(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
16 October 2014 (16.10.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/169215 A2

(51) International Patent Classification:
A61B 17/24 (2006.01)

(21) International Application Number:
PCT/US2014/033813

(22) International Filing Date:
11 April 2014 (11.04.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
61/810,876 11 April 2013 (11.04.2013) US

(71) Applicant: **UNIVERSITY OF UTAH RESEARCH FOUNDATION** [US/US]; 615 Arapeen Drive, Suite #310, Salt Lake City, UT 84108 (US).

(72) Inventors: **LANGEL, John, Thomas**; 525 16th Avenue, Salt Lake City, UT 84103 (US). **MADSEN, Spencer, Charles**; 248 East St. Germain Way, Sandy, UT 84070 (US). **JOHNSON, Paul, Michael**; 724 Westwood Avenue, Moab, UT 84532 (US). **FOGARTY, Michael, Paul**; 1091 Eastgate Drive, Provo, UT 84606 (US).

(74) Agent: **KEATING, Thomas, J.**; Michael Best & Friedrich LLP, 100 East Wisconsin Avenue, Suite 3300, Milwaukee, WI 53202-4108 (US).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *without international search report and to be republished upon receipt of that report (Rule 48.2(g))*

(54) Title: SELF-CLOSING LAPAROSCOPIC PORT

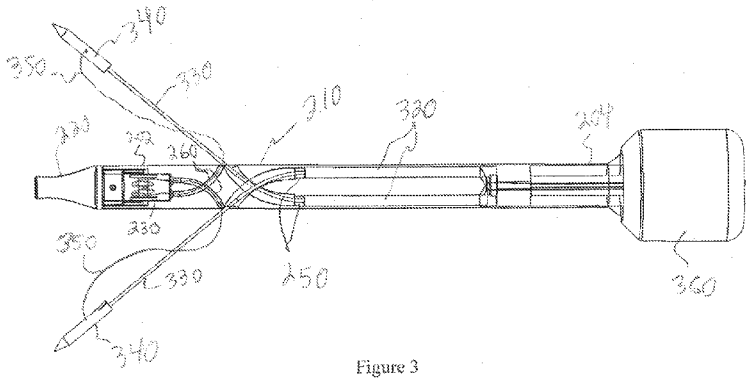

Figure 3

(57) Abstract: A self-closing trocar. The self-closing trocar includes an elongated body having a first end, a second end opposite the first end, and a side wall between the first end and the second end, the body further including at least two channels therein, each of the channels originating near the second end, running parallel to the elongated body, and curving towards and forming an opening in the side wall near the first end. The self-closing trocar also includes at least two flexible needles, each disposed within one of the at least two channels, and a handle insertable into the second end of the elongated body, the handle having at least two needle drivers coupled thereto, each needle driver being insertable into one of the at least two channels and engagable with an end of a needle.

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SELF-CLOSING LAPAROSCOPIC PORT

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application No. 61/810,876 filed April 11, 2013, the content of which is incorporated herein by reference in its entirety.

BACKGROUND

[0002] The present invention relates to laparoscopic ports and in particular to self-closing laparoscopic ports.

[0003] Approximately 2.5 million laparoscopic surgeries are performed each year in the U.S and more than 5 million worldwide. Laparoscopic surgeries use a device known as a trocar to insert a cannula through the abdominal wall. Once through the abdominal wall the trocar is removed from the cannula and the cannula is left in place, traversing the abdominal wall. The cannula serves as a port that facilitates surgical instruments and endoscopes, which allows the surgery to be performed inside the abdomen through small incisions in the abdominal wall (Figure 1). Trocars are typically 5-15 mm in diameter and most surgeries use at least three, including one that is 10 mm or larger to accommodate larger instruments and specimen removal. The wounds left by the larger trocars require closure of the intra-abdominal port to prevent intestinal herniation through the defect in the abdominal wall.

[0004] Current methods for closing these larger port sites are either difficult to perform or are cumbersome, can require considerable time to execute, and may place the surgeon at risk for needle sticks. The current "standard of care" for the closure of intra-abdominal defects is performed using a needle attached to suture and guided through the trasversalis fascia with needle-nosed forceps. Ineffective closure of intra-abdominal defects increases the patient's risk to herniation at the closure site. Additionally, patients with thick abdominal walls increase the difficulty, time, and risk for proper port closure. This often results in misplaced suture and ineffective closure of the port. In 2011, the NIH published a study reporting that patients suffered from trocar site herniation 1.85% of the time on average. The results were highly dependent on surgical technique and complication rates ranged from 0.07% to 22%. Accordingly, there is a need for a consistent method for port closure following laparoscopic surgery.

SUMMARY

[0005] In one embodiment, the invention provides a self-closing trocar. The self-closing trocar includes an elongated body having a first end, a second end opposite the first end, and a side wall between the first end and the second end, the body further including at least two channels therein, each of the channels originating near the second end, running parallel to the elongated body, and curving towards and forming an opening in the side wall near the first end. The self-closing trocar also includes at least two flexible needles, each disposed within one of the at least two channels, and a handle insertable into the second end of the elongated body, the handle having at least two needle drivers coupled thereto, each needle driver being insertable into one of the at least two channels and engagable with an end of a needle.

[0006] In another embodiment, the invention provides a self-closing laparoscopic port system. The system includes a self-closing trocar and a cannula. The self-closing trocar includes an elongated body having a first end, a second end opposite the first end, and a side wall between the first end and the second end. The body further includes at least two channels therein, each of the channels originating near the second end, running parallel to the elongated body, and curving towards and forming a trocar opening in the side wall near the first end. The self-closing trocar further includes at least two flexible needles, each disposed within one of the at least two channels, and a handle insertable into the second end of the elongated body, the handle having at least two needle drivers coupled thereto, each needle driver being insertable into one of the at least two channels and engagable with an end of a needle. The cannula is configured to receive the self-closing trocar.

[0007] In still another embodiment, the invention provides a suture anchor. The suture anchor includes an elongated body having a first, pointed end and a second end opposite the first pointed end and an attachment point on the elongated body between the first, pointed end and the second end.

[0008] In yet another embodiment, the invention provides a handle assembly for a self-closing trocar. The handle assembly includes a handle having at least two needle drivers coupled thereto, each needle driver being engagable with an end of a needle. The handle assembly also includes at least two flexible needles, each needle being coupled to one of the at least two needle drivers. Finally, the handle assembly also includes at least two anchors, each anchor being engaged with a free end of the at least two flexible needles.

[0009] Other aspects of the invention will become apparent by consideration of the detailed description and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0010] Figure 1 shows a diagram of a practitioner performing laparoscopic surgery in an abdominal region of a patient, with a laparoscope being inserted through one port and an instrument through another port.

[0011] Figure 2 shows an exploded perspective view of a self-closing laparoscopic port.

[0012] Figure 3 is a side view of a trocar for a self-closing laparoscopic port.

[0013] Figure 4 is a perspective view of an anchor.

[0014] Figure 5 is a cross-sectional view of an anchor.

[0015] Figure 6A is a perspective view of a needle driver.

[0016] Figure 6B is a perspective view of a needle driver cross-sectioned at the point indicated by B-B' in Figure 6A.

[0017] Figure 7 is a perspective view of a gear key.

[0018] Figure 8 is a perspective view of a tip for a trocar.

[0019] Figure 9 is a perspective view of an end of a trocar body.

[0020] Figure 10 is a perspective view of a suture spool.

[0021] Figure 11A is a perspective view of a trocar prior to use with the anchors inside of the trocar body.

[0022] Figure 11B is a series of perspective views of a trocar (as well as a cannula in panel 4) illustrating steps for deploying suture anchors for a self-closing laparoscopic port.

[0023] Figure 12 is a side view of a for a self-closing laparoscopic port in which anchors have been deployed into a patient's tissue.

[0024] Figure 13 is a side view of a trocar body half piece.

[0025] Figure 14 is a perspective view of a trocar body half piece with a needle driver and a gear key.

[0026] Figure 15 is a side view of a trocar body half piece with a needle driver and a gear key showing a locking mechanism for engaging the needle drivers with the handle.

[0027] Figure 16 is a side view of a trocar body with a modified handle.

[0028] Figures 17A-17D show side (17A, 17B) and front (17C, 17D) views of the first (17A, 17C) and second (17B, 17D) portions of the modified handle.

[0029] Figure 18 shows a construction of a tip for use with a trocar as disclosed herein.

[0030] Figure 19 shows a side view of a trocar with a modified handle and tip.

[0031] Figure 20 is a perspective view of another construction of a trocar body half piece.

DETAILED DESCRIPTION

[0032] Before any embodiments of the invention are explained in detail, it is to be understood that the invention is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the following drawings. The invention is capable of other embodiments and of being practiced or of being carried out in various ways.

[0033] Figure 2 shows an embodiment of a self-closing laparoscopic port 100. In the embodiment shown in Figure 2, the port 100 includes a cannula 110 and a trocar 200. The trocar 200 in various embodiments includes the trocar body 210, a removable tip 220 which attaches at a first end 202 of the trocar body 210, a suture spool 230, a cap 240 which attaches at a second end 204 of the trocar body 210, and a handle assembly 300. The handle assembly 300 includes a handle 360 coupled to a gear key 310 which is engaged with a pair of needle drivers 320 in a manner that permits coupling and decoupling of the gear key 310 from the needle drivers 320, e.g. by rotating the handle 360. Each of the needle drivers 320 is in communication with a needle 330, and each needle 330 has an anchor 340 in communication with a free end thereof; the free ends of the needles 330 may be flat, rounded, or pointed. Each anchor 340 has a length of suture 350 attached thereto (Figure 2).

[0034] The trocar body 210 includes two anchor channels 250 (Figure 3), each of which terminates an opening at the second end 204 of the trocar body 210. Each of the anchor channels 250 extends parallel to the long axis of the trocar body 210 and then curves near the first end 202 to terminate at an opening on the side of the trocar body 210. To maximize the radius of curvature, each anchor channel 250 may be configured to exit the side of the trocar body 210 opposite to the side on which the anchor channel 250 runs (Figure 3), although other configurations are also possible. Generally the exit points of the channels near the first end 202 are on opposite sides of the trocar body 210 so that, ultimately, the sutures 350 are placed on approximately opposite sides of the opening in the patient's tissue, which optimizes closure and healing of the opening. The needles 330 and needle drivers 320 are inserted into the anchor channels 250 at the second end 204 (Figures 2, 3). The needles 330 are advanced into the anchor channels 250 to a point where the free ends of the needles 330 are still contained within the anchor channels 250 and are engaged with the anchors 340. Prior to use, each of the anchors 340 is located within one of the anchor channels 250, generally at or near the opening near the first end 202 of the trocar body 210 (Figures 3, 11A).

