



(51) International Patent Classification:

A61B 17/34 (2006.01) A61M 39/02 (2006.01)

A61B 17/02 (2006.01) A61M 25/00 (2006.01)

A61B 17/3209 (2006.01)

(21) International Application Number:

PCT/US2023/020045

(22) International Filing Date:

26 April 2023 (26.04.2023)

(25) Filing Language:

English

(26) Publication Language:

English

(30) Priority Data:

63/335,000 26 April 2022 (26.04.2022) US

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(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, CV, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IQ, IR, IS, IT, JM, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, MG, MK, MN, MU, 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, ST, SV, SY, TH,

(54) Title: LAPAROSCOPIC TROCAR DEVICES AND METHODS FOR PERITONEAL ACCESS

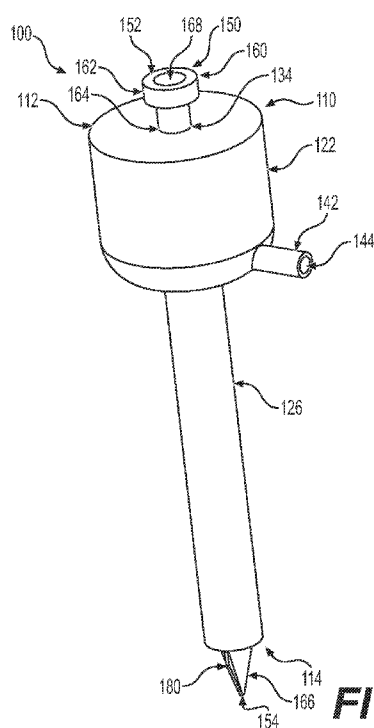


FIG. 1A

(57) Abstract: A laparoscopic trocar device may include a port and a trocar. The port may include a proximal portion extending from a proximal end toward a distal end of the port, an inner tube and an outer tube each extending from the proximal portion to the distal end of the port, and a side port extending from the proximal portion. The inner tube and the proximal portion may define an inner passage therethrough. The outer tube and the inner tube may define an outer passage therebetween. The side port may define a side passage in fluid communication with the outer passage. The trocar may be configured for extending through the inner passage and beyond the distal end of the port. The trocar may include a trocar body and a blade configured for moving relative to the trocar body between a retracted position and an extended position.



TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, WS,
ZA, ZM, ZW.

(84) Designated States (*unless otherwise indicated, for every kind of regional protection available*): ARIPO (BW, CV, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SC, SD, SL, ST, 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, ME, 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).

Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

Published:

— *with international search report (Art. 21(3))*

LAPAROSCOPIC TROCAR DEVICES AND METHODS FOR PERITONEAL ACCESS

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application claims the benefit of U.S. Provisional Patent Application No. 63/335,000, filed April 26, 2022, the contents of which is incorporated herein by reference in its entirety.

FIELD

[0002] The present disclosure relates generally to medical devices and more particularly to laparoscopic trocar devices and methods for peritoneal access.

BACKGROUND

[0003] Minimally invasive surgery in general refers to a surgeon utilizing techniques that minimize the number of incisions and size of incisions to perform a specific surgery. This is beneficial to the patient as it results in less pain and a shorter hospital stay. Laparoscopic surgery is one of the first types of minimally invasive surgery performed. It utilizes multiple small incisions and medical instruments such as tubes and cameras to perform the operation. In a study conducted in 2015, out of the 6,477,708 operations that had the option to use minimally invasive techniques, 37% of those were conducted using minimally invasive approaches. The most common operations that were done using minimally invasive approaches were appendectomy, cholecystectomy, groin hernia repair, abdominal exploration, and anti-reflux procedures. Currently, there are three common techniques used to provide peritoneal access for performing these surgeries: the optical trocar technique, the Veress technique, and the Hasson technique. Each of these techniques has their own lists of benefits and complications. Most of the complications result in damage to surrounding tissue while trying to achieve internal access.

[0004] The laparoscopic optical trocar technique and the Veress needle technique are the two shorter of the three techniques but do introduce a higher risk of complications, such as nicking a bowel or vessel. The laparoscopic optical trocar technique is performed by inserting a trocar to the muscle layer and using a pelviscope to push through the muscle layer. Since this technique uses positive force from a blunt trocar to reach the peritoneum, it can potentially damage underlying layers and organs. An example optical trocar is the VersaOne

Optical Trocar by Medtronic. This device is inserted into the abdomen after a small slit is created. The main advantage of this device is that the obturator contains a clear, blunt end that a laparoscopy can be placed in, so the surgeon has a clear view of what layer they are in. The main drawback to this device is that it requires a lot of force to enter the cavity, therefore it has an increased risk of puncturing bowel or blood vessels.

[0005] The Veress needle technique is performed by creating a small incision (5 mm) near the umbilical and pushing the needle at a 45-degree angle through the patient until two “pops” are felt, and the needle retracts. The first pop signifies the surgeon has passed through the abdominal fascia and the second signifies peritoneal access. An example Veress Needle is made by Buffalo Filter. This Veress needle has a diameter of 2 mm and is inserted directly into the abdomen above or to the right of the umbilicus. Once peritoneal access is achieved, the instrument will light up green so the surgeon can prepare for the next part of the surgery. Although this signaling technology is helpful to the surgeon, the device cannot tell what layer of the peritoneal tissue they are in, or when they are nearing entry to the peritoneal cavity. One study found that of 17,216 general surgery procedures, a Veress Needle was used 78% of the time. *See* Molloy, David *et al.* Laparoscopic Entry: a literary review and analysis of techniques and complications or primary port entry. Aust N Z J Obstet Gynaecol. 2002 Aug;42(3):246-54.

[0006] The Hasson technique is the longest of the three techniques, adding 10-15 minutes to the procedure, but has the smallest risk of complication. This technique is performed by creating a small incision through the abdominal wall, finding the preperitoneal fat, and using a blunt-ended trocar to push through the incision and insufflate the abdomen with CO₂. CO₂ insufflation delivers CO₂ into the body cavity to increase space and viewing area of the cavity. The most used Hasson Open blunt tip trocar is made by Medtronic. This trocar has port-site sealing, durable fixation, and an atraumatic blunt obturator. The device also comes with a balloon used for sealing the cavity for long procedures and a low profile to help instruments successfully reach the cavity.

