rail **120** is positioned in the lower housing **102**, the jaw closer **130** is positioned within the main rail **120**. Specifically, the channel **530** is configured to receive the jaw closer **130**, which sits atop the base **510** of the main rail **120**. The jaw closer **130** is further described and illustrated in FIGS. 6A, 6B and 6C.

FIG. 5G illustrates yet another example of the main rail **120** (e.g., the main rail **120** of FIG. 1J). Similar to the main rail **120** of FIG. 5F, the main rail **120** of FIG. 5G also includes the base **510**, the sidewalls **520a** and **520b** that form channel **530**, and include the holes **542a** and **542b**. Additionally, in the illustrated example of FIG. 5G, the main rail **120** also includes a plurality of elongate members (hereinafter referred to as elongate members **560**) exemplified by elongate members **560a**, **560b**, and **560c**. In some examples, the elongate members **560** can be used to mechanically couple the main rail **120** to a window cover (e.g., the window cover **108** of FIG. 1K).

As illustrated in FIGS. 6A, 6B and 6C, the jaw closer **130** includes an elongate base **610** with two drive flanges **682** and **684** that are configured to couple to respective ends of levers **184b** and **184a** (see FIG. 1B), which is discussed in more detail below. The jaw closer **130** has a proximal end **601** and a distal end **603**. Additionally, the jaw closer **130** includes a slot **640** that accommodates jaw anchor **190**. The slot **640** is an oval slot that is adapted to limit the range of motion of the jaw closer **130** by providing a front-stop **642** and a back-stop **644** for the jaw anchor **190**. Specifically, the jaw closer **130** may move forward, towards the distal end **103** of the clip applier **100**, until the jaw anchor **190** abuts the back-stop **644**. Similarly, the jaw closer **130** may move backward, toward the proximal end **101** of the clip applier **100**, until the jaw anchor **190** abuts the front-stop **642** of the slot **640**.

The jaw closer **130** also includes a pawl track **652** to accommodate a positioning post **1120** and flanges **1130a** and

1130b of the ratchet pawl **192** (see FIG. 11A). The pawl track **652** is sized and shaped to allow the ratchet pawl **192** to rotate and freely move within the pawl track **652** while the main rail **120** remains fixedly coupled to the bottom housing **104**.

The jaw closer **130** also includes an engagement indent **650** with cam members **652a** and **652b** that cooperate with ramps or protrusions on the clip applying jaws **140** (see FIGS. 7B and 7C). For example, the cam members, generally referred to as cam members **652**, may form the indent **650**, which is configured to close the clip applying jaws **140** as the jaw closer **130** is extended towards the distal end **103** (e.g., clip applying end) of the clip applier **100**. As illustrated in FIG. 6C, which is an enlarged detail view of the distal end **603** of the jaw closer **130** showing the geometry of engagement indent **650**, the engagement indent **650** has a triangular shape. It should be appreciated that the engagement indent **650** is sized and shaped to cooperate with corresponding camming surfaces on the clip applying jaws **140**, and therefore other shapes, geometries or means of closing the clip applying jaws **140** may be implanted. Similar to the main rail **120**, the jaw closer **130** may be fabricated from plastic or metal. In an example, the jaw closer is fabricated as a stamped metal piece. In one example, the jaw closer **130** is made from stainless steel (e.g., half hard 304 SS).

After the jaw closer **130** is positioned within the main rail **120**, the clip applying jaws **140** are positioned atop the jaw closer **130**. Specifically, the clip applying jaws **140** are positioned above the main rail **120** and secured in place via jaw anchor **190**, which passes through a corresponding slot or thru-hole of the clip applying jaws **140** before passing through slot **640** of jaw closer **130** and thru-hole **540** of the main rail. The jaw anchor **190** secures the clip applying jaws **140** in place by anchoring the clip applying jaws to the corresponding slot **195** in the lower housing **104**.

FIGS. 6D and 6E illustrate an alternative embodiment of the jaw closer **130**. In the alternate embodiment (e.g., jaw closer **130** of FIG. 1C), the jaw closer **130** includes many of the same features of the jaw closer **130** illustrated in FIGS. 6A-6D. However, in the illustrated example, the jaw closer **130** is shown without a pawl track **652**.

The clip applying jaws **140** are further described and illustrated in FIGS. 7A, 7B, 7C and 7D. In the illustrated example, the clip applying jaws include a body portion **710** at a proximal end and arms **720a**, **720b** (e.g., right arm **720a** and left arm **720b**) that extend from the body portion **710** towards a distal end of the clip applying jaws **140**. Additionally, the clip applying jaws **140** includes an opening or thru-hole **741** that accommodates jaw anchor **190**. The arms **720a** and **720b**, hereinafter referred to generally as arms **720** terminate in cooperating jaw heads **730a**, **730b** at the distal end **703**.

The jaw heads **730a**, **730b**, which are referred to generally as jaw heads **730**, are oriented in a downward sloping position. At the end of the arms **720**, where the jaw heads **730** start, the jaw heads **730** are initially positioned above the arms **720**, such that the jaw heads **730** are stepped above a top surface **722** of the arms and slope downward such that the end of the jaw heads **730** at the distal end **703** are approximately in-line with a bottom surface **724** of the arms **720** (see FIG. 7B).