[0035] In various embodiments, the anchors 340 have a pointed end 342 for penetrating tissue and a dimpled end 344 for engaging the needles 330 (Figure 4). The dimpled end 344 may include a flap 346, for example a portion of material protruding outward, to help the anchor 340 engage with and remain inside of the anchor channel 250. The anchors 340 also include an attachment point 348 such as a hole to which a length of suture 350 is attached, where the attachment point 348 is generally located near a midpoint of the anchor 340 (Figure 4). The attachment point 348 may be continuous with an attachment channel 349, where the attachment channel 349 may include an enlarged portion at a blind end to facilitate secure attachment of suture 350 (e.g. to hold the end of the suture 350 using a knot or a drop of adhesive). The dimpled end 344 in various embodiments may have a conical, rounded, or other concave shape and may include an additional blind channel 345 in which the needle 330 may be inserted (Figure 5). In still other embodiments, the end of the anchor 340 opposite the pointed end 342 may be flat or may have a convex shape. In use, the free ends of the needles 330 are placed against the ends of the anchors 340 opposite the pointed ends 342 in a manner that permits the needles 330 to push the anchors 340 through the tissue and to then detach and leave the anchors 340 and suture 350 in place when the needles 330 are retracted.

[0036] In certain embodiments, the anchor 340 is made of PGLA (glycolide-co-L-lactide) an absorbable copolymer of lactic and glycolic acid, due to its absorbable qualities and biocompatibilities. In one particular embodiment, the suture 350 may be made of O Vicryl™ (polylacticacid/polycycolicacid, Ethicon), although other materials may also be employed. In still other embodiments, the anchor 340 and suture 350 may each be made from the same or different materials. Although the sizes and shapes of the anchors 340 may vary, in some embodiments the anchors 340 are cylindrical rods approximately 21 mm in length and 3 mm in diameter.

[0037] The needles 330 are sufficiently flexible to adapt to the shapes of the anchor channels 250 (Figure 3) while retaining sufficient stiffness to push the anchors 340 through the patient's tissue. In one embodiment the needles 330 may be made from a flexible alloy such as nitinol (nickel-titanium), although other materials may also be used. Although the needles 330 may vary in length according to the particular embodiment, in some embodiments the needles are approximately 60 mm in length. Similarly, while the dimensions of the needle drivers 320 may vary depending on the particular embodiment, in some embodiments the needle drivers 320 may consist of cylindrical rods approximately 57 mm long and 2.75 mm in diameter.

[0038] Prior to use, each length of suture 350 connected to a respective anchor 340 may be wound around the suture spool 230 (Figures 3, 11A), which is located at the first end 202 of the trocar body 210. The remaining portion of the suture 350 that is not wound around the suture spool 230 then leads to the anchor 340 (Figure 3). In some embodiments, the trocar body 210 includes one or more suture channels 260 through which the suture 350 is fed from the suture spool 230 to the anchor 340. In certain embodiments, the suture channels 260 terminate on the side of the trocar body 210 in a location immediately adjacent to and continuous with the ends of the openings of the anchor channels 250. Thus, prior to use, the lengths of suture 350 can be fed to the anchors 340 without protruding from the side of the trocar body 210. Once the suture spool 230 and suture 350 have been properly configured, the tip 220 can be placed on the first end 202 of the trocar body 210.

[0039] The needle drivers 320 are attached to a base 322 which engages with the gear key 310 (Figures 6A, 6B, 7). The base 322 includes slots 324 and a locking mechanism 326 (Figure 6B). The gear key 310 includes ridges 312 which engage with the slots 324 and arms 314 which engage with the locking mechanism 326 (Figure 7). The gear key 310 is connected

to the handle 360 (Figure 2) so that the handle 360 can be used to push, pull, and rotate the gear key 310. When the trocar 200 is being used to create an opening in the patient's tissue and prior to deploying the needles 330, the arms 314 of the gear key 310 are aligned with the base 322 of the needle driver 320 and the ridges 312 are engaged with the slots 324 so that the arms 314 can slide through the base 322 without engaging the locking mechanism 326.

[0040] When the clinician wishes to close the opening that was made in the patient's tissue, the trocar 200 is inserted into the cannula 110. Figure 11B, panels 1-3 show the trocar 200 at various points of the deployment procedure, omitting the cannula 110 for clarity; Figure 11B, panel 4 shows the trocar 200 inserted into a cannula after deployment of the needles 330 and anchors 340. The handle 360 is pulled so that the gear key 310 is slid at least partway out of the base 322 (Figure 11B, panel 2); the handle 360 is rotated (e.g. approximately 90° clockwise) so that the arms 314 are engaged with the locking mechanism 326. The clinician can then push on the handle 360 such that the force of the handle 360 is transmitted to the gear key 310, then to the needle driver 320, then to the needles 330, and eventually to the anchors 340 (Figure 11B, panel 3). The anchors 340 are then driven through the patient's tissue and into a cavity such as the abdominal cavity (Figure 12), where the anchors 340 are prevented from moving backwards into the tissue due to the connection of the suture 350 at the midpoint of each anchor 340. The trocar 200 and cannula 110 can then be withdrawn, leaving the two anchors 340 on approximately opposite sides of the opening in the patient's tissue, each with a length of suture 350 extending therefrom. The clinician then ties the lengths of suture 350 in order to close the opening in the patient's tissue.

[0041] In certain embodiments the tip 220 includes a bladeless tip 222 (Figure 8). The use of a bladeless tip minimizes abdominal wall and vessel trauma by separating and pushing the tissue fibers apart along natural lines instead of cutting the tissue. Bladeless tips (which might be, e.g., 1 mm x 4 mm) create 41% smaller fascial defects than bladed trocars. The tip 220 also includes a neck 224 which fits into the first end 202 of the trocar body 210 (Figure 9), where the neck 224 may have a smaller diameter than the trocar body 210 so that the connection between the tip 220 and the trocar body 210 is flush. The neck 224 may include one or more protrusions 226 (Figure 8) which fit into matching depressions 206 in the trocar body 210 to ensure a tight connection between the tip 220 and the trocar body 210. The neck 224 may also include extensions 228 that fit into matching slots 208 in the trocar body 210 and which include rounded cutouts to support the suture spool 230 (Figures 8, 9).

[0042] The suture spool 230 includes an axle 232 with two flat wheels 234 and extensions 236 adjacent to the wheels 234 (Figure 10). The axle 232 may also include an opening 238 into which suture 350 may be inserted. In use, one or more lengths of suture 350 are inserted into the opening 238 and wound around the axle 232 of the suture spool 230 between the wheels 234. The spool 230 is inserted into the first end 202 of the trocar body 210 and the tip 220 is placed over the first end 202, engaging the extensions 236 of the suture spool 230. The length(s) of suture 350 then extend into the suture channel(s) 260 as described above. In use, the suture 350 is released from the opening 238 when the anchors 340 have been inserted into the tissue and the trocar 200 is withdrawn.

[0043] In various embodiments, the cannula 110 includes one or more exit openings 112 matched to the openings through which the anchors 340 project from the trocar body 210 (Figures 11B, 12). The exit openings 112 may be circular, oval, or other suitable shape to permit the anchors 340 to exit from the trocar body 210 without being obstructed. The exit openings 112 may be somewhat larger than is strictly needed for the size of the anchors 340 to permit some leeway in alignment between the cannula 110 and the trocar 200. The exit openings 112 may also be aligned (in conjunction with the depth guidance line discussed below) slightly below the openings through which the anchors 340 exit from the trocar body 210 due to the downward angle of exit of the anchors 340.

[0044] The cannula 110 and/or the trocar body 210 may also include a depth guidance line 212 (shown on the trocar body 210 in Figure 12) to assist the clinician in setting the trocar 200 at the correct depth before the anchors 340 are deployed (Figure 12). The clinician can visualize the depth guidance line 212 from within the patient's body cavity using a camera (see, e.g. Figure 1). The camera is generally inserted through a smaller port (e.g. 5 mm diameter) than the trocar (e.g. 15-25 mm diameter) and so the camera port typically does not need to be closed with sutures following surgery. In other embodiments, the cannula 110 may also include a depth guidance line, depending on the overall length of the cannula 110 relative to the thickness of tissue. The depth guidance line may be printed with a biocompatible ink or dye (generally FDA-approved for use in humans) and/or may include a raised or indented portion of the cannula 110 or trocar body 210 to facilitate visualization.

[0045] In various embodiments the anchors 340 and needles 330 project from the trocar body 210 at approximately 45° angles, although other angles are also possible. As shown in Figure 12, when the cannula 110 and trocar 200 are set at the correct depth, the deployed

anchors 340 penetrate the patient's tissue (including, for example, the transversalis fascia) and are lodged in the body cavity. In one embodiment the anchors 340 are located approximately 1 cm from the exterior of the wound opening created by the trocar/cannula. When the needles 330 are retracted the anchors 340 and suture 350 will remain in place, permitting the clinician to close the opening made by the laparoscopic port.

[0046] In various alternative embodiments, instead of using the suture spool 230, the length of suture 350 may instead be stored in another manner in association with the trocar body 210, for example packed into the space behind the tip 220 or in the central portion of the trocar body 210 (e.g. coiled or folded in a manner that prevents tangling), in other embodiments the suture 350 is fed through the anchor channels 250 back towards second end 204 of the trocar body 210.

[0047] Although the description and drawings provided herein recite a self-closing laparoscopic port 100 having two anchors 340, two needles 330, etc., in various embodiments other numbers of anchors, needles, and related components are also possible. For example, three, four, or more anchors, needles, etc. may be used on ports having larger openings, both because the opening is larger and may require more sutures to repair and because a larger opening and trocar body would be available to accommodate the additional space required for three or more channels in the trocar body.

[0048] In some embodiments the clinician may make a larger opening, for example an elongated opening to permit removal of tissue, requiring more than one set of sutures to close the surgical opening. In this case, a trocar 200 and associated cannula 110 may be inserted more than once at different locations along the surgical opening to place sutures at multiple locations. The same trocar 200 may be used for each set of sutures or a new trocar 200 may be used for inserting each set of sutures.

[0049] Various embodiments of the self-closing laparoscopic port 100 disclosed herein may be used in various procedures including, but no limited to, laparoscopic surgery in the abdomen or thorax and may be used for placing anchors in connection with other medical procedures such as placement of feeding tubes in a patient's stomach. Patients may include humans or other animals, with suitable accommodations being made to the dimensions of the components for the type of patient and the part of the anatomy that is being anchored or sutured.

[0050] In general the trocar body 210 is designed to be compatible with standard sizes of cannulas 110 and the handle 360 and other components are designed for comfortable and ergonomic use. For example, the handle 360 is sized (e.g. in some embodiments the handle 360 is a cylindrical rod of approximately 36 mm in length and 33 mm in diameter) to fit into a user's palm and the trocar/cannula unit is designed so that not more than 8 psi of force is required for insertion. The trocar body 210 is generally cylindrical, for example 10 mm in diameter and 20 cm in length, although dimensions will vary depending on the application and the type of cannula that is being used, where standard inside diameters for cannulas include 8, 10, 12, and 15 mm diameters. The handle 360 may be made of a variety of suitable materials including, for example, polystyrene, whereas the trocar body 210 and related components may be made of materials such as ABS (Acrylonitrile butadiene styrene) plastic.

[0051] In some embodiments the trocar body 210 may be formed as two pieces, for example two identical pieces such as a trocar body half piece 210a shown in Figure 13, which can be brought together to form a complete body 210. Each trocar body half piece 210a includes a half-cylindrical portion which accommodates the needle driver base 322 as well as the gear key 310. Each trocar body half piece 210a also includes an anchor channel 250, each of which accommodates a needle driver 320. The anchor channel 250 on each trocar body half piece 210a is curved at the end in order to guide the needles 330 and anchors 340 out of the trocar and into the tissue. Instead of being cylindrical, the needle drivers 320 in some embodiments may be rounded on one side (i.e. the side which fits into the anchor channel 250) and flattened on the other side, as shown in Figure 14. In addition, the first end 202 of each trocar body half piece 210a may be modified (e.g. including a step portion as shown in Figures 13, 14) for attachment of a tip 220 and rounded profiles to hold a suture spool 230 within the tip 220.