[0007] Though Hasson open technique shows the lowest rate of complication, all three techniques have an incidence-rate greater than 0. A study on the laparoscopic optical trocar technique showed that 0.3% of procedures resulted in complications such as perforating organs or vessels. *See* Ciravolo, G. *et al.* (2020). Laparoscopic access with optical gasless trocar: a single-center experience of 7431 procedures. Journal of Minimally Invasive Gynecology, 27(2), 535–540. The Hasson open technique has a visceral complication rate of

0.048% and vascular complication rate of 0.000%, while the Veress needle technique has a visceral complication rate of 0.083% and vascular complication rate of 0.075%. *See Bonjer HJ et al* Open versus closed establishment of pneumoperitoneum in laparoscopic surgery. *Br J Surg.* 1997 May;84(5):599-602. PMID: 9171741. Most of the complications in these surgeries are caused when attempting to reach peritoneal access. Specifically, laparoscopic gynecological surgeries in general have been shown to have a 57% complication rate just from trying to access the peritoneum. *See Jansen F W et al.* Complications of laparoscopy: a prospective multicentre observational study. *Br J Obstet Gynecol.* (1997); 104:595–600.

[0008] To achieve peritoneal access, a device must be able to penetrate the outer tissue layers of the peritoneal cavity, also known as the abdominal wall. The specific tissue layers of the anterior abdominal wall, in order from most superficial to deepest, are as follows: skin, Camper's fascia, Scarpa's fascia, external oblique muscle (m.), internal oblique m., transversus abdominis m., fascia transversalis, extraperitoneal tissue, and parietal layer of peritoneum. However, the skin and Camper's fascia tissue layers can be cut using a scalpel, so the device must be able to penetrate the seven deeper tissue layers at a minimum.

[0009] A need exists for improved laparoscopic trocar devices and methods for peritoneal access, which devices and methods may overcome one or more of the challenges associated with current techniques.

SUMMARY

[0010] The present disclosure provides laparoscopic trocar devices and methods for peritoneal access. In one aspect, a laparoscopic trocar device is provided. In one embodiment, the laparoscopic trocar device may include a port and a trocar. The port may include a proximal portion extending from a proximal end toward a distal end of the port, an inner tube extending from the proximal portion to the distal end of the port, an outer tube extending from the proximal portion to the distal end of the port, and a side port extending from the proximal portion. The inner tube and the proximal portion may define an inner passage therethrough. The outer tube and the inner tube may define an outer passage therebetween. The side port may define a side passage in fluid communication with the outer passage. The trocar may be configured for extending through the inner passage and beyond the distal end of the port. The trocar may include a trocar body and a blade configured for moving relative to the trocar body between a retracted position and an extended position.

[0011] In some embodiments, each of the inner tube and the outer tube may have a circular cross-sectional shape. In some embodiments, each of the inner tube and the outer tube may be fixedly attached to the proximal portion. In some embodiments, the proximal portion, the inner tube, and the outer tube may be integrally formed with one another. In some embodiments, the inner passage may extend from the proximal end of the port to the distal end of the port. In some embodiments, the inner passage may have a circular cross-sectional shape. In some embodiments, the outer passage may extend from the distal end of the port to a location within the proximal portion. In some embodiments, the outer passage may have an annular cross-sectional shape. In some embodiments, the side port may extend perpendicular to the outer passage. In some embodiments, the side port may be configured for attaching to a vacuum source such that suction is applied through the outer passage. In some embodiments, the side port may be configured for attaching to a carbon dioxide source such that carbon dioxide is delivered through the outer passage.

[0012] In some embodiments, the trocar body may include a proximal flange extending from a proximal end of the trocar body toward a distal end of the trocar body, a trocar tube extending from the proximal flange toward the distal end of the trocar body, and a tip portion extending from the trocar tube to the distal end of the trocar body. In some embodiments, the proximal flange may be configured for abutting the proximal end of the port when the trocar extends through the inner passage and beyond the distal end of the port. In some embodiments, the trocar tube may be configured for positioning within the inner passage when the trocar extends through the inner passage and beyond the distal end of the port. In some embodiments, the tip portion may be configured for extending beyond the distal end of the port when the trocar extends through the inner passage and beyond the distal end of the port. In some embodiments, the proximal flange and the trocar tube may define a central passage therethrough. In some embodiments, the tip portion may be hollow and may define an interior space therein. In some embodiments, the interior space may be configured for receiving an endoscope therein. In some embodiments, the tip portion may be formed of a clear material. In some embodiments, the tip portion may include a frustoconical portion and a pair of wings extending outward from the frustoconical portion. In some embodiments, the wings may define a recess, and the blade may be positioned at least partially within the recess when the blade is in the retracted position. In some embodiments, the blade may be positioned entirely within the recess when the blade is in the retracted position, and the blade may extend at least partially outside of the recess when the blade is in the extended position.

In some embodiments, the recess may have a V shape, and the blade may have a V shape. In some embodiments, the blade may be biased to the retracted position.

[0013] In some embodiments, the trocar also may include a blade actuation mechanism configured for moving the blade from the retracted position to the extended position. In some embodiments, the blade actuation mechanism may include a button extending from the proximal end of the trocar body and configured for moving between an extended position and a depressed position, a spring engaging the button, a shaft coupled to the button and extending through the trocar tube, and a pair of connectors coupled to each of the shaft and the blade. In some embodiments, the blade may be in the retracted position when the button is in the extended position, and the blade may be in the extended position when the button is in the depressed position. In some embodiments, movement of the button from the extended position to the depressed position may cause the blade to move from the retracted position to the extended position. In some embodiments, the spring may bias the button to the extended position. In some embodiments, each of the connectors may extend through the tip portion.

[0014] These and other aspects and improvements of the present disclosure will become apparent to one of ordinary skill in the art upon review of the following detailed description when taken in conjunction with the several drawings and the appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] FIG. 1A is a perspective view of an example laparoscopic trocar device in accordance with embodiments of the disclosure, showing a port and a trocar of the laparoscopic trocar device.

[0016] FIG. 1B is a partial cross-sectional perspective view of the laparoscopic trocar device of FIG 1A.

[0017] FIG. 1C is a partial cross-sectional side view of the laparoscopic trocar device of FIG 1A.

[0018] FIG. 1D is a perspective view of the port of the laparoscopic trocar device of FIG 1A.

[0019] FIG. 1E is a side view of the port of the laparoscopic trocar device of FIG 1A.

[0020] FIG. 1F is a bottom view of the port of the laparoscopic trocar device of FIG 1A.

[0021] FIG. 1G is a cross-sectional side view of the port of the laparoscopic trocar device of FIG 1A.

[0022] FIG. 1H is a side view of the trocar of the laparoscopic trocar device of FIG 1A.

[0023] FIG. 11 is a detailed perspective view of a tip portion and a blade of the trocar of the laparoscopic trocar device of FIG 1A.