Each respective arm **720** includes a ramp or protrusion (e.g., ramps **740a** and **740b**) that are configured to cooperate with cam members **652** or indent **650** of the jaw closer (see FIGS. 6B and 6C). When the ramps **740a** and **740b**, generally referred to herein as ramps **740**, cooperate with the indent **650**, the clip applying jaws **140** are transitioned to a

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closed position. In the closed position, the jaw heads **730** are moved towards each other to crimp or pinch together a surgical clip. Specifically, as the jaw closer **130** is extended towards the distal end **103** (e.g., clip applying end) of the clip applier **100**, the ramps **740** ride along the cam members **652** of the jaw closer, which forces the arms **720** and the jaw heads **730** closer together.

In the illustrated examples, FIG. 7C illustrates the clip applying jaws **140** in an open configuration with the arms **720** and jaw heads **730** spread apart. Conversely, FIG. 7A illustrates the clip applying jaws **140** in a closed configuration with the arms **720** and jaw heads **730** in a parallel arrangement with a smaller clip gap. For example, the clip gap **760** (open position) of FIG. 7C is larger than the clip gap **760** (closed position) of FIG. 7A.

As illustrated in FIG. 7C, the ramps **740**, which function as cam surfaces, are located behind the respective jaw heads **730**, towards the distal end **703** of the clip applying jaws **140**. The ramps **740**, when pressed together and viewed from above, may have a triangular shape that cooperates with the triangular shaped indent **650** of the jaw closer **130**. As the jaw closer **130** retreats, the arms **720** and their corresponding jaw heads **730** are released to move back to the open position. In an example, the arms **720** and their corresponding jaw heads **730** are biased (e.g., spring biased) to the open position and only close through interaction with the jaw closer **130**. For example, the jaws may have a natural spring bias to an open position and are forced closed when the jaw closer **130** is extended towards the distal end **703** of the clip applying jaws **140** for crimping a surgical clip during surgery.

As illustrated in FIG. 7D, each jaw head **730** has a recessed channel **761** (e.g., recessed channel **761a** on jaw head **730a** and recessed channel **761b** on jaw head **730b**) that cooperate to form a clip track **770**. For example, the recessed channels **760** or groove is sized and shaped to allow a leg of a surgical clip to slide along the channel **760**. The clip track **770** formed between the jaw heads **730** is configured to provide a track that guides a surgical clip as the surgical clip travel to the distal end **703** of the clip applying jaws **140**. For example, and as discussed in more detail below, as the clip applying jaws **140** open, a clip pusher assembly **150** (see FIGS. 2A, 2B, 2C and 8A) moves towards the distal end **703** of the clip applying jaws **140** and pushes a surgical clip into the jaw heads **730**. More specifically, the clip pusher pushes and positions the surgical clip into the clip track **770** formed by the cooperating recessed channels **761** of the jaw heads **730**. Then, the surgical clip travels along the clip track **770** until the surgical clip reaches the distal end **703**, where the clip applying jaws are transitioned to a closed position to crimp the surgical clip.

Each recessed channel **761** starts with an opening **762** and ends at a stop surface **764** before reaching the distal end of the clip applying jaws **140**. The opening **762** may be larger than the height or diameter of the channel **761** to aid in aligning and positioning the respective surgical clip leg within the channel **761**. The stop surface **764** may advantageously prevent surgical clips from traveling beyond the distal end **703** of the clip applying jaws **140** prior to application. For example, without stop surface **764**, surgical clips may incidentally fall out of the clip applier **100** before the clip applier **100** and the clip applying jaws **140** transition to a closed position to crimp and apply the surgical clip to the surgical site.

FIGS. 7E and 7F illustrate another example of jaw head **730**. Specifically, in an alternate embodiment, the jaw head **730** may similarly include a recessed channel **761** (e.g.,

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recessed channel **761a** on jaw head **730a** and recessed channel **761b** on jaw head **730b**) that cooperate to form a clip track **770**. For example, as illustrated in FIG. 7F, a portion of the jaw head **730** may be removed thereby forming a larger opening **762** at the start of the channel **761**. The opening **762** may be larger than the height or diameter of the channel **761** to aid in aligning and positioning the respective surgical clip leg within the channel **761**. Additionally, the material removed from the jaw head **730** near region **765** may further aid in aligning and positioning the respective surgical clip leg within the channel **761**.

Once the clip applying jaws **140** are positioned within the enclosure, the clip loader assembly **150** is positioned above the clip applying jaws. As mentioned above, the clip loader assembly **150** includes a proximal clip loader **154** and a distal clip loader **152**. The clip loader assembly **150** cooperates with handles **106** and various other internal components, such that the distal clip loader **154** moves in a linear reciprocating motion for loading clips into the clip applying jaws.

FIG. 8A illustrates an example of the clip loader assembly **150** having a proximal end **801** and a distal end **803**. The clip loader assembly **150** includes a proximal clip loader **154** and a distal clip loader **152**. In an example, the proximal clip loader **154** and the distal clip loader **152** may be spot welded together at various locations or points within weld region **802**.