[0052] In various embodiments, an alternative mechanism is provided for lockingly engaging the handle 360 with the needle driver base 322 and the needle drivers 320. In some embodiments, the gear key 310 includes a pair of outwardly-biased legs 316 which are flexibly attached to the shaft of the gear key 310. The legs 316 are initially located (position A in Figure 15) between the needle driver base 322 and the distal end of the trocar body 210. When the handle 360 is pulled away from the trocar body 210, the gear key 310 slides through the needle driver base 322 until the legs 316 are pulled completely through, extend away from the shaft of the gear key 310, and engage with the needle driver base 322 (position

B in Figure 15). With the legs 316 of the gear key 310 engaged with the needle driver base 322, the handle 360 is then pushed back towards the trocar body 210, advancing the needle drivers 320 through the anchor channels 250 and driving the needles 330 and anchors 340 out of the trocar and into the tissue. In some embodiments, the gear key 310 includes a stop 318 which allows the needle driver base 322, needle drivers 320, and needles 330 to be retracted once the anchors 340 have been inserted into the tissue (Figure 15). The stop 318 also prevents the gear key 310 from being completely disengaged from the needle driver base 322.

[0053] In certain embodiments, a modified handle 360 facilitates engagement of the legs 316 with the needle driver base 322 and driving of the needles 330 and anchors 340 out of the trocar and into the tissue. The modified handle 360 includes a first handle portion 360a and a second handle portion 360b (Figures 16, 17A-17D). The first handle portion 360a engages with the end of the shaft of the gear key 310 and is removably engaged with the second handle portion 360b. The second handle portion 360b is engaged with the trocar body 210 and includes a central opening through which the gear key 310 slides freely (Figures 17A-17D).

[0054] In use, a clinician or other user disengages the first handle portion 360a from the second handle portion 360 and pulls the first handle portion 360a away from the second handle portion 360b. As discussed above, the gear key 310 is pulled out until the legs 316 are drawn completely through and engage with the needle driver base 322 (position B in Figure 15). At this point the first handle portion 360a is pushed towards the second handle portion 360b in order to advance the needle drivers 320 through the anchor channels 250 and drive the needles 330 and anchors 340 out of the trocar and into the tissue.

[0055] In various embodiments, the anchor channels 250 curve and terminate at openings which are located on the trocar body 210 further down the first end 202 and closer to the tip 220 than what is shown, for example, in Figure 3. In certain embodiments, when the locations of the openings at the ends of the anchor channels 250 are located sufficiently far down towards the first end 202, the tip 220 may be modified to include openings 229 (Figure 18) through which the needles 330 and anchors 340 may exit (see dashed arrows in Figure 19). One advantage of locating the exit points of the anchor channels 250 further down the trocar body is that it may not be necessary to use a modified cannula with an exit hole, instead facilitating the use of the disclosed trocar with standard cannulas currently available on the market.

[0056] In some embodiments, an alternative tip 220a includes not only the openings 229 but also a modified bladeless tip 222a (Figure 18).

[0057] In another embodiment, the trocar body 210 may be formed by joining together two identical copies of another construction of a trocar body half piece 210a as shown in Figure 20. In this construction, each trocar body half piece 210a includes a tip portion 220b integrated therein. The tip portion 220b includes a cavity 223 (e.g. a cylindrical cavity as shown) for holding suture material 350, where the suture material 350 may be wound around a suture spool 230 that is placed within the cavity 223. The cavity 223 may be joined to the anchor channels 250 by way of a suture channel 260 (Figure 20). The pointed end of the tip portion 220b may also include a bladeless tip 222 or a modified bladeless tip 222a as discussed above, or may include other adaptations to facilitate insertion of the trocar.

[0058] Thus, the invention provides, among other things, a self-closing laparoscopic port. Various features and advantages of the invention are set forth in the following claims.

CLAIMS

What is claimed is:

1. A self-closing trocar, comprising:

an elongated body having a first end, a second end opposite the first end, and a side wall between the first end and the second end, the body further including at least two channels therein, each of the channels originating near the second end, running parallel to the elongated body, and curving towards and forming an opening in the side wall near the first end;

at least two flexible needles, each disposed within one of the at least two channels; and

a handle insertable into the second end of the elongated body, the handle having at least two needle drivers coupled thereto, each needle driver being insertable into one of the at least two channels and engagable with an end of a needle.

2. The self-closing trocar of claim 1, wherein each of the at least two flexible needles has a free end disposed near the opening at the side wall.

3. The self-closing trocar of claim 2, further comprising at least two anchors, each of which is associated with the free end of one of the at least two flexible needles.

4. The self-closing trocar of claim 3, further comprising a length of suture attached to each of the at least two anchors.

5. The self-closing trocar of claim 4, wherein inserting the handle into the second end of the elongated body drives each of the at least two flexible needles through an opening in the side wall and out of the elongated body.

6. The self-closing trocar of claim 5, wherein each of the at least two flexible needles is driven through respective openings on opposite sides of the side wall of the elongated body.

7. The self-closing trocar of claim 6, wherein each of the at least two flexible needles exits at angle of approximately 45° relative to the elongated body.

8. The self-closing trocar of claim 7, wherein pulling the handle out of the second end of the elongated body retracts each of the at least two flexible needles into one of the at least two channels.

9. The self-closing trocar of claim 1, wherein the end of the elongated body comprises a bladeless tip.

10. The self-closing trocar of claim 4, further comprising a suture spool disposed at the first end of the elongated body, wherein at least a portion of the length of suture is wound around the suture spool.

11. The self-closing trocar of claim 1, wherein the handle further comprises a gear key, and wherein the gear key either slidingly engages with the needle drivers or lockingly engages with the needle drivers.

12. A self-closing laparoscopic port system, the system comprising:

a self-closing trocar, the trocar including

an elongated body having a first end, a second end opposite the first end, and a side wall between the first end and the second end, the body further including at least two channels therein, each of the channels originating near the second end, running parallel to the elongated body, and curving towards and forming a trocar opening in the side wall near the first end,

at least two flexible needles, each disposed within one of the at least two channels, and

a handle insertable into the second end of the elongated body, the handle having at least two needle drivers coupled thereto, each needle driver being insertable into one of the at least two channels and engagable with an end of a needle; and

a cannula configured to receive the self-closing trocar.

13. The self-closing laparoscopic port system of claim 12, wherein the cannula comprises two openings along a length thereof, the cannula openings configured to align with the trocar openings in the body.

14. The self-closing laparoscopic port system of claim 13, wherein at least one of the cannula and the self-closing trocar comprises a depth guidance line.

15. The self-closing laparoscopic port system of claim 14, wherein each of the at least two flexible needles has a free end disposed near the trocar opening.

16. The self-closing laparoscopic port system of claim 15, further comprising at least two anchors, each of which is associated with the free end of one of the at least two flexible needles.

17. The self-closing laparoscopic port system of claim 16, further comprising a length of suture attached to each of the at least two anchors.

18. The self-closing laparoscopic port system of claim 17, wherein inserting the handle into the second end of the elongated body drives each of the at least two flexible needles through a trocar opening in the side wall and out of the elongated body.

19. The self-closing laparoscopic port system of claim 18, wherein each of the at least two flexible needles is driven through one of the cannula openings.

20. A suture anchor, comprising:

an elongated body having a first, pointed end and a second end opposite the first pointed end and an attachment point on the elongated body between the first, pointed end and the second end.

21. The suture anchor of claim 20, wherein the second end comprises a concave surface configured to receive a free end of a needle.

22. The suture anchor of claim 21, wherein the concave surface comprises a conical surface.

23. The suture anchor of claim 22, wherein the conical surface comprises a blind channel at an end thereof, the blind channel configured to receive a free end of a needle.

24. The suture anchor of claim 23, wherein the attachment point comprises an attachment channel having an enlarged cavity at a blind end thereof, the attachment channel being configured to receive a free end of a suture.

25. The suture anchor of claim 24, wherein the elongated body comprises PGLA.

26. A handle assembly for a self-closing trocar, comprising:

a handle having at least two needle drivers coupled thereto, each needle driver being engagable with an end of a needle;

at least two flexible needles, each needle being coupled to one of the at least two needle drivers; and

at least two anchors, each anchor being engaged with a free end of the at least two flexible needles.

27. The handle assembly of claim 26, further comprising a length of suture attached to each of the at least two anchors.

28. The handle assembly of claim 27, wherein the handle further comprises a gear key, and wherein the gear key either slidingly engages with the needle drivers or lockingly engages with the needle drivers.