[0024] The detailed description is set forth with reference to the accompanying drawings. The drawings are provided for purposes of illustration only and merely depict example embodiments of the disclosure. The drawings are provided to facilitate understanding of the disclosure and shall not be deemed to limit the breadth, scope, or applicability of the disclosure. The use of the same reference numerals indicates similar, but not necessarily the same or identical components. Different reference numerals may be used to identify similar components. Various embodiments may utilize elements or components other than those illustrated in the drawings, and some elements and/or components may not be present in various embodiments. The use of singular terminology to describe a component or element may, depending on the context, encompass a plural number of such components or elements and vice versa.

DETAILED DESCRIPTION

[0025] In the following description, specific details are set forth describing some embodiments consistent with the present disclosure. Numerous specific details are set forth in order to provide a thorough understanding of the embodiments. It will be apparent, however, to one skilled in the art that some embodiments may be practiced without some or all of these specific details. The specific embodiments disclosed herein are meant to be illustrative but not limiting. One skilled in the art may realize other elements that, although not specifically described here, are within the scope and the spirit of this disclosure. In addition, to avoid unnecessary repetition, one or more features shown and described in association with one embodiment may be incorporated into other embodiments unless specifically described otherwise or if the one or more features would make an embodiment non-functional. In some instances, well known methods, procedures, components, and circuits have not been described in detail so as not to unnecessarily obscure aspects of the embodiments.

[0026] The present disclosure provides laparoscopic trocar devices and methods for peritoneal access. The disclosed laparoscopic trocar device is modelled after devices that are already present in the field today but do not possess a zero-insertion force on the body. The objective of the laparoscopic trocar device is to enter one's abdominal wall with zero force to mitigate complications and injury to any bodily organs. Current trocar devices have a

complication rate of 1.4 per 1,000 cases. *See* Krishnakumar, S., & Tambe, P. (2009, January). Entry complications in laparoscopic surgery. One objective of the disclosed laparoscopic trocar device is to decrease the rate of complication. Although failure generally is inevitable when it comes to any human-made devices and a complication rate of 0% may be impracticable, the laparoscopic trocar device may be used to decrease the complication rate of minimally invasive surgeries. To achieve this, the laparoscopic trocar device may create a negative force by reversing the direction of force on the tissue. This would result in an upward force onto the trocar rather than a downward force into the tissue. When less force is applied directly to the patient's abdomen, the chance of harming anything below it like the intestines or arteries reduces significantly.

[0027] The laparoscopic trocar device may be used for any patient that needs a minimally invasive operation of the abdomen, like gallbladder removal, hernia repair, or gastric bypass. There are no direct restrictions, like BMI, when it comes to patients that qualify for minimally invasive surgery. There are also no restrictions on the user of the laparoscopic trocar device, for it is intended to be usable by all surgeons and surgical first assistants. As research is further explored, BMI and other qualities that affect a patient's abdominal wall, like scar tissue from a previous surgery, will be explored. If necessary, the device can be altered to fit the criteria of the patient.

[0028] As described herein, the laparoscopic trocar device may be used to achieve peritoneal access. The purpose of this access is to create an unobstructed path from outside of the patient to the peritoneal cavity to allow for carbon dioxide insufflation and insertion of the devices required to perform minimally invasive surgery. The laparoscopic trocar device also may be used to automatically allow carbon dioxide insufflation of the abdomen. In particular, the laparoscopic trocar device may be compatible with most carbon dioxide insufflators found in operating rooms. For carbon dioxide insufflation to occur, the device may be compatible with and form an airtight seal with the tubing connected to the insufflator. This will ensure that no carbon dioxide will leak undesirably from the insufflator and will protect the unit from fluid invasion from the peritoneal cavity.

[0029] As described herein, the laparoscopic trocar device may result in Zero Insertion Force (ZIF) on the tissue layers of the abdomen using vacuum suction. The force required to push and twist the trocar through the layers of the abdominal wall and into the peritoneal cavity is considered positive force because it is towards the body. As vacuum suction is applied to the tissue layers, this will cause the skin to "tent" and move away from the

peritoneum to meet the blade rather than the blade being pushed down into the skin. The vacuum pulling the skin away from the body is considered negative force. Therefore, the net force of these two forces will hypothetically equal zero, resulting in a Zero Insertion Force. Since this mechanism requires a vacuum, the device must be compatible with existing medical vacuums found in operating rooms. To create a more sustainable design, the carbon dioxide insufflation port will also serve as the vacuum port, so it must be compatible with both medical devices in the operating rooms.

[0030] As described herein, the laparoscopic trocar device may allow for direct visualization of the layer of tissue being cut with the help of an endoscope, enhancing the ease of use of the device. In some embodiments, the laparoscopic trocar device may be automated, with the only surgeon intervention being the pressing of a button or twisting of the device. In some embodiments, the laparoscopic trocar device may be reusable, instead of one-time use, to avoid buildup of waste and to save on cost. In some embodiments, the laparoscopic trocar device may ensure that the surgeon does not apply an excessive amount of force to reach the peritoneal cavity or once access has been reached. In some embodiments, the laparoscopic trocar device may include a mechanism that allows for the various layers of tissue being cut to be distinguished from one another. This would assist with only cutting tissue that is necessary to cut and could help prevent unnecessary cutting of other tissue layers. In some embodiments, the laparoscopic trocar device may include a mechanism that informs the surgeon when peritoneal access has been reached via an auditory or visual stimulus. In some embodiments, the mechanism may provide specific information about the current tissue layer the device has reached to allow the surgeon to determine the insertion progression for themselves. In some embodiments, the laparoscopic trocar device may include a retractable blade to ensure that cutting of selective tissue layers occurs. For example, the blade may retract down a few millimeters to penetrate a specific tissue layer of the abdominal wall, either mechanically controlled (*e.g.*, the push of a button) or automatically once the device has indicated that it has reached a layer to be cut.

[0031] The laparoscopic trocar device generally may include a trocar having a clear tip portion at its distal end, a blade, and a port. The clear tip portion may be cone-shaped. The trocar may include a hollow cylindrical tube with room for an endoscope and a blade actuation mechanism to pass through. The distal end of the trocar tube may be attached to the clear tip portion, and the proximal end of the trocar tube may have a button extending therefrom that allows the surgeon to operate the retractable blade. The trocar tube itself may

not be clear, unlike the tip. The entire trocar may be able to slide into the inner tube of the port and fit flush within it. The tip portion of the trocar may be provided as a pointed clear tip. The tip portion may be hollow to allow for space for an endoscope therein. The tip portion may help guide the surgeon by allowing visualization using the endoscope. The tip portion may not be used to cut layers of tissue but rather may be used to separate layers of already cut tissue. The blade will rest within the outer lining of the tip and may be operated by a button that the surgeon can press.