FIGS. 8B, 8C, 8D and 8E illustrate various views of an example proximal clip loader **154**. The proximal clip loader **154** may be fabricated from plastic or metal. In an example, the proximal clip loader **154** is fabricated as a stamped piece(s) of metal. In one example, the proximal clip loader is made from stainless steel (e.g., 316 SS). The proximal clip loader **154** includes an elongate base **810** with two retention flanges **820a** and **820b** that are adapted to engage corresponding structures on the top housing **102** to further align (e.g., align in the horizontal direction) and secure the proximal clip loader **154** in place. Additionally, a portion of the elongate base **810** has an engagement portion **815** that includes a plurality of teeth **817**. The engagement portion, and more specifically the plurality of teeth **817** are configured to cooperate with ratchet pawl **192**. For example, the proximal clip loader has an engagement portion **815** with teeth **817** and two indented notches **818a** and **818b** positioned on opposite sides of the engagement portion **815**. The plurality of teeth **815** and indented notches **818a**, **818b** (hereinafter referred to generally as indented notches **818**) function as an anti-backup mechanism, which is described in more detail below. The plurality of teeth **817** are illustrated in more detail in FIG. 8E, which is a detail view of FIG. 8D.

The proximal clip loader **154** also includes a drive aperture **830** that is configured to accommodate a drive flange (e.g., drive flange **1510**, see FIG. 15A) of the proximal lever **182a** of the right lever assembly **180a**. For example, proximal clip loader **154** is positioned over the proximal lever **182a**, such that the drive flange **1510** (see FIG. 15A) of the proximal lever **182a** extends upwards through the drive aperture **830**. Once the drive flange of the proximal lever **182a** is positioned through the drive aperture **830**, a corresponding thru-hole (e.g., thru-hole **1404**, see FIG. 14A) of proximal lever **182b** is positioned over the remaining portion of the drive flange **1510** that extends above the proximal clip loader **154**. For example, the drive aperture **830** is aligned with the corresponding thru-hole **1404** of the proximal lever **182b**.

FIGS. 8F, 8G, 8H and 8J illustrate various views of an example distal clip loader **152**. The distal clip loader **152**

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may be fabricated from plastic or metal. In an example, the distal clip loader **152** is fabricated as a stamped piece(s) of metal. In one example, the proximal clip loader is made from stainless steel (e.g., 316 SS). The proximal clip loader **152** includes an elongate base **860** with two flanges **862a** and **862b** that are adapted to engage corresponding structures on the proximal clip loader **154** for alignment prior to spot welding. The distal clip loader **152** also includes a notched window **864**, such that when the distal loader **152** is positioned over the proximal clip loader **154**, the window **864** provides access to the engagement portion **815** with teeth **817** and two indented notches **818** of the proximal clip loader **154**. It should be appreciated that instead of stacking and spot welding the proximal clip loader **154** to the distal clip loader **152**, the clip loader assembly **150** may instead be fabricated as a single piece.

The end of the distal clip loader (e.g., the end corresponding to the distal end **803** of the clip loader assembly **150**), includes a clip loading tip **870**. Prior to reaching the clip loading tip **870**, the elongate base **860** narrows at a clip loading portion **866** of the elongate base **860**. Additionally, the clip loading portion **866** curves upward at shoulder **871** until terminating at the clip loading tip **870**. The clip loading portion **866** narrows to reduce the width of the elongate base **860**, thereby allowing the distal clip loader **152**, and more specifically the clip loading tip **870** to engage with individual surgical clips of a clip magazine. During application, the distal clip loader **152** pushes a leading surgical clip from the clip magazine over a retention prong **950** of the dispenser **160** (see FIGS. 9C and 9D).

In an example, and as illustrated in FIG. 8J, the clip loading tip **870** is curved upwards and forms a U-shaped channel with base **872** and sidewalls **874a** and **874b**. The U-shaped channel is sized and shaped to fit around the retention prong **950** and between the forks **940a** and **940b** of the dispenser (see FIGS. 2A, 2B, 9C and 9D), allowing the clip loading tip **870** to engage the leading surgical clip without the clip loading tip **870** contacting the retention prong **950** or forks **940a**, **940b**. For example, sidewalls **874a** and **874b** contact respective points of the leading surgical clip **50** that overhang on each side of the retention prong. Pushing the leading surgical clip **50** over the retention prong is further illustrated in FIGS. 2A and 2B.

FIGS. 8K, 8L and 8M illustrate another example clip loader assembly **150**. In the illustrated example, the clip loader assembly **150** includes a distal clip loader **152** and a proximal clip loader **154**. The detail view illustrated in FIG. 8M illustrates where the proximal clip loader **154** and the distal clip loader **152** may be spot welded together. For example, the proximal clip loader **154** may be spot welded to the distal clip loader **152** at various locations or points (e.g., weld points **802a** and **802b**) within a weld region. The distal clip loader **152** illustrated in FIG. 8K has many of the same features as the clip loader **152** illustrated in FIG. 8F.