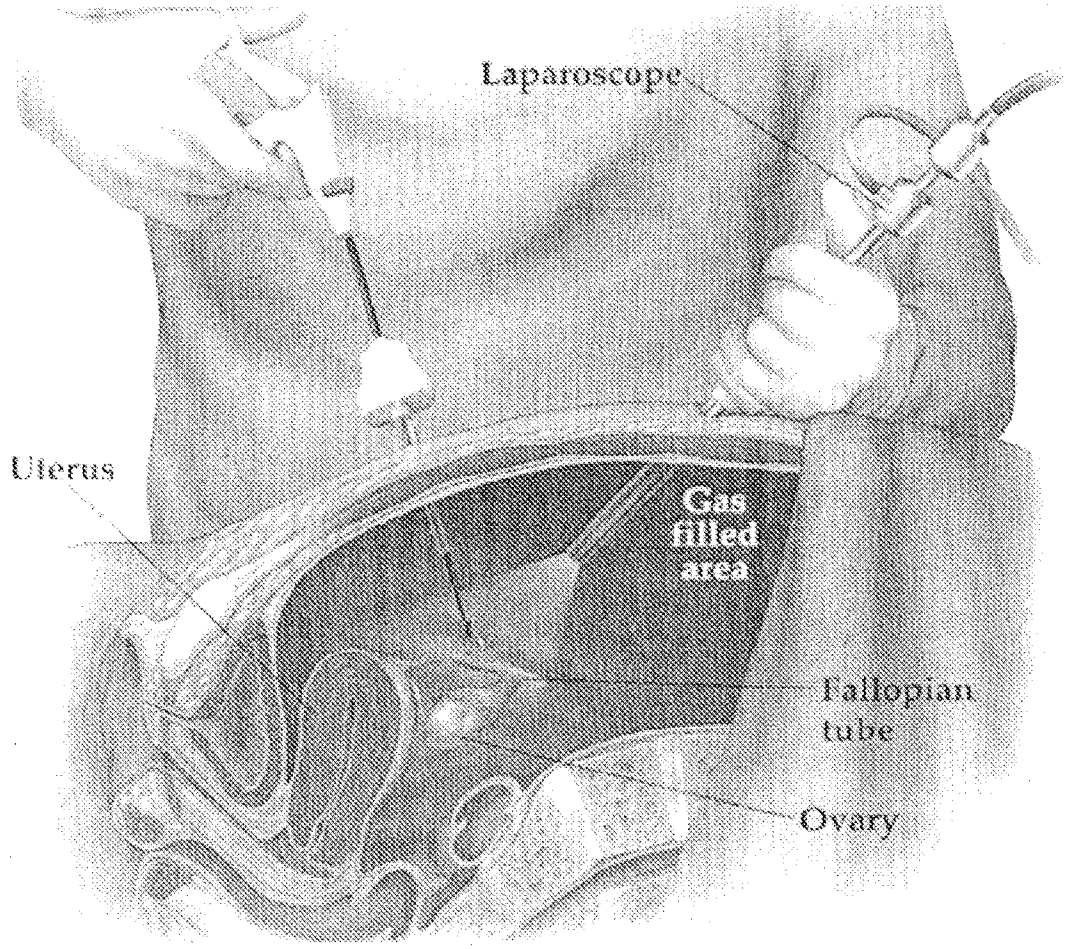


Figure 1

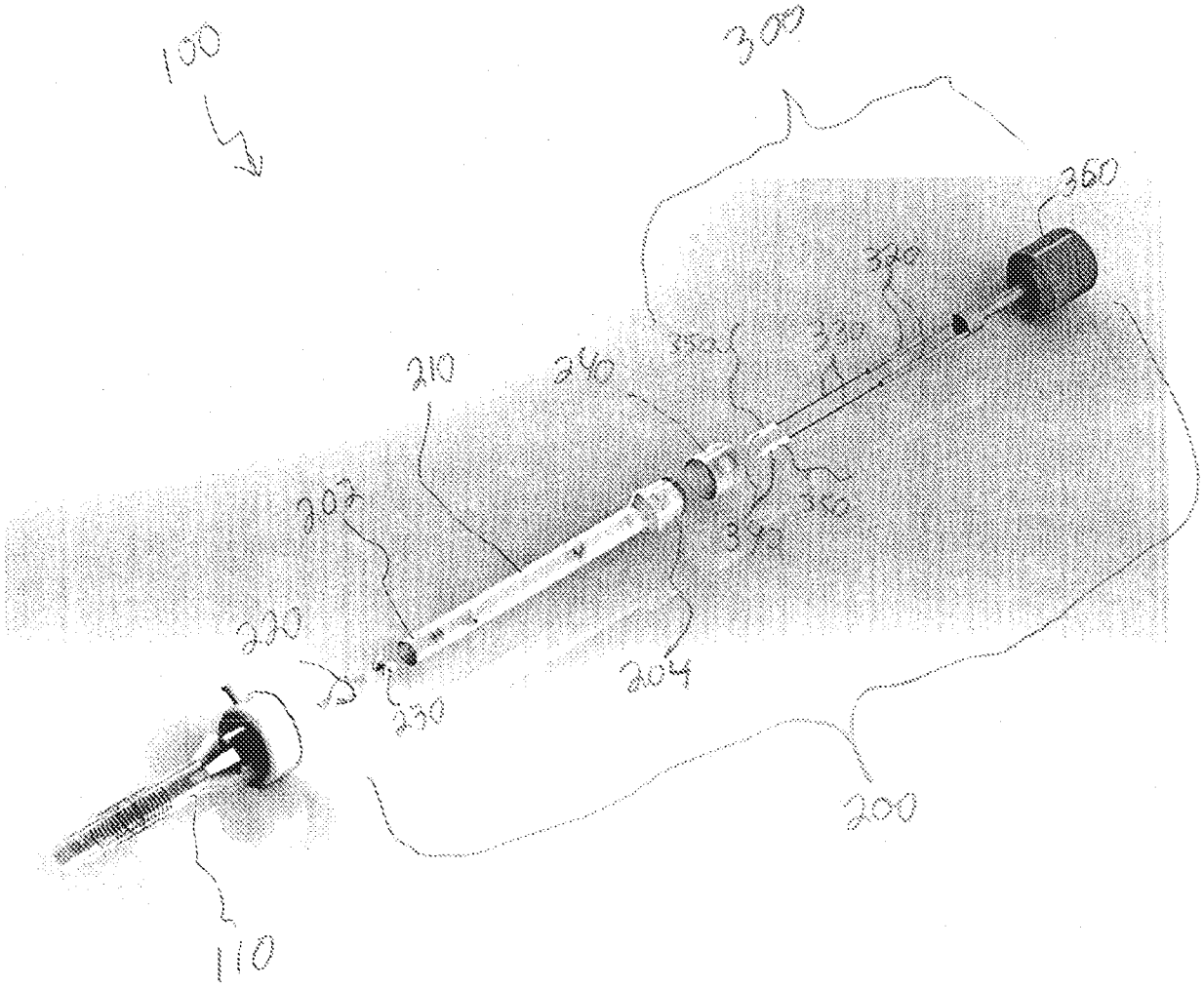


Figure 2

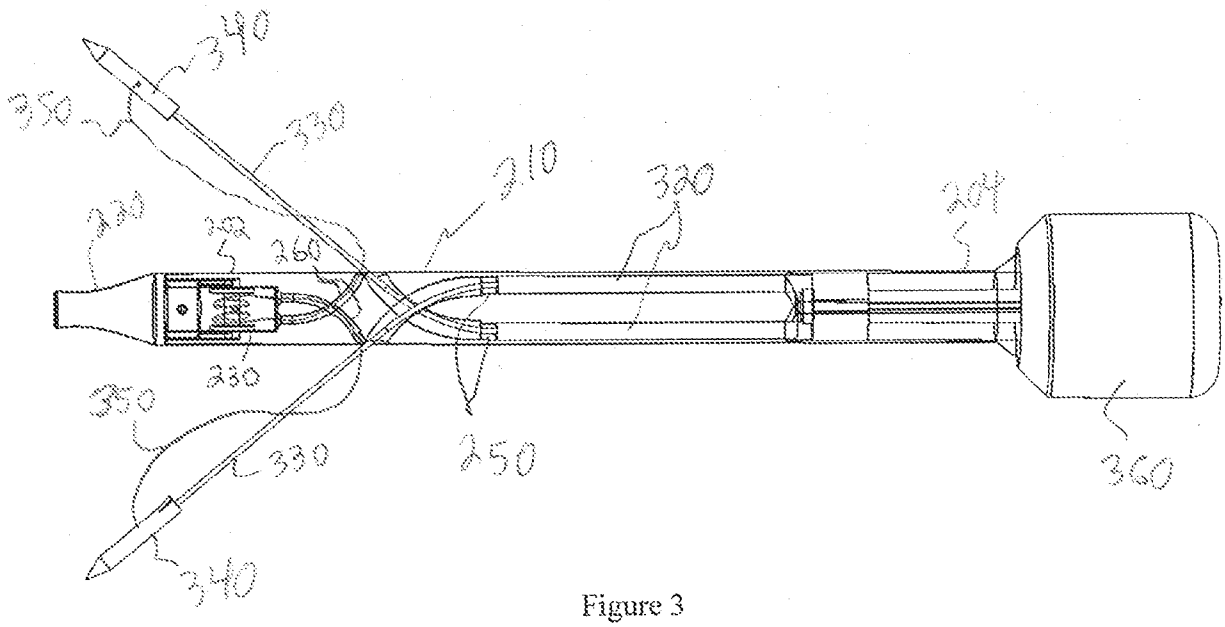


Figure 3

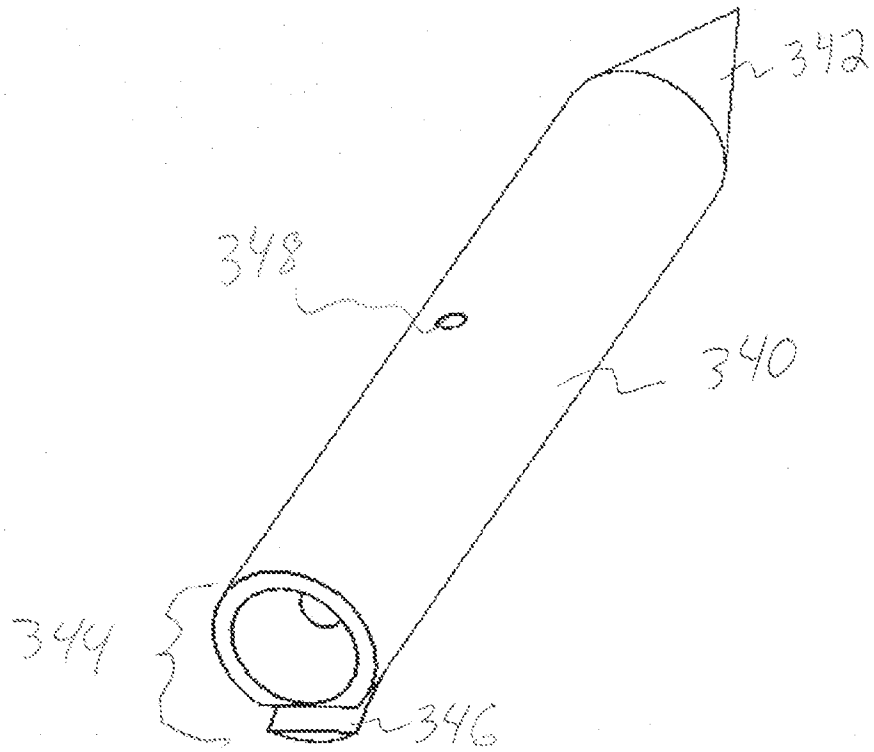


Figure 4

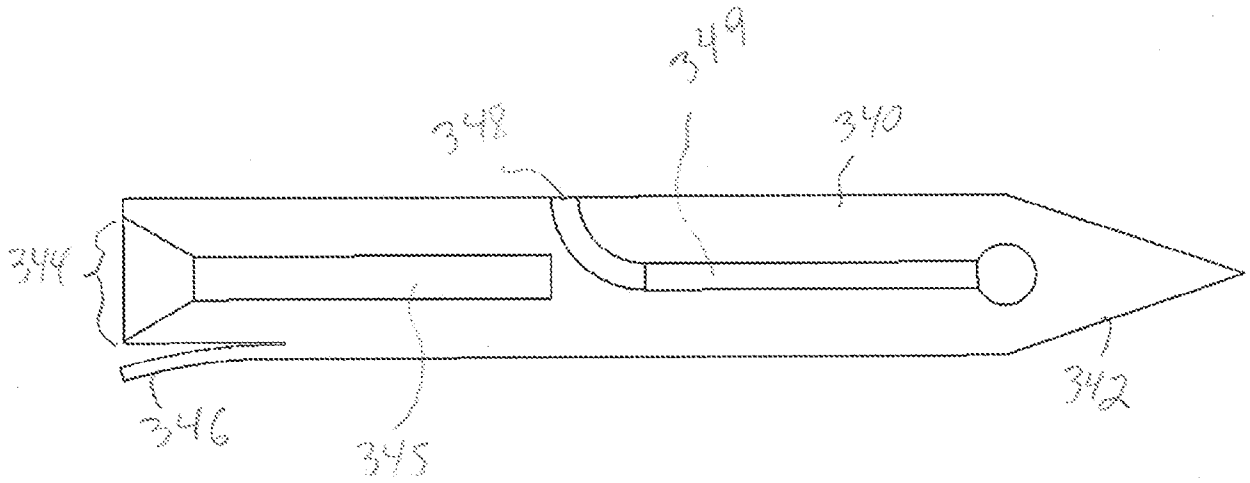


Figure 5