[0032] Within the trocar may be the blade actuation mechanism. The blade actuation mechanism may include a simple spring-loaded button that controls the blade. The blade actuation mechanism may be connected to the blade through two small holes on the outside wings of the tip portion. This configuration may reduce the chances of any bodily fluid entering the tip and inhibiting the view of the endoscope. When the button on the top of the trocar is pressed, the spring may compress until it hits a stopper which may be calibrated to only extend the blade 2 mm. Once the surgeon removes their finger from the button, the blade may retract, and the spring may reload. The blade may be extended only 2 mm to ensure there will not be any injury to a crucial organ, artery, etc. When the blade is not extended, it may be safely tucked into the wings located on the sides of the clear tip. This may ensure that the blade will not do any unwanted cutting while the surgeon is not using it.

[0033] The port may be provided as a long cylindrical piece with two tubes, an inner tube and an outer tube. The inner tube may be where the trocar slides into and the space between the inner and outer tubes may be where the suction will take effect. In some embodiments, the space may be guarded by a mesh at the distal end of the port. The mesh may ensure that large pieces of cut up tissue or fat globules do not get sucked up and clog up the system. A smaller side port may be provided near the top of the port for connecting to the vacuum disposal system in the operating room. This will create the required suction force in between the two tubes of the port to pull up tissue. Once the tissue is pulled, the surgeon can press the button on the trocar to extend the blade and cut through the tissue. This process can be repeated until access to the peritoneal cavity is achieved. Then, to perform the actual laparoscopic surgery, the trocar can be removed, and the inner tube of the port can be used as a tunnel for other surgical instruments. The side port can be disconnected from the vacuum filtration system and then connected to a CO₂ insufflation device for insufflating the peritoneal cavity.

[0034] FIGS. 1A-II illustrate an example laparoscopic trocar device 100 and components thereof in accordance with embodiments of the disclosure. As shown, the laparoscopic trocar device 100 may include a port 110 and a trocar 150.

[0035] The port 110 may be formed as an elongate structure having a proximal end 112 and a distal end 114. As shown, the port 110 may include a proximal portion 122 extending from the proximal end 112 toward the distal end 114 of the port 110, an inner tube 124 extending from the proximal portion 122 to the distal end 114 of the port 110, an outer tube 126 extending from the proximal portion 122 to the distal end 114 of the port 110, and a side port 142 extending from the proximal portion 122. The outer tube 126 may encircle the inner tube 124. The inner tube 124 and the proximal portion 122 may define an inner passage 134 therethrough. The outer tube 126 and the inner tube 124 may define an outer passage 136 therebetween. The side port 142 may define a side passage 144 in fluid communication with the outer passage 136.

[0036] In some embodiments, each of the inner tube 124 and the outer tube 126 may have a circular cross-sectional shape. In some embodiments, each of the inner tube 124 and the outer tube 126 may be fixedly attached to the proximal portion 122. In some embodiments, the proximal portion 122, the inner tube 124, and the outer tube 126 may be integrally formed with one another. In some embodiments, the inner passage 134 may extend from the proximal end 112 of the port 110 to the distal end 114 of the port 110. In some embodiments, the inner passage 134 may have a circular cross-sectional shape. In some embodiments, the outer passage 136 may extend from the distal end 114 of the port 110 to a location within the proximal portion 122. In some embodiments, the outer passage 136 may have an annular cross-sectional shape. In some embodiments, the side port 142 may extend perpendicular to the outer passage 136. In some embodiments, the side port 142 may be configured for attaching to a vacuum source such that suction is applied through the outer passage 136. In some embodiments, the side port 142 may be configured for attaching to a carbon dioxide source such that carbon dioxide is delivered through the outer passage 136.

[0037] The trocar 150 may be configured for extending through the inner passage 134 and beyond the distal end 114 of the port 110. The trocar 150 may be formed as an elongate structure having a proximal end 152 and a distal end 154. As shown, the trocar 150 may include a trocar body 160 and a blade 180 configured for moving relative to the trocar body 160 between a retracted position and an extended position.

[0038] In some embodiments, the trocar body 160 may include a proximal flange 162 extending from the proximal end 152 of the trocar body 160 toward the distal end 154 of the trocar body 160, a trocar tube 164 extending from the proximal flange 162 toward the distal end 154 of the trocar body 160, and a tip portion 166 extending from the trocar tube 164 to the distal end 154 of the trocar body 160. In some embodiments, the proximal flange 162 may be configured for abutting the proximal end 112 of the port 110 when the trocar 150 extends through the inner passage 134 and beyond the distal end 114 of the port 110. In some embodiments, the trocar tube 164 may be configured for positioning within the inner passage 134 when the trocar 150 extends through the inner passage 134 and beyond the distal end 114 of the port 110. In some embodiments, the tip portion 166 may be configured for extending beyond the distal end 114 of the port 110 when the trocar 150 extends through the inner passage 134 and beyond the distal end 114 of the port 110. In some embodiments, the proximal flange 162 and the trocar tube 164 may define a central passage 168 therethrough. In some embodiments, the tip portion 166 may be hollow and may define an interior space therein. In some embodiments, the interior space may be configured for receiving an endoscope therein. In some embodiments, the tip portion 166 may be formed of a clear material. In some embodiments, the tip portion 166 may include a frustoconical portion 172 and a pair of wings 174 extending outward from the frustoconical portion 172. In some embodiments, the wings 174 may define a recess 176, and the blade 180 may be positioned at least partially within the recess 176 when the blade 180 is in the retracted position. In some embodiments, the blade 180 may be positioned entirely within the recess 176 when the blade 180 is in the retracted position, and the blade 180 may extend at least partially outside of the recess 176 when the blade 180 is in the extended position. In some embodiments, the recess 176 may have a V shape, and the blade 180 may have a V shape. In some embodiments, the blade 180 may be biased to the retracted position.

[0039] In some embodiments, the trocar 150 also may include a blade actuation mechanism 190 configured for moving the blade 180 from the retracted position to the extended position. In some embodiments, the blade actuation mechanism 190 may include a button 192 extending from the proximal end 152 of the trocar body 160 and configured for moving between an extended position and a depressed position, a spring 198 engaging the button 192, a shaft 194 coupled to the button 192 and extending through the trocar tube 164, and a pair of connectors 196 coupled to each of the shaft 194 and the blade 180. In some embodiments, the blade 180 may be in the retracted position when the button 192 is in the

extended position, and the blade 180 may be in the extended position when the button 192 is in the depressed position. In some embodiments, movement of the button 192 from the extended position to the depressed position may cause the blade 180 to move from the retracted position to the extended position. In some embodiments, the spring 198 may bias the button 192 to the extended position. In some embodiments, each of the connectors 196 may extend through the tip portion 166.