FIGS. 8N, 8P and 8Q illustrate another example of proximal clip loader **154**. Similar to the proximal clip loader **154** illustrated in FIG. 8B, the proximal clip loader **154** illustrated in FIG. 8N includes an elongate base **810** and drive aperture **830** that is configured to accommodate a drive flange (e.g., drive flange **1510**, see FIG. 15A) of the proximal lever **182a** of the right lever assembly **180a**. For example, proximal clip loader **154** is positioned over the proximal lever **182a**, such that the drive flange **1510** (see FIG. 15A) of the proximal lever **182a** extends upwards through the drive aperture **830**. Once the drive flange of the proximal lever **182a** is positioned through the drive aperture **830**, a corresponding thru-hole (e.g., thru-hole **1404**, see

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FIG. 14A) of proximal lever **182b** is positioned over the remaining portion of the drive flange **1510** that extends above the proximal clip loader **154**. For example, the drive aperture **830** is aligned with the corresponding thru-hole **1404** of the proximal lever **182b**. The proximal clip loader **154** also includes an alignment slot **832** as well as a vertical spacing and alignment protrusion **834**.

FIGS. 9A, 9B, 9C, 9D and 9E illustrate various views of an example dispenser **160**. The dispenser **160** may be fabricated from plastic or metal. In an example, the dispenser **160** is fabricated as a stamped piece(s) of metal. In one example, the dispenser **160** is made from stainless steel (e.g., half hard 304 SS). The dispenser **160** includes an elongate base **910** with flanges **920a**, **920b**, **920c** and **920d**, which may serve as a securing flange or snap. For example, the flanges **920a-d** may form a press-fit or snap-fit with corresponding structures on bottom housing **104**. Additionally, the dispenser **160** includes two openings or thru-holes **930a** and **930b**, which may be adapted to assist with initial placement and alignment of the dispenser **160**. The dispenser **160** has a proximal end **901** and a distal end **903**.

At the distal end **903**, the dispenser includes forks **940a** and **940b** that curve downward from the elongate base **910** at shoulder **942**. Additionally, the dispenser **160** includes a retention prong **950** that curves upward from the elongate base **910** at the shoulder **942** (see FIGS. 9C and 9D). The forks **940a** and **940b**, hereinafter referred to generally as forks **940**, create both a support surface and a track for the legs of a surgical clip **50**. Additionally, the forks **940** are sized and shaped similar to the cooperating recessed channels **760** of the jaw heads **730**, which form the clip track **770**. For example, the forks **940** curve downward such that the end of forks directly lead into the cooperating recessed channels **760** of the jaw heads (see FIGS. 2A and 2B). Therefore, the forks **940** curve to have the same slope (at their distal ends) as the cooperating recessed channels **760**.

As mentioned above, the retention prong **950** is curved upwards to retain the leading surgical clip **50** until the leading clip is pushed off of the retention prong **950** by the clip loading tip **870**. The retention prong **950** is adapted to have enough rigidity to support and retain a leading surgical clip **50** while also having enough flexibility to enable the clip loading tip **870** to temporarily bend the retention prong **950** downward to allow the leading surgical clip **50** to advance beyond the retention prong **950**, along the forks **940** and through the clip track **770** formed by the cooperating recessed channels **760** of the jaw heads **730**.

As illustrated in FIG. 9E, the elongate base **910** may include two ridges **912a** and **912b** that form a channel **970**. The channel **970** is adapted to receive the clip pusher assembly **170**, which includes a clip pusher spring **172** and a clip pusher bar **174**, described in more detail below. Additionally, the elongate base **910** includes two V-shaped flanges **914a** and **914b** with a first leg of each V-shaped flange **914** extending downward from the ridge **912** below the elongate base **910** before the second leg of the V-shaped flange **914** extends back upward to the height of the top of the ridge **912**. The V-shaped flange(s) **914** may be adapted for alignment and attachment. For example, the V-shaped flange(s) **914** may be press-fit into a corresponding mating structure in the housing. For example, the V-shaped flange(s) **914** may first compress inwardly and then snap-back and hook into the corresponding mating structure in the housing.

FIGS. 9F, 9G, 9H and 9I illustrate another example dispenser **160**. Similar to the dispenser **160** illustrated in FIG. 9A, the dispenser **160** illustrated in FIG. 9F includes an elongate base **910**. Instead of flanges (e.g., flanges **920a**,

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920b, 920c and 920d illustrated in FIG. 9A), the dispenser 160 may include various attachment members 925a-f, which may include square shaped thru-holes that are adapted to engage with corresponding securing features of the bottom housing 104 (e.g., in a snap-fit or press-fit engagement).

The dispenser 160 has a proximal end 901 and a distal end 903. Similar to the embodiment illustrated in FIG. 9A, the example illustrated in FIG. 9F includes forks 940a and 940b (at the distal end 903) that curve downward from the elongate base 910. Additionally, the dispenser 160 includes a retention prong 950 that curves upward from the elongate base 910 to retain the leading surgical clip 50 until the leading clip is pushed off of the retention prong 950 by the clip loading tip 870.

As illustrated in FIG. 9G and FIG. 9H, the dispenser 160 may include sidewalls 935a and 935b that fold over to form a spring retention channel 937 near the proximal end 901 of the dispenser 160. The spring retention channel 937 may advantageously house clip pusher spring 172 (see FIG. 1B) and prevent the clip pusher spring 172 from buckling and popping out of channel 937 or channel 970. For example, without spring retention channel 937, the clip pusher spring 172 may buckle and lose containment when the stack 105 of clips is near empty. Moving from the proximal end 901 towards the distal end 903, and after the spring retention channel 937, the attachment members (e.g., attachment members 925c and 925f) may be formed from sidewalls of the dispenser 160 and may form channel 970 (as illustrated in FIG. 9I). The channel 970 is adapted to receive the clip pusher assembly 170, which includes a clip pusher spring 172 and a clip pusher bar 174, described in more detail below.

