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(54) **LAPAROSCOPIC SURGICAL DEVICE AND RELATED SYSTEMS AND METHODS**

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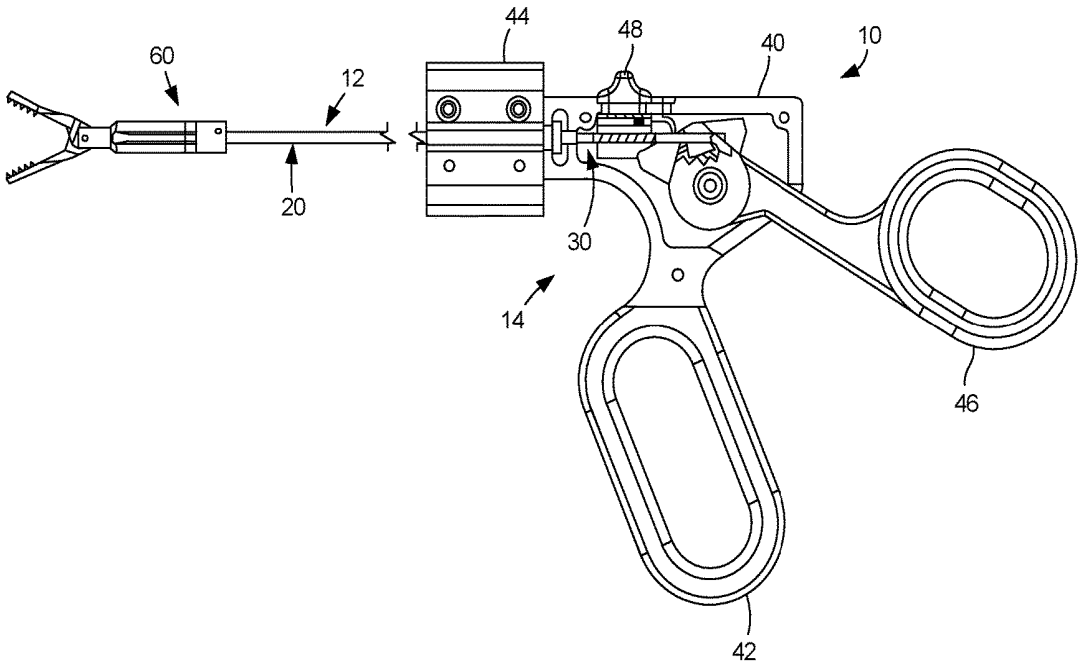
CPC .. ***A61B 17/282*** (2013.01); *A61B 2017/00473* (2013.01)

(57) **ABSTRACT**

The various embodiments herein relate to surgical systems having a surgical tool, a detachable tool head, and an introducer tool. The various systems can be used for minimally invasive laparoscopic surgical procedures.