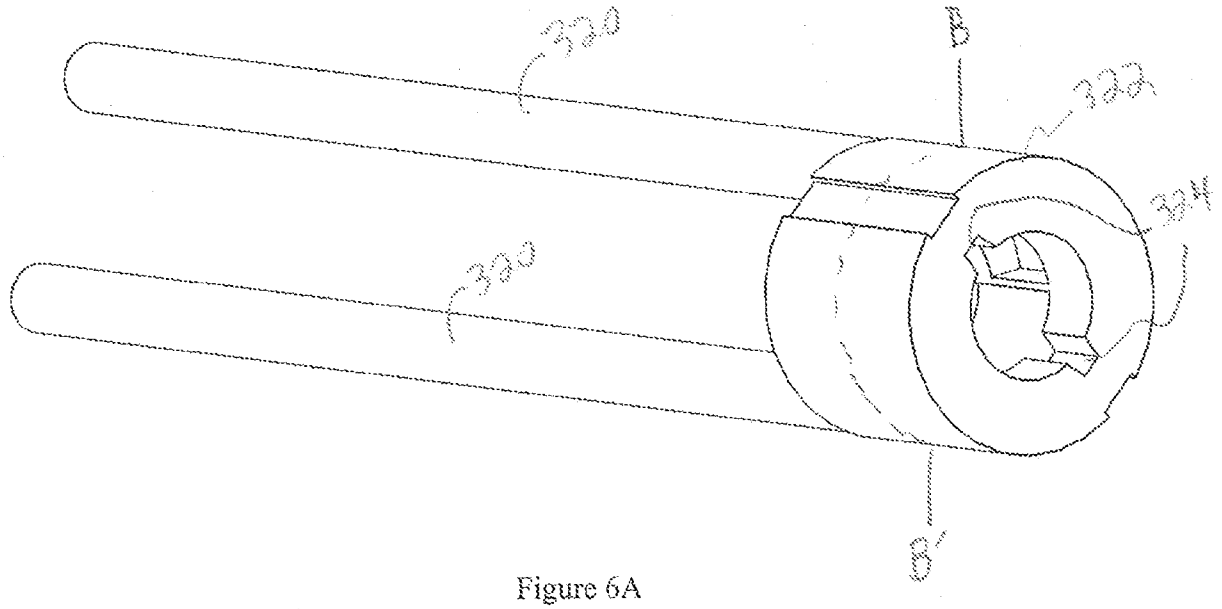


Figure 6A

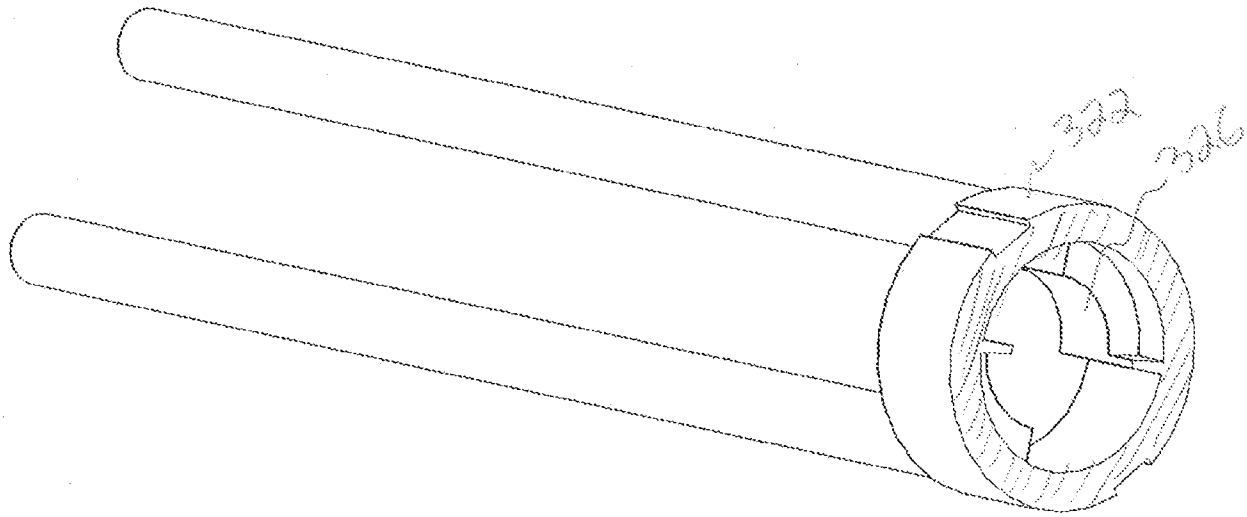
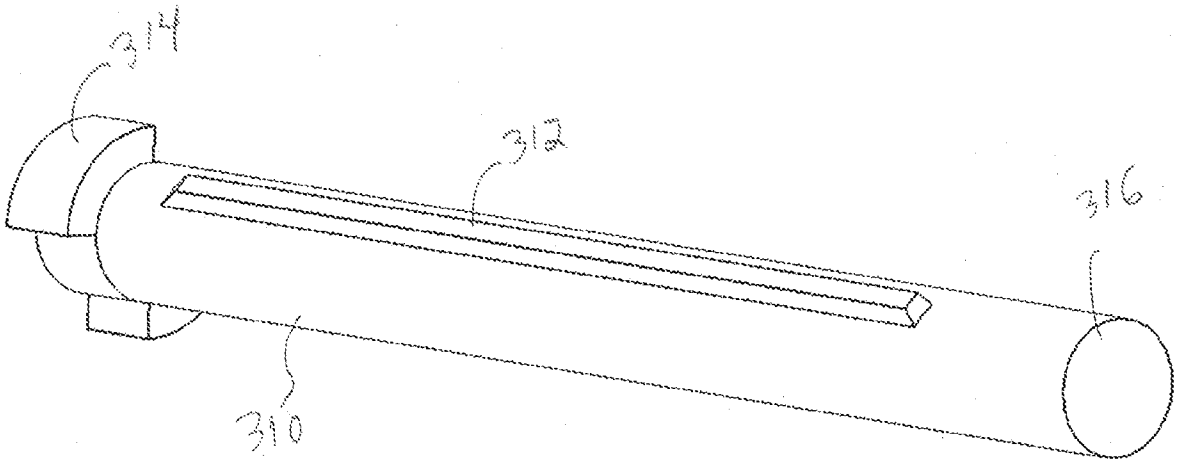


Figure 6B



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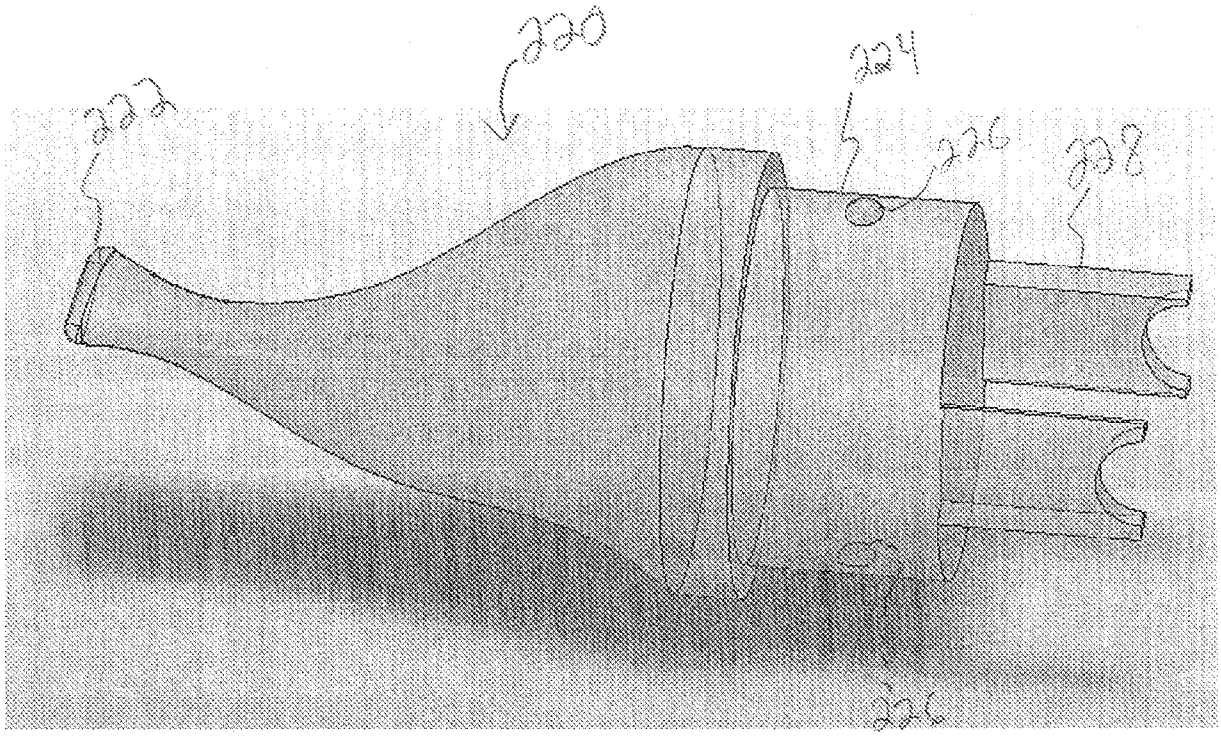
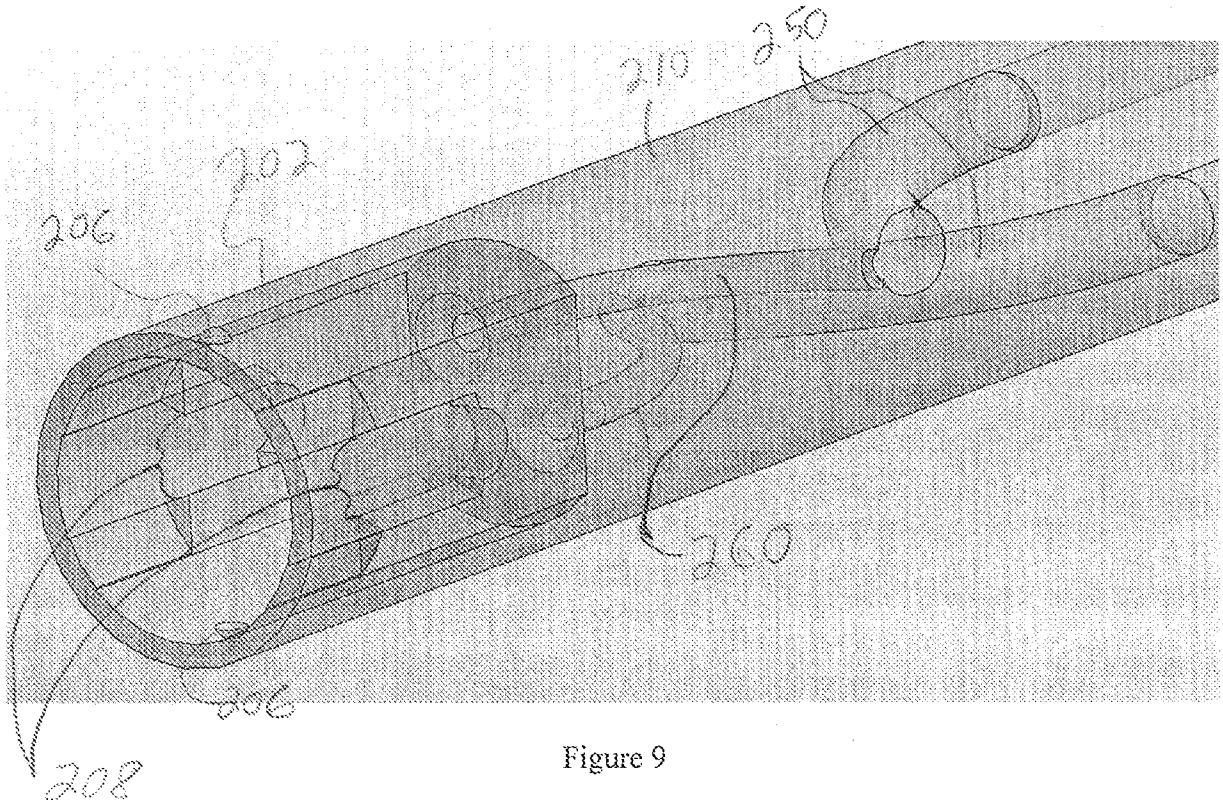