FIGS. 9J, 9K, 9L, 9M, and 9N illustrate yet another example dispenser 160 (e.g., the dispenser 160 of FIG. 1K). FIG. 9J illustrates a perspective view of an alternate embodiment of the dispenser 160. FIGS. 9K, 9L, and 9M illustrate cross-section views of the dispenser 160 of FIG. 9J. FIG. 9N illustrates a partial side view of the dispenser 160 of FIG. 9J. The example dispenser 160 illustrated in FIGS. 9J-9N includes a proximal end 901, a distal end 903, an elongate base 910, a spring retention channel 937, forks 940a and 940b, a retention prong 950, and a channel 970 that are similar, respectively, to the proximal end 901, the distal end 903, the elongate base 910, the spring retention channel 937, the forks 940a and 940b, the retention prong 950, and the channel 970 of the example dispenser 160 of FIGS. 9F-9I. However, it is noted that the shapes and sizes of one or more of these components may vary. For example, the dimensions and/or shapes of channels 937 and/or 970 of the dispenser 160 of FIGS. 9J-9N could differ from the dimensions/shapes of the channels 937 and/or 970 of the dispenser of FIGS. 9F-9I. As another example, as best shown in FIG. 9N, the retention prong 950 of this illustrated example has a different shape than the example retention prong 950 illustrated in FIG. 9C.

In the illustrated example of FIGS. 9J-9N, the dispenser 160 also includes a plurality of connectors (hereinafter referred to as connectors 926) exemplified by connectors 926a, 926b, and 926c (e.g., attachment mechanisms, etc.). The connectors 926 can be used to mechanically couple the dispenser 160 to corresponding sockets of a window cover (e.g., sockets 1304a, 1304b, 1304c, etc. of the window cover 108 illustrated in FIGS. 13D-13F).

As best shown in FIG. 9L, a shape (e.g., width) of channel 970 is defined by various walls (e.g., connectors 926b, 926c, base 910, etc.) of the dispenser 160. In this example, the

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channel 970 is adapted to receive clip pusher spring 172 and the clip pusher bar 174 (e.g., see FIGS. 1G and 1K). Similarly, as best shown in FIG. 9M, a shape (e.g., width, etc.) of the spring retention channel 937 is defined by various walls of the dispenser 160, including folded side-walls 936a and 936b. Similar to the example dispenser 160 of FIGS. 9F-9I, the spring retention channel 937 of FIGS. 9J-9N could prevent and/or reduce the likelihood of clip pusher spring 172 popping out of the channels 937 and/or 970.

FIGS. 10A and 10B illustrate an example of the clip pusher bar 174. The clip pusher bar 174 and clip pusher spring 172 (see FIG. 1B) may be coupled together to form the clip pusher assembly 170. For example, the proximal end 1001 of the clip pusher bar 174 may be mounted to a distal end of the clip pusher spring 172. The clip pusher bar 174 includes an elongate shaft 1010 that is adapted to couple to the clip pusher spring 172. At the other end of the elongate shaft 1010, the clip pusher bar 174 includes a clip pusher head 1020 with a surgical clip contact notch 1030. Additionally, the clip pusher bar 174 may include a lock-out window 1040 that is adapted to be grabbed by prong 950 to bring the clip pusher head 1020 into the jaws 730 thereby locking-out the jaws 730 after the last surgical clip 50 was applied and dispensed. FIG. 10C illustrates another example clip pusher bar 174 that has many of the same features as the clip pusher bar illustrated in FIGS. 10A and 10B, but instead of including a lock-out window 1040, the clip pusher bar 174 of FIG. 10C is adapted for use with a lock-out clip (e.g., lock-out clip 185 as illustrated in FIG. 1C, FIG. 1K, FIGS. 16A-B, and/or FIG. 16C).

The clip pusher spring 172 provides a constant biasing force to the clip pusher bar 174 thereby causing the clip pusher head 1020, and more specifically the clip contact notch 1030, to continually apply pressure to the clip magazine. The constant pressure ensures that a next-leading surgical clip is advanced to the retention prong 950 of the dispenser 160. For example, both the clip pusher bar 174 and the clip magazine travel along the channel 970 of the dispenser 160 until the leading surgical clip 50 contacts the retention prong 950. As discussed above, the leading surgical clip 50 is retained by the retention prong 950 until the clip is released (e.g., pushed forward) by the clip loading tip 870.

In an example, a surgical clip magazine (not pictured) may carry a stack 105 of surgical clips 50 (e.g., a stack 105 of fifteen surgical clips 50). The clip pusher assembly 170 provides a biasing force to the stack of surgical clips in the magazine until the magazine is empty. Referring back to FIG. 2F, the stack of surgical clips are illustrated with a leading surgical clip 50 at the end of the clip applying jaws 140.