[0040] Although specific embodiments of the disclosure have been described, one of ordinary skill in the art will recognize that numerous other modifications and alternative embodiments are within the scope of the disclosure. For example, any of the functionality and/or processing capabilities described with respect to a particular device or component may be performed by any other device or component. Further, while various illustrative implementations and architectures have been described in accordance with embodiments of the disclosure, one of ordinary skill in the art will appreciate that numerous other modifications to the illustrative implementations and architectures described herein are also within the scope of this disclosure.

[0041] Although embodiments have been described in language specific to structural features and/or methodological acts, it is to be understood that the disclosure is not necessarily limited to the specific features or acts described. Rather, the specific features and acts are disclosed as illustrative forms of implementing the embodiments. Conditional language, such as, among others, “can,” “could,” “might,” or “may,” unless specifically stated otherwise, or otherwise understood within the context as used, is generally intended to convey that certain embodiments could include, while other embodiments do not include, certain features, elements, and/or steps. Thus, such conditional language is not generally intended to imply that features, elements, and/or steps are in any way required for one or more embodiments or that one or more embodiments necessarily include logic for deciding, with or without user input or prompting, whether these features, elements, and/or steps are included or are to be performed in any particular embodiment. The term “based at least in part on” and “based on” are synonymous terms which may be used interchangeably herein.

CLAIMS

What is claimed is:

1. A laparoscopic trocar device comprising:
a port comprising:
a proximal portion extending from a proximal end of the port toward a distal end of the port;
an inner tube extending from the proximal portion to the distal end of the port, the inner tube and the proximal portion defining an inner passage therethrough;
an outer tube encircling the inner tube and extending from the proximal portion to the distal end of the port, the outer tube and the inner tube defining an outer passage therebetween; and
a side port extending from the proximal portion, the side port defining a side passage in fluid communication with the outer passage; and
a trocar configured for extending through the inner passage and beyond the distal end of the port, the trocar comprising:
a trocar body; and
a blade configured for moving relative to the trocar body between a retracted position and an extended position.
2. The laparoscopic trocar device of claim 1, wherein each of the inner tube and the outer tube has a circular cross-sectional shape.
3. The laparoscopic trocar device of claim 1 or claim 2, wherein each of the inner tube and the outer tube is fixedly attached to the proximal portion.
4. The laparoscopic trocar device of any one of claims 1-3, wherein the proximal portion, the inner tube, and the outer tube are integrally formed with one another.
5. The laparoscopic trocar device of any one of claims 1-4, wherein the inner passage extends from the proximal end of the port to the distal end of the port.

6. The laparoscopic trocar device of any one of claims 1-5, wherein the inner passage has a circular cross-sectional shape.
7. The laparoscopic trocar device of any one of claims 1-6, wherein the outer passage extends from the distal end of the port to a location within the proximal portion.
8. The laparoscopic trocar device of any one of claims 1-7, wherein the outer passage has an annular cross-sectional shape.
9. The laparoscopic trocar device of any one of claims 1-8, wherein the side port extends perpendicular to the outer passage.
10. The laparoscopic trocar device of any one of claims 1-9, wherein the side port is configured for attaching to a vacuum source such that suction is applied through the outer passage.
11. The laparoscopic trocar device of any one of claims 1-10, wherein the side port is configured for attaching to a carbon dioxide source such that carbon dioxide is delivered through the outer passage.
12. The laparoscopic trocar device of any one of claims 1-11, wherein the trocar body comprises:
 - a proximal flange extending from a proximal end of the trocar body toward a distal end of the trocar body;
 - a trocar tube extending from the proximal flange toward the distal end of the trocar body; and
 - a tip portion extending from the trocar tube to the distal end of the trocar body.
13. The laparoscopic trocar device of claim 12, wherein the proximal flange is configured for abutting the proximal end of the port when the trocar extends through the inner passage and beyond the distal end of the port.

14. The laparoscopic trocar device of claim 12 or claim 13, wherein the trocar tube is configured for positioning within the inner passage when the trocar extends through the inner passage and beyond the distal end of the port.
15. The laparoscopic trocar device of any one of claims 12-14, wherein the tip portion is configured for extending beyond the distal end of the port when the trocar extends through the inner passage and beyond the distal end of the port.
16. The laparoscopic trocar device of any one of claims 12-15, wherein the proximal flange and the trocar tube define a central passage therethrough.
17. The laparoscopic trocar device of any one of claims 12-16, wherein the tip portion is hollow and defines an interior space therein.
18. The laparoscopic trocar device of claim 17, wherein the interior space is configured for receiving an endoscope therein.
19. The laparoscopic trocar device of any one of claims 12-18, wherein the tip portion is formed of a clear material.
20. The laparoscopic trocar device of any one of claims 12-19, wherein the tip portion comprises a frustoconical portion and a pair of wings extending outward from the frustoconical portion.
21. The laparoscopic trocar device of claim 20, wherein the wings define a recess, and wherein the blade is positioned at least partially within the recess when the blade is in the retracted position.
22. The laparoscopic trocar device of claim 21, wherein the blade is positioned entirely within the recess when the blade is in the retracted position, and wherein the blade extends at least partially outside of the recess when the blade is in the extended position.

23. The laparoscopic trocar device of claim 21 or claim 22, wherein the recess has a V shape, and wherein the blade has a V shape.
24. The laparoscopic trocar device of any one of claims 12-23, wherein the blade is biased to the retracted position.
25. The laparoscopic trocar device of claim 24, wherein the trocar further comprises a blade actuation mechanism configured for moving the blade from the retracted position to the extended position.
26. The laparoscopic trocar device of claim 25, wherein the blade actuation mechanism comprises:
- a button extending from the proximal end of the trocar body and configured for moving between an extended position and a depressed position;
 - a spring engaging the button;
 - a shaft coupled to the button and extending through the trocar tube; and
 - a pair of connectors coupled to each of the shaft and the blade.
27. The laparoscopic trocar device of claim 26, wherein the blade is in the retracted position when the button is in the extended position, and wherein the blade is in the extended position when the button is in the depressed position.
28. The laparoscopic trocar device of claim 26, wherein movement of the button from the extended position to the depressed position causes the blade to move from the retracted position to the extended position.
29. The laparoscopic trocar device of any one of claims 26-28, wherein the spring biases the button to the extended position.
30. The laparoscopic trocar device of any one of claims 26-29, wherein each of the connectors extends through the tip portion.