Figure 8



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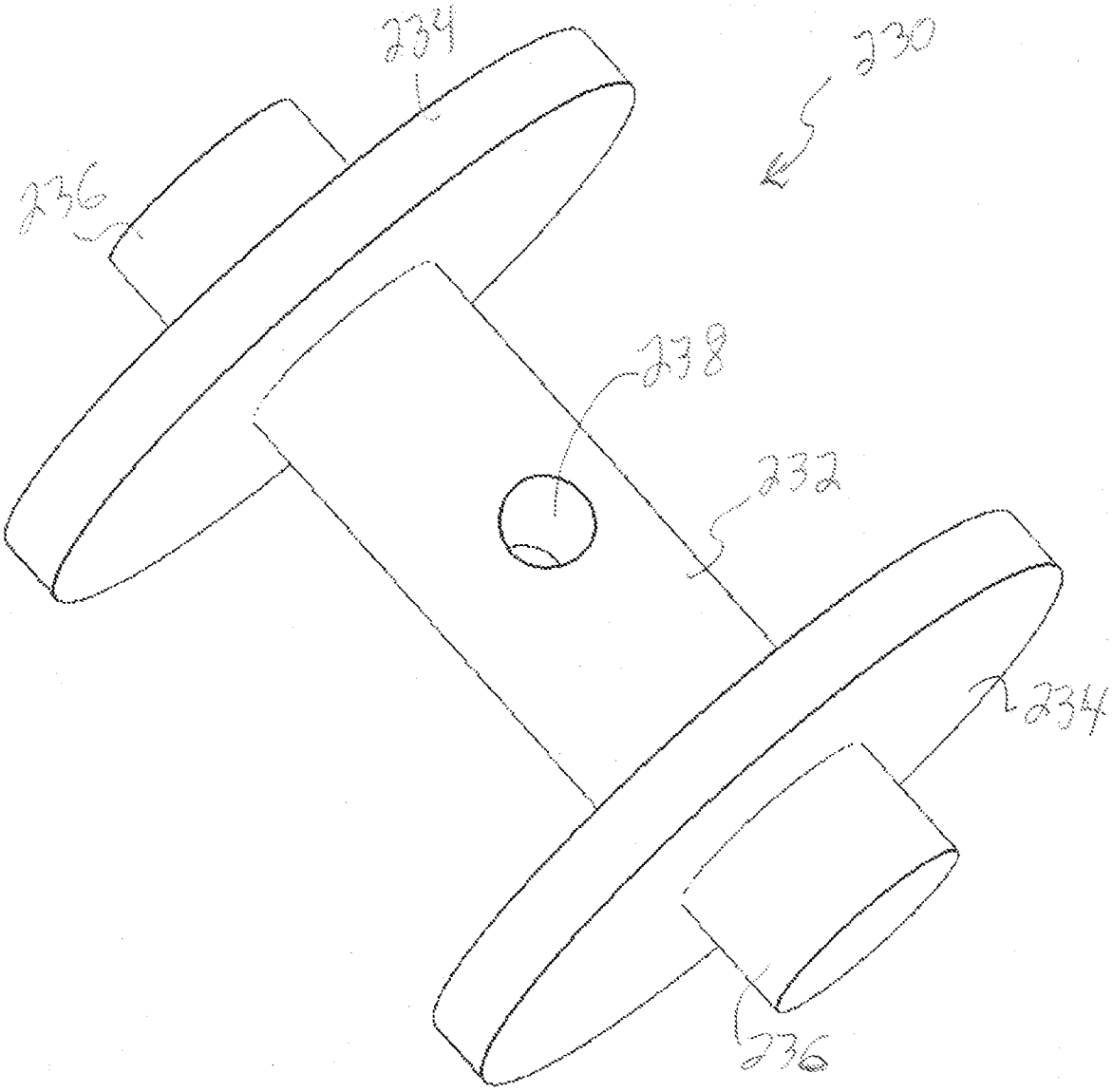