FIGS. 11A to 11E illustrate an example of ratchet pawl 192. The ratchet pawl 192 includes a pawl pin 1102. As discussed above, the pawl pin 1102 is adapted to fit through the opening or thru-hole 550 of the main rail 120 and into the corresponding slot 193 of the bottom housing 104. The ratchet pawl 192 includes a pick 1110 and a positioning post 1120 with flanges 1130a and 1130b. As illustrated in FIG. 11E, the flanges 1130a and 1130b form a curved oval-shaped flange, referred to generally as flange 1130, that corresponds to the shape of the pawl slot 552 of the main rail 120. The positioning post 1120 sits within the curved oval-shaped pawl slot 552 of the main rail 120, which allows the ratchet pawl 197 to rotate. The positioning post 1120 may also be coupled to a torsion spring (not pictured) that advances ratchet pawl pick 1110 beyond a respective notch 818a or

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818b (depending on movement in a forward or reverse direction) such that the ratchet pawl pick **1110** can engage teeth **817** of engagement portion **815** of the clip loader assembly **150** (see FIGS. **8B** and **8E**). For example, the pick **1110** may advance forward along teeth **817** (towards notch **818a**) when pushing a clip from dispenser **160** and may advance backward along teeth **817** (towards notch **818b**) when retreating after a clip has been loaded into the jaws.

The ratchet pawl **192** also includes protrusions **1140a** and **1140b** that are sized and shaped to extend beyond pawl slot **552** such that the ratchet pawl **192** maintains a level orientation without pivoting or tilting within the pawl slot **552**. As noted above, the pawl slot **552** is sized and shaped to allow flange **1130** of the ratchet pawl **192** to pass through the main rail **120** and sit below the main rail **120**, thereby allowing the ratchet pawl **192** to rotate while the main rail **120** remains fixedly coupled to the bottom housing **104**.

The main rail **120** may be fabricated from plastic or metal. In an example, the main rail **120** is fabricated as a stamped piece(s) of metal. As illustrated in the detail view of FIG. **5E**, the pawl slot **552** is a curved oval slot or track that allows the ratchet pawl **192** to rotate while the slot **552**.

FIGS. **12A** to **12E** illustrate an example embodiment of trough **110**, which is configured to cover the clip pusher spring **172** within the enclosure of the clip applier **100**. The trough **110** may include tabs **1202a**, **1202b**, **1202c** and **1202d**, hereinafter referred to generally as tabs **1202**, that are configured to snap into corresponding mating features on the top housing **102**.

FIGS. **13A**, **13B** and **13C** illustrate an example window cover **108**. In this example, the window cover **108** and trough **110** are assembled onto the top housing **102** after the remaining surgical clip drive components (e.g., clip pusher assembly **170** are positioned into track or channel formed by the clip dispenser **160**) are installed into the clip applier **100**. In this example, the window cover **108** provides a transparent window to enable viewing of the surgical clip magazine and clip pusher assembly **170**. In this example, the window cover **108** may attach to the top housing **102** via tabs **1302a**, **1302b**, **1302c** and **1302d**, hereinafter referred to generally as tabs **1302**. The tabs **1302** are configured to snap into corresponding mating features on the top housing **102**.

The window cover **108** has a proximal end **1301** and a distal end **1303**. At the distal end **1303**, the window cover **108** is curved and slopes downward to further assist in retaining, guiding and directing surgical clips **50** into the jaw heads of the clip applying jaws **140** (see FIGS. **2B** and **2C**). The transparent window also enables the user to monitor and track the motion of a surgical clip **50** as it travels through the clip applier **100** to the end of the clip applying jaws **140**.

FIGS. **13D**, **13E**, and **13F** illustrate top, side, and cross-section views of another example window cover **108** (e.g., the window cover **108** of FIG. **1K**). In this example, the window cover **108** includes a plurality of sockets (interchangeably referred to herein as sockets **1304**) exemplified by sockets **1304a**, **1304b**, and **1304c**. Each of the sockets **1304** is configured to attach and/or align with (e.g., in a snap-fit or press-fit engagement, etc.) corresponding connectors or other types of attachment members in a dispenser (e.g., the dispenser **160** of FIG. **1K**). Alternatively or additionally, in some examples, the example window cover **108** is crimped or otherwise mechanically attached to a main rail (e.g., the main rail **120** of FIG. **1J**).

FIGS. **14A** and **14B** illustrate an example embodiment of proximal lever **182b**, distal lever **184a** and distal lever **184b**. As illustrated in FIG. **1B**, proximal lever **182b** may be longer than distal levers **184a** and **184b**. Each lever includes two

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openings or thru-holes **1402** and **1404** on each side of the lever. The levers may be made of metal. In an example, the levers are fabricated as a stamped piece(s) of metal. In one example, the levers made from stainless steel (e.g., 304 SS). Additionally, each lever may include a spring retention slot **1406** (also spring retention slot **1506** for lever **182a** illustrated in FIG. **15A**) adapted to receive and retain an end of either spring **186a** or spring **186b**, such that the levers of each lever assembly are spring biased towards each other. Specifically, once spring **186a** is positioned within spring retention slots **1406** of the proximal lever **182a** and distal lever **184a**, the ends of the levers are spring biased towards each other. Similarly, spring **186b** couples levers **182b** and **184b** together.