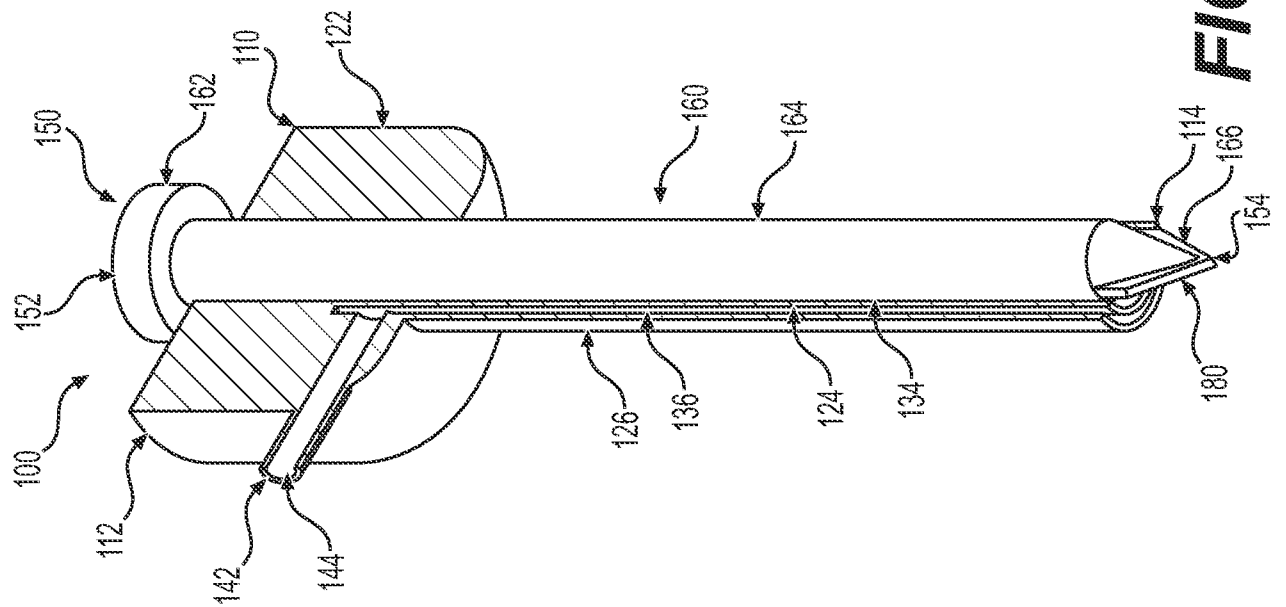


FIG. 1B

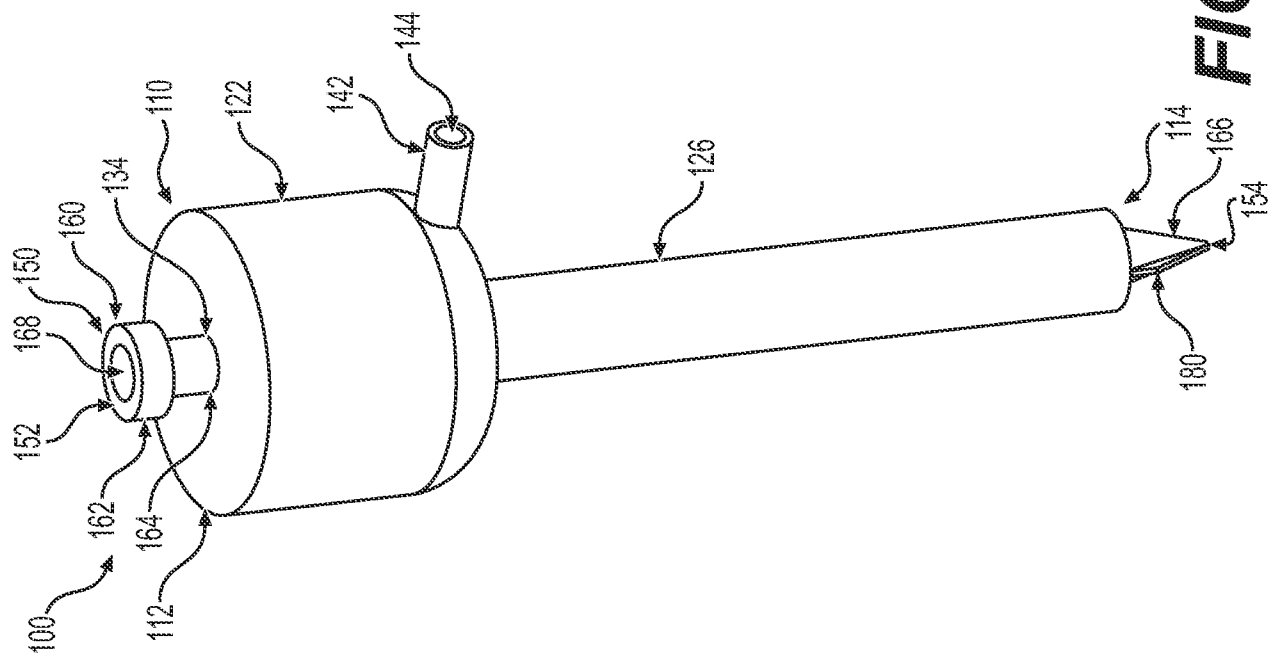


FIG. 1A

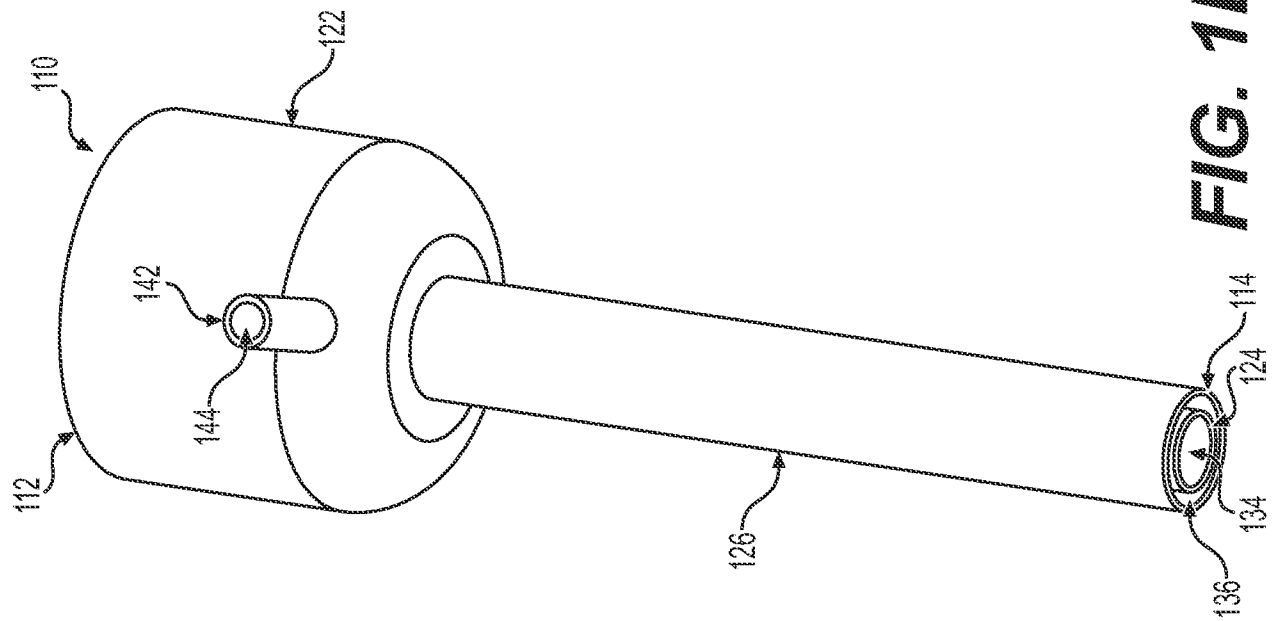


FIG. 1D

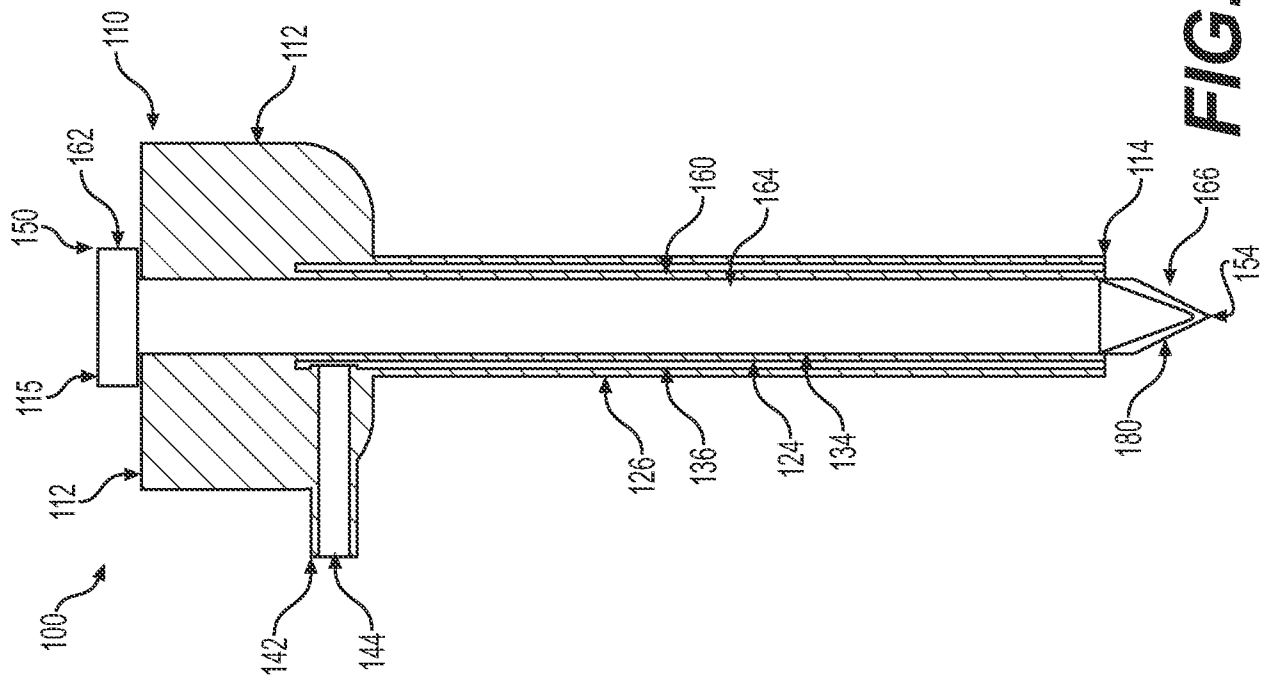


FIG. 1C

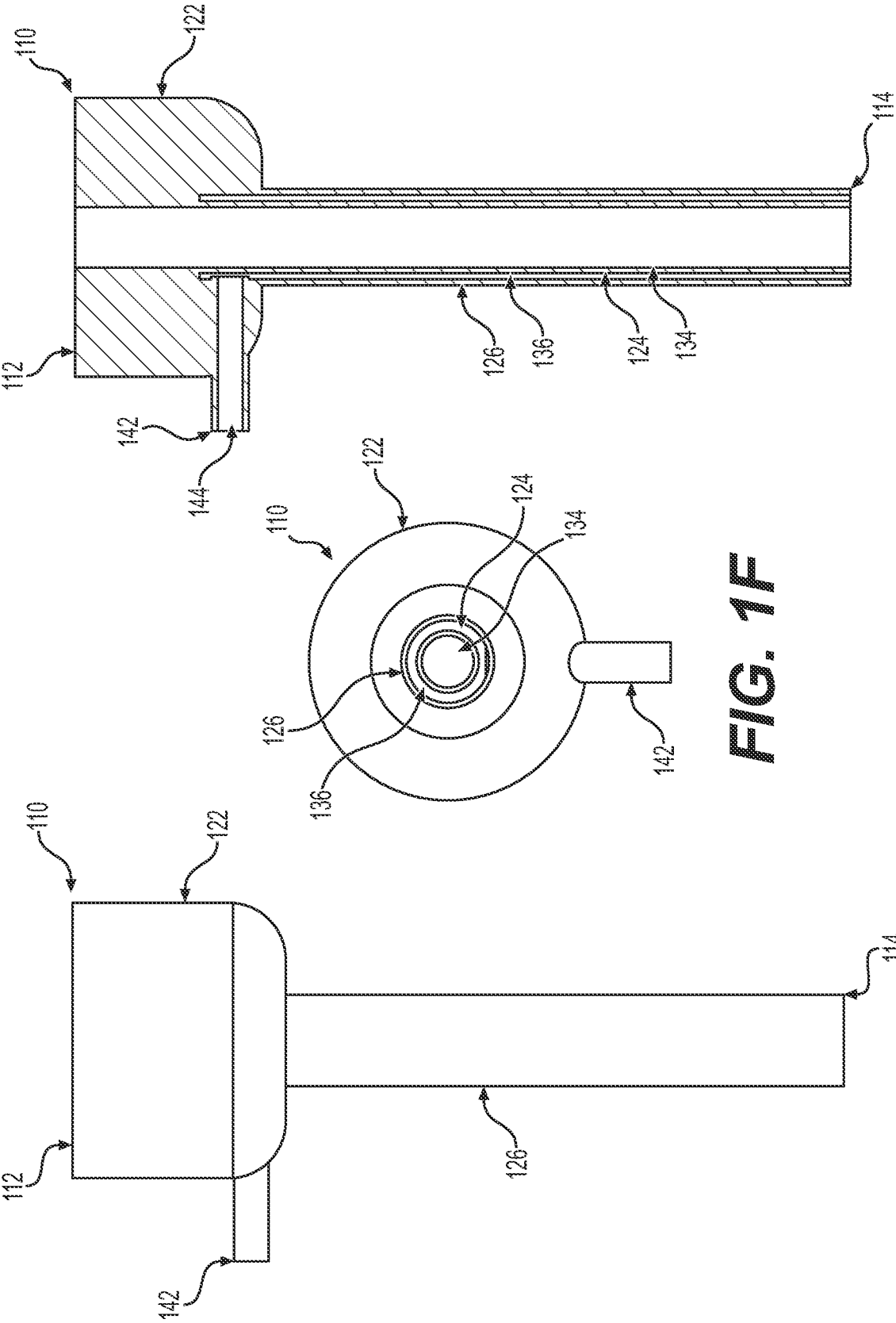


FIG. 1F

FIG. 1G

FIG. 1E

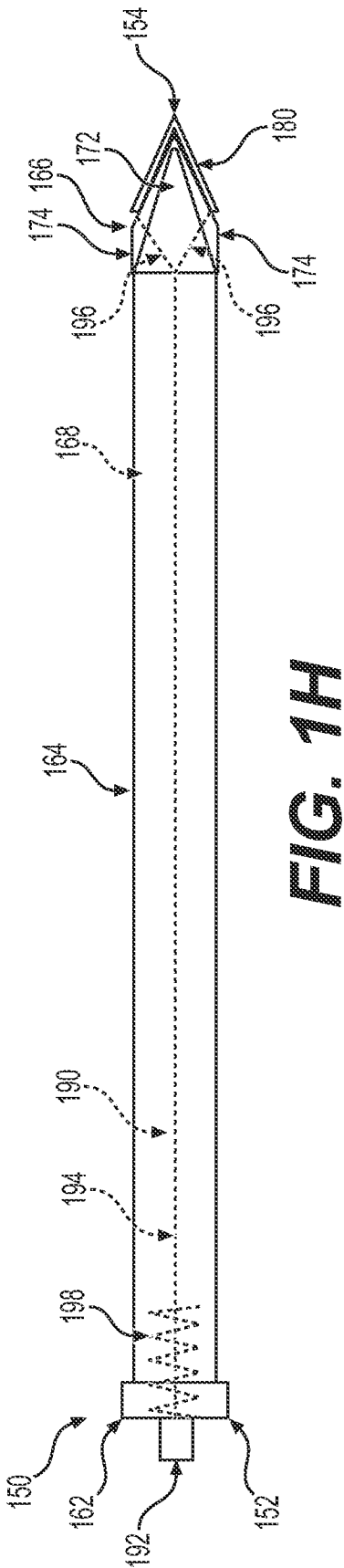


FIG. 1H

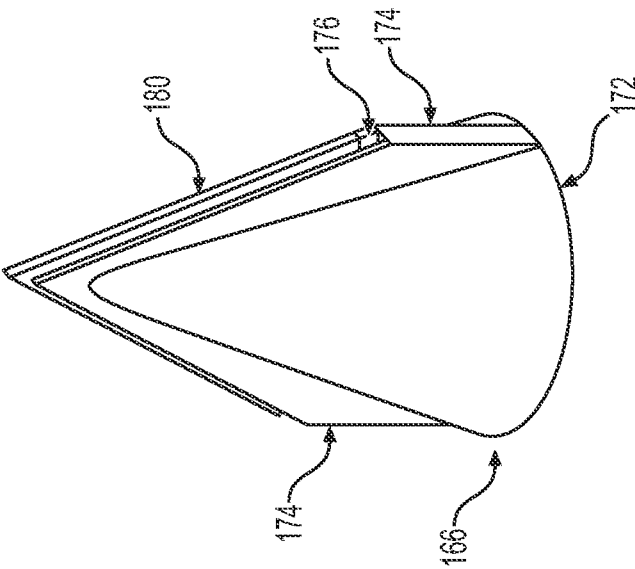


FIG. 1I

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2023/020045

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - INV. - A61B 17/34; A61B 17/02; A61B 17/3209; A61M 39/02 (2023.01)

ADD. - A61M 25/00 (2023.01)

CPC - INV. - A61B 17/3423; A61B 17/00234; A61B 17/0218; A61B 17/3209; A61B 17/3496; A61M 39/02 (2023.05)

ADD. - A61M 2025/0004 (2023.05)

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History document

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

See Search History document

Electronic database consulted during the international search (name of database and, where practicable, search terms used)

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 2020/0397468 A1 (LEXION MEDICAL LLC) 24 December 2020 (24.12.2020) entire document	1-3
Y	US 2005/0177188 A1 (TUROVSKIY et al.) 11 August 2005 (11.08.2005) entire document	1-3
A	US 2020/0163541 A1 (COVIDIEN LP) 28 May 2020 (28.05.2020) entire document	1-3
A	US 2006/0025749 A1 (MOENNING) 02 February 2006 (02.02.2006) entire document	1-3
☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.		

* Special categories of cited documents:

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

"D" document cited by the applicant in the international application

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

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

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

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

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

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

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

"&" document member of the same patent family

Date of the actual completion of the international search

20 June 2023

Date of mailing of the international search report

JUL 17 2023

Name and mailing address of the ISA/

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Facsimile No. 571-273-8300

Authorized officer

Taina Matos

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2023/020045

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

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

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:
2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. ☒ Claims Nos.: 4-30
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying additional fees, this Authority did not invite payment of additional fees.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- ☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- ☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- ☐ No protest accompanied the payment of additional search fees.