Figure 10

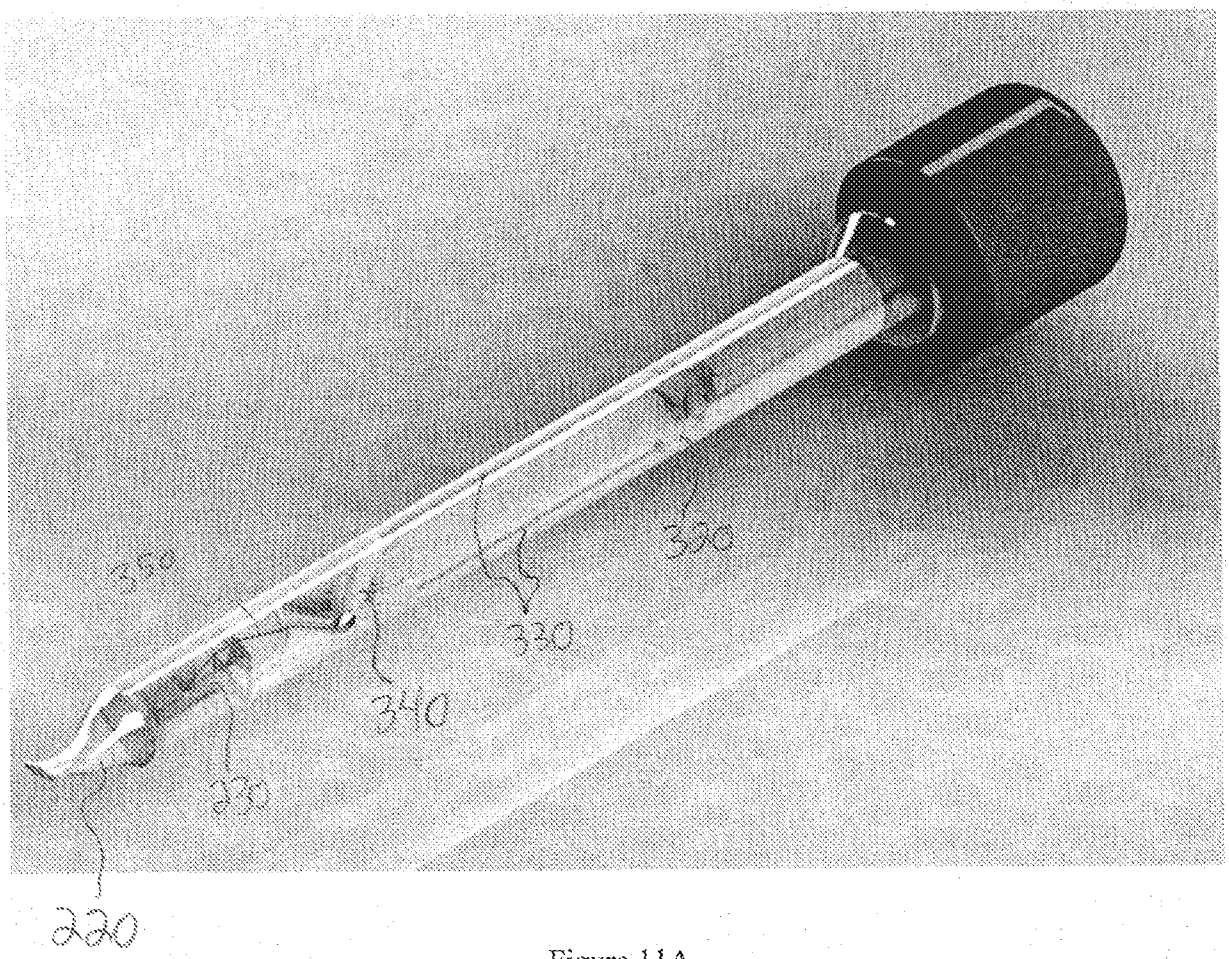


Figure 11A

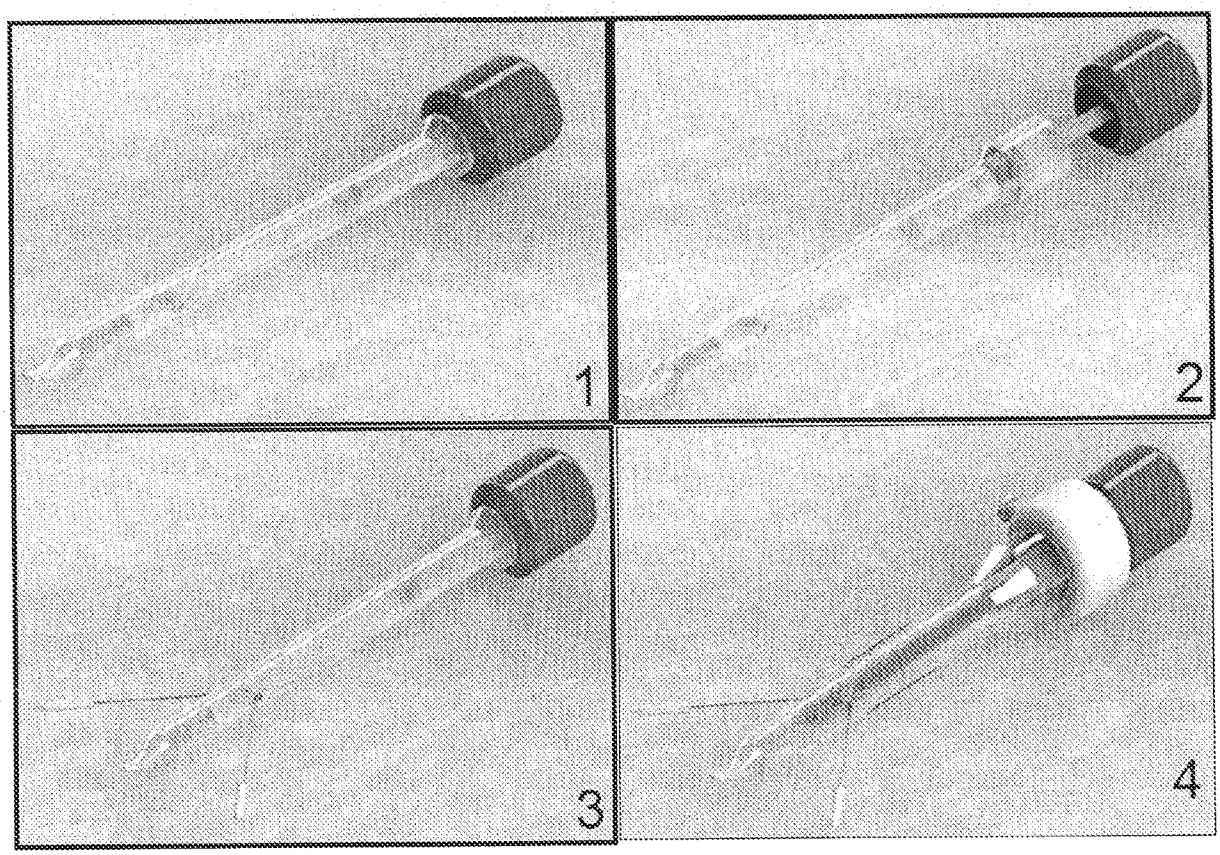


Figure 11B

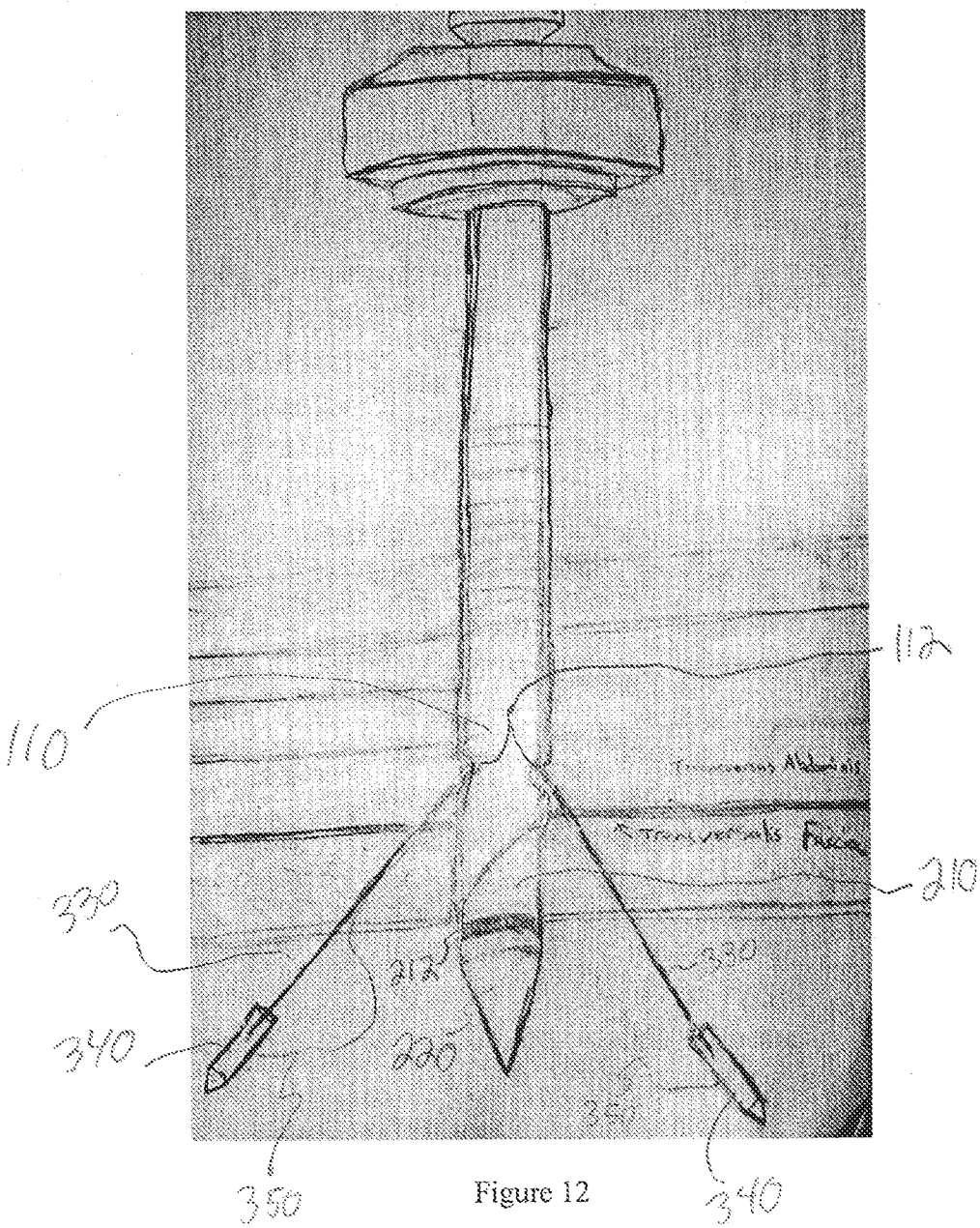


Figure 12

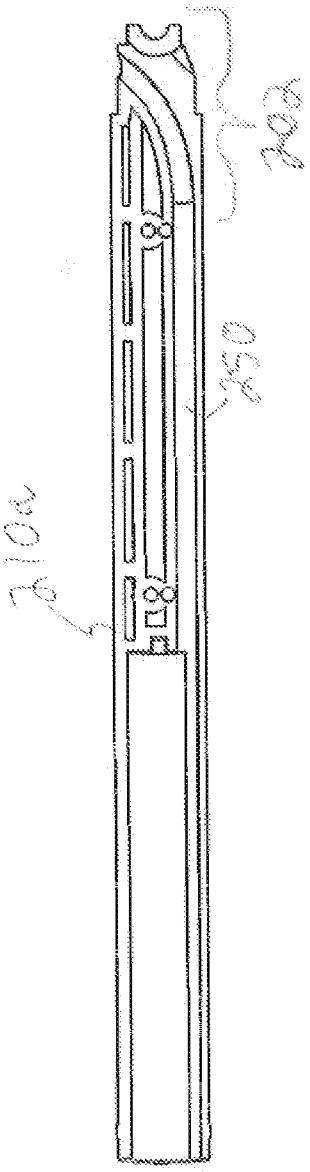


Figure 13

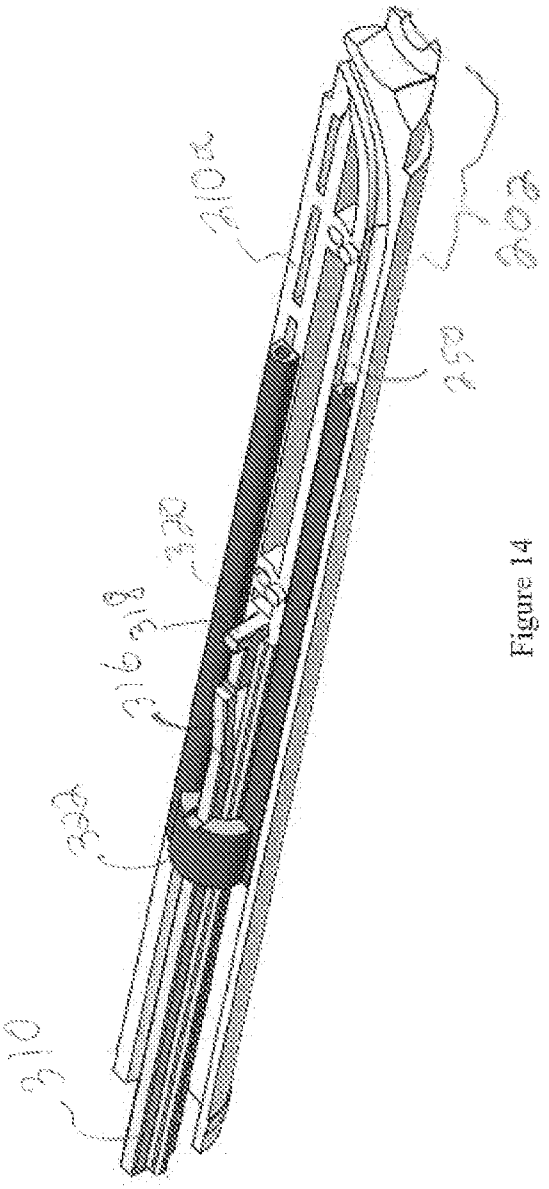


Figure 14

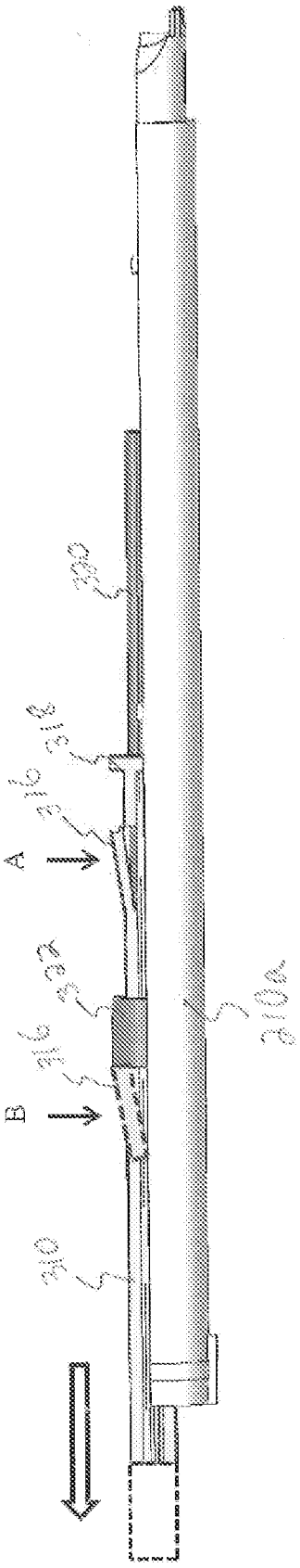