For each of the proximal lever **182b**, distal lever **184a** and distal lever **184b**, the thru-holes **1402** are adapted to fix one end of each lever to its respective handle via pins **194** (see FIG. **1B**). For the proximal lever **182b**, the thru-hole **1404** corresponds with the drive aperture **830** of the proximal clip loader **154**. As noted above, the drive flange **1510** of the proximal lever **182a** (see FIGS. **15A**, **15B** and **15C**) passes through the bottom of the drive aperture **830** through the proximal clip loader **154** and also extends through the thru-hole **1404** of the proximal lever **182b**, which controls the linear motion of the clip loader assembly **150** during handle actuation.

The thru-hole **1404** of distal lever **184b** corresponds with the left drive flange **684** of the jaw closer **130**. Similarly, the thru-hole **1404** of distal lever **184a** corresponds with the right drive flange **682** of the jaw closer **130**. The distal levers **184a**, **184b** cause the jaw closer **130** to move linearly towards the distal end of the clip applier **100** by urging the drive flanges **682**, **684** (and therefore the jaw closer **130**) forward during handle actuation.

FIGS. **15A**, **15B** and **15C** illustrate an example embodiment of a proximal lever **182a** of the right lever assembly **180a**. As illustrated in FIG. **1B**, proximal lever **182a** may be longer than distal levers **184a** and **184b**. The proximal lever **182a** includes an opening or thru-hole **1502** on one side of the lever and a drive flange **1510** on the opposite end. The proximal lever **182a** may be made of metal. In an example, the proximal lever **182a** is fabricated as a stamped piece(s) of metal. In one example, the proximal lever **182a** is made from stainless steel (e.g., 304 SS). Additionally, the proximal lever **182a** may include a spring retention slot **1506** adapted to receive and retain an end of the spring **186**, such that the levers of each lever assembly are spring biased towards each other. For example, spring retention slot **1506** may provide the same functionality and have the same features as spring retention slot **1406** described in FIG. **14A**.

The thru-hole **1502** is adapted to fix one end of the proximal lever **182a** to its respective handle via pin **194** (see FIG. **1B**). As noted above, the drive flange **1510** of the proximal lever **182a** (see FIGS. **15A**, **15B** and **15C**) passes through the bottom of the drive aperture **830** through the proximal clip loader **154** and also extends through the thru-hole **1404** of the proximal lever **182b**, which controls the linear motion of the clip loader assembly **150** during handle actuation.

FIGS. **16A** and **16B** illustrate an example lock-out clip **185**. The lock-out clip **185** may include two legs **1610a** and **1610b** that are sized and shaped similar to the legs of a surgical clip, such that the lock-out clip **185** may advance through the clip applier **100** and into the clip track **770** formed by jaw heads **730** of the clip applying jaws **140**. However, the lock-out clip **185** also includes a resilient section **1620** that has sufficient rigidity and strength to

prevent the clip applying jaws **140** from closing. For example, when the resilient section is positioned within the clip track **770**, the strength and stiffness of the resilient section **1620** advantageously prevents the clip applying jaws **140** from closing, thereby preventing the clinician from unintentionally closing the clip applying jaws **140** when a surgical clip is not present. In some examples, the lock-out clip **185** (including the resilient section **1620**) is formed from a titanium grade 5 material, and other clips (e.g., clip **50** or any other clip of the stack **105** illustrated in FIG. **1K**) is formed from a titanium grade 1 material. In alternative examples, the lock-out clip **185**, the clip **50** (shown in FIG. **1K**), and/or the stack **105** (shown in FIG. **1K**) are formed from one or more different materials.

FIG. **16C** illustrates another example lock-out clip **185** (e.g., the lock-out clip **185** of FIG. **1K**). Similar to the example lock-out clip **185** of FIGS. **16A-16B**, the example lock-out clip **185** of FIG. **16C** includes two legs **1610a**, **1610b** and a resilient section **1620**. For example, a shape of the leg **1610a**, the **1610b**, and/or the resilient section **1620** of the lock-out clip **185** of FIG. **16C** may vary from a corresponding shape of a corresponding component of the lock-out clip **185** of FIGS. **16A-16B**.

FIGS. **17A**, **17B**, **17C**, **17D**, **17E**, **17F** and **17G** illustrate the jaw portion of the clip applicator **100** in various stages of loading a surgical clip **50**, crimping the surgical clip **50**, and applying the surgical clip **50** to ligate a vessel.

It should be appreciated that for each component with multiple or alternative embodiments, each or any of the embodiments may include the same or similar features as a previously described or a later described embodiment. Specifically, any of the components or features illustrated in FIG. **1B**, which are illustrated or described in more detail with relation to other figures, may be attributed to any of the components or features illustrated in FIG. **1C** and vice versa.

Additionally, it should be appreciated that some example embodiments herein may include fewer or more components than other example embodiments. For instance, some example embodiments of the clip application device **100** herein can be implemented without one or more of the ratchet pawl **192**, the trough **110**, and/or any other component (e.g., pin, screw, etc.) used in other example embodiments of the clip application device **100**.

Aspects of the subject matter described herein may be useful alone or in combination with one or more other aspects described herein. In an example, a surgical clip applying device includes an enclosure formed from a top housing, a bottom housing and a window cover. The clip applying device also includes a pair of handles including a left handle and a right handle, a main rail supporting a jaw closer, and a pair of clip applying jaws fixedly attached to the bottom housing and retained within the main rail. The pair of clip applying jaws has arms terminating with a pair of jaw heads. Additionally, the clip applying device includes a clip loader assembly with a clip loading tip at the clip loader assembly's distal end and a dispenser positioned above the clip loader assembly. The dispenser includes a pair of clip forks and a retention prong positioned between the pair of clip forks at the dispenser's distal end. The clip loading tip is configured to push a surgical clip supported by the pair of clip forks over the retention prong. The clip applying device also includes a clip pusher assembly configured to advance a plurality of clips towards the pair of jaw heads and a drive mechanism including a plurality of levers and at least one spring. The drive mechanism is configured to translate an actuation of the pair of handles to linear motion of the jaw closer and the clip loader assembly.

In another aspect of the present disclosure, the jaw closer includes an indent with cam members at its distal end. The cam members are configured to engage and compress corresponding ramps on the arms of the clip applying jaws thereby forcing the arms and the jaw heads together as the jaw closer is advanced towards the jaw heads.

In another aspect of the present disclosure, the clip applying device includes a lock-out clip.

In another aspect of the present disclosure, the lock-out clip is sized and shaped to advance into the jaw heads.

In another aspect of the present disclosure, the lock-out clip is configured to prevent the clip applying jaws from closing once positioned within the jaw heads.

To the extent that any of these aspects are mutually exclusive, it should be understood that such mutual exclusivity shall not limit in any way the combination of such aspects with any other aspect whether or not such aspect is explicitly recited. Any of these aspects may be claimed, without limitation, as a system, method, apparatus, device, medium, etc.

The many features and advantages of the present disclosure are apparent from the written description, and thus, the appended claims are intended to cover all such features and advantages of the disclosure. Further, since numerous modifications and changes will readily occur to those skilled in the art, the present disclosure is not limited to the exact construction and operation as illustrated and described. Therefore, the described embodiments should be taken as illustrative and not restrictive, and the disclosure should not be limited to the details given herein but should be defined by the following claims and their full scope of equivalents, whether foreseeable or unforeseeable now or in the future.

The invention is claimed as follows:

1. A surgical clip applying device comprising:
 - an enclosure formed from a top housing, a bottom housing and a window cover;
 - a pair of handles including a left handle and a right handle each mounted for pivotal movement in the bottom housing;
 - a main rail fixedly mounted to the bottom housing within the enclosure including an elongate base and upstanding sidewalls defining a U-shaped channel;
 - a pair of clip applying jaws fixedly attached to the bottom housing and mounted through the main rail, the pair of clip applying jaws having arms terminating with a pair of spaced opposing jaw heads and including a pair of angled ramp surfaces disposed in said arms spaced inwardly from said jaw heads;
 - a jaw closer comprising an elongate base including a pair of upstanding drive flanges disposed at a proximal end of the jaw closer, the elongate base including a V-shaped indent at a distal end of the jaw closer defining cam members at its distal end and an elongate slot defined in the base intermediate the distal end and proximal end of the jaw closer, the jaw closer being disposed between the clip applying jaws and the base of the rail and mounted for slideable movement in the channel toward and away from the jaw heads, the cam members being configured to engage and compress corresponding ramp surfaces on the arms of the clip applying jaws thereby forcing the arms and the jaw heads together as the jaw closer is advanced towards the jaw heads; and
 - a drive mechanism including a plurality of levers and at least one spring, connecting the handles to the upstanding drive flanges of the jaw closer, the drive mechanism

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configured to translate an actuation of the pair of handles to linear motion of the jaw closer.

2. The surgical clip applying device as defined in claim 1, further comprising:

a clip loader assembly disposed in the enclosure above the clip applying jaws including a clip loading tip at a distal end of the clip loader assembly and a drive aperture at the proximal end of the clip loader assembly;

a dispenser positioned above the clip loader assembly, the dispenser including a pair of clip forks and a retention prong positioned between the pair of clip forks at the distal end of the dispenser, wherein the clip loading tip is configured to push a surgical clip supported by the pair of clip forks over the retention prong;

a clip pusher assembly configured to advance a plurality of clips towards the pair of jaw heads; and

a drive mechanism including a plurality of levers and at least one spring, connecting the handles to the drive aperture of the clip loader assembly, the drive mecha-

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nism configured to translate an actuation of the pair of handles to linear motion of the jaw closer and clip loader clip loader assembly.

3. The surgical clip applying device of claim 2, further comprising a lock-out clip.

4. The surgical clip applying device of claim 3, wherein the lock-out clip is sized and shaped to advance into the jaw heads.

5. The surgical clip applying device of claim 4, wherein the lock-out clip is configured to prevent the clip applying jaws from closing once positioned within the jaw heads.

6. The surgical clip applying device as recited in claim 2, wherein the clip loader assembly and the drive mechanism provide automatic surgical clip reloading to the jaws as the handles move from a closed position to an open position.

7. The surgical clip applying device as recited in claim 2, wherein the window cover provides visibility to a clip count of surgical clips loaded in the dispenser.

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