Figure 15

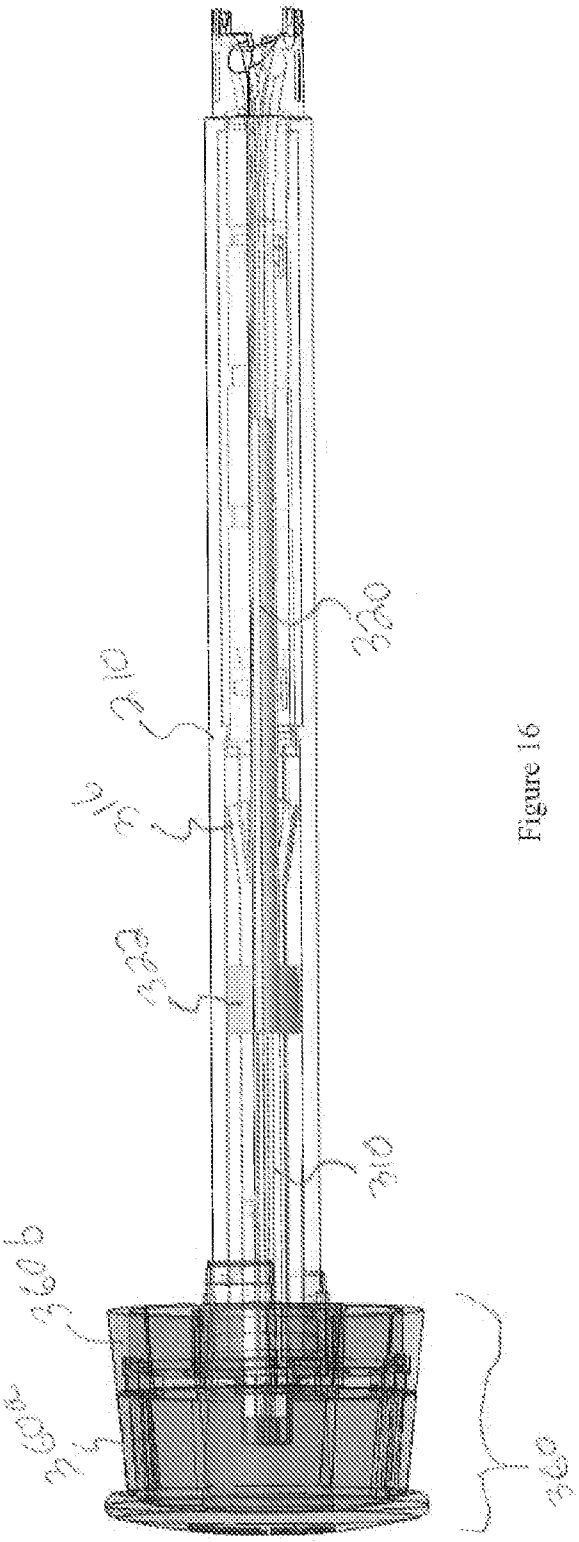


Figure 16

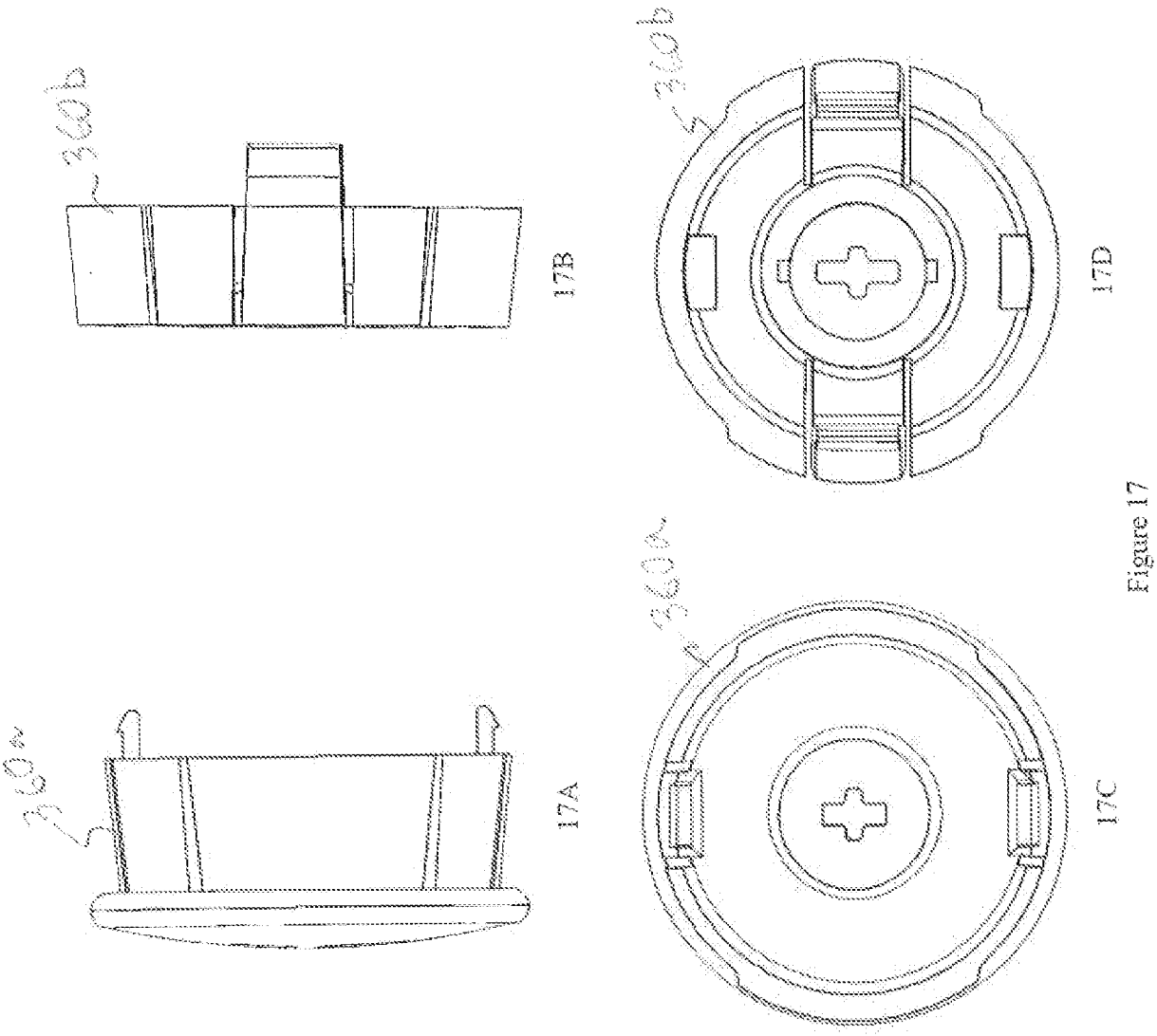


Figure 17

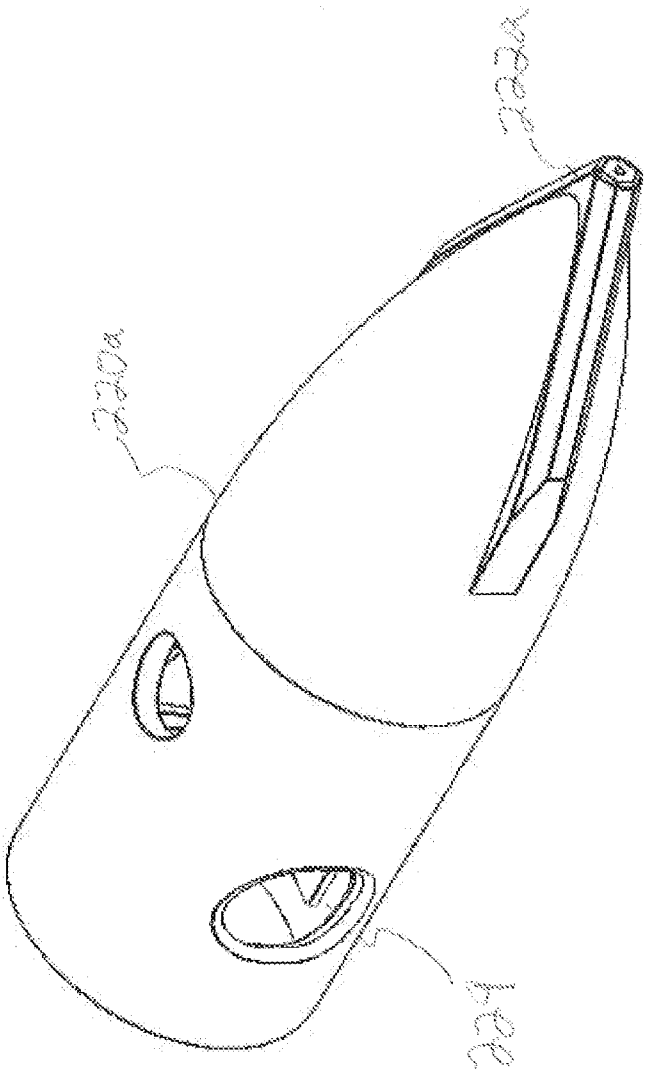
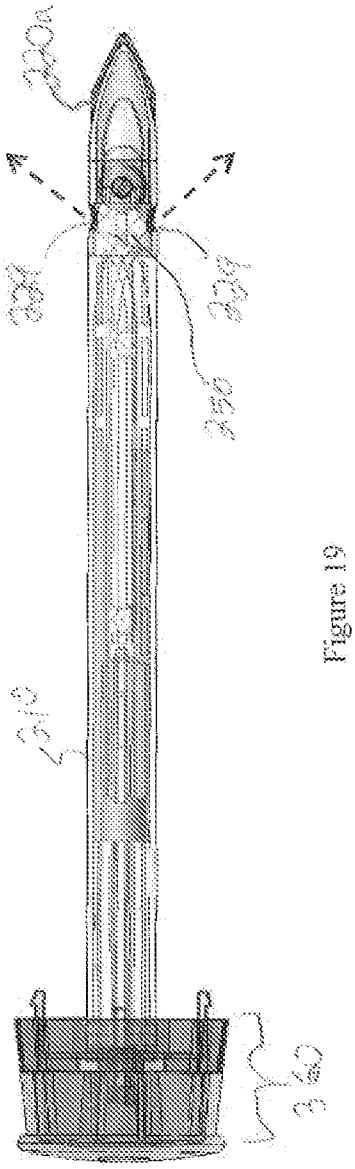


Figure 18



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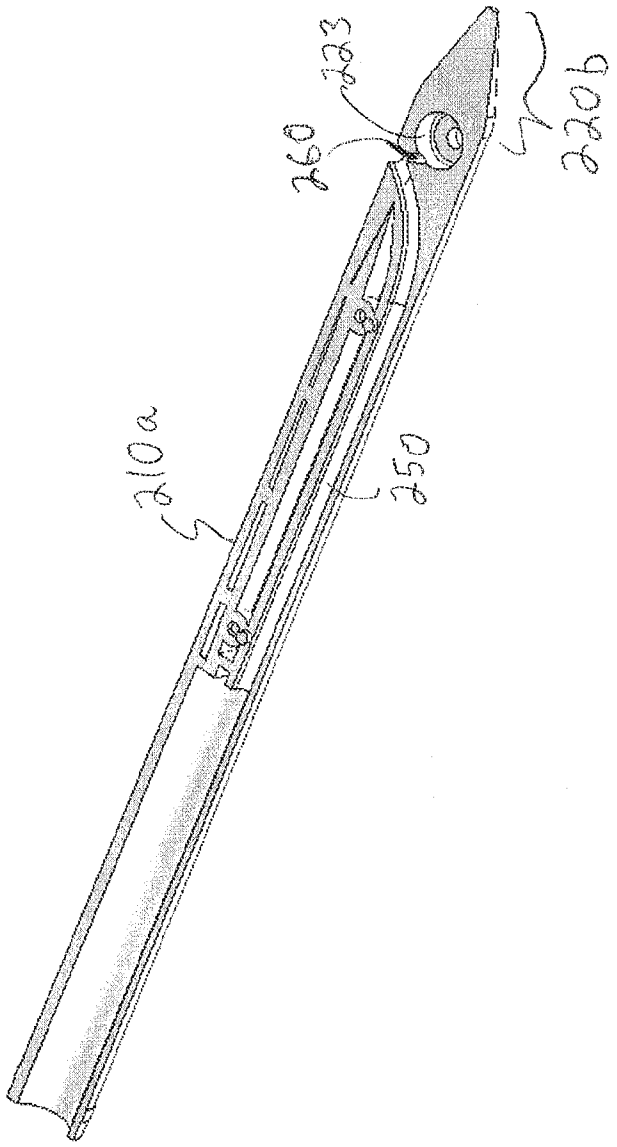

Figure 20