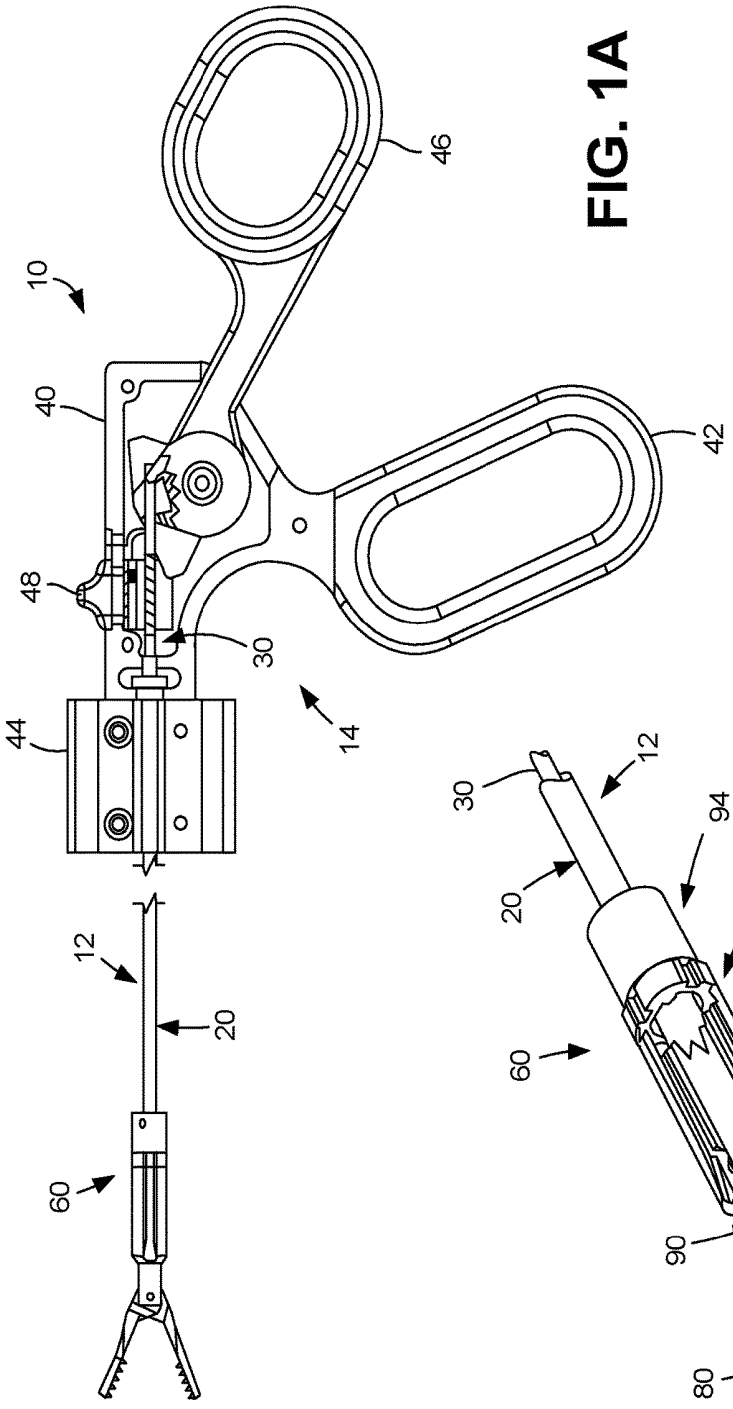


FIG. 1A

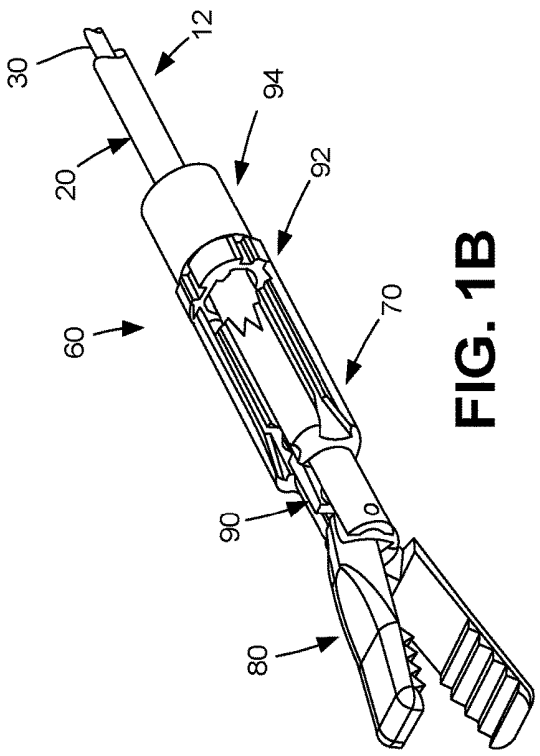


FIG. 1B

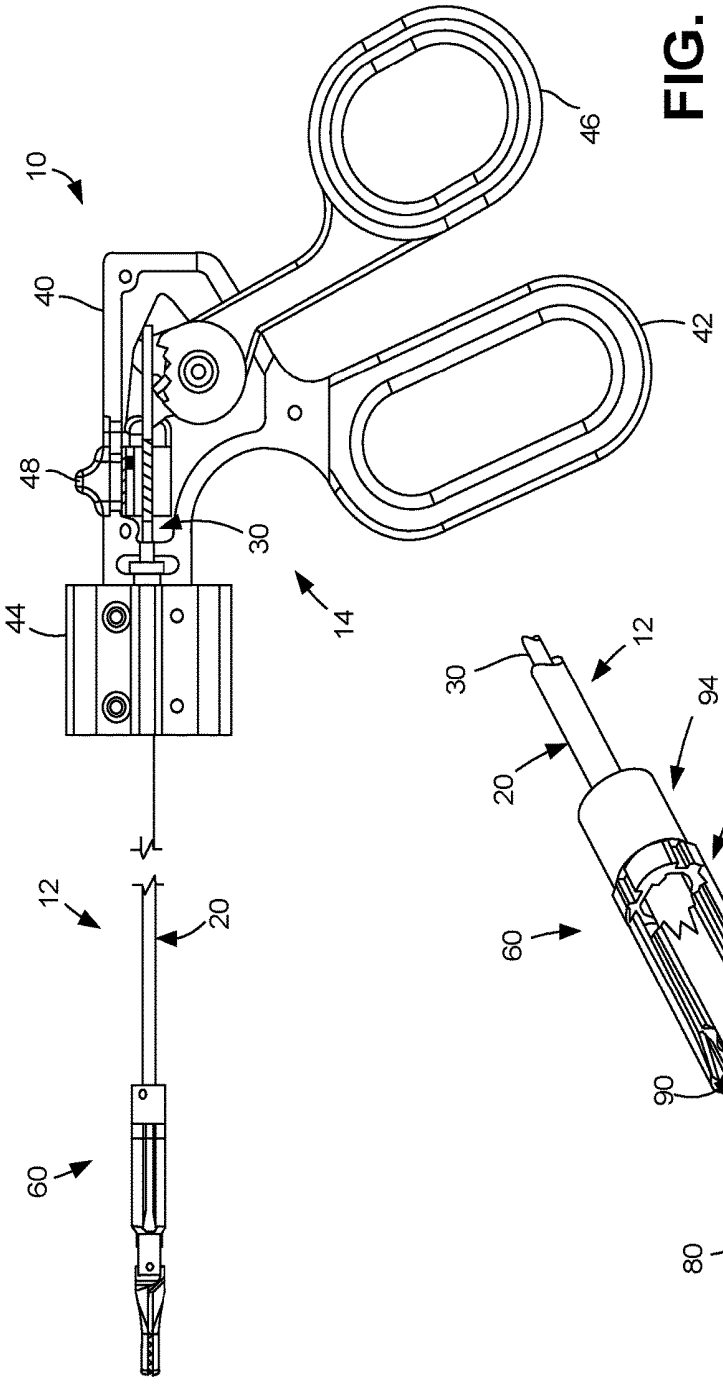


FIG. 1C

FIG. 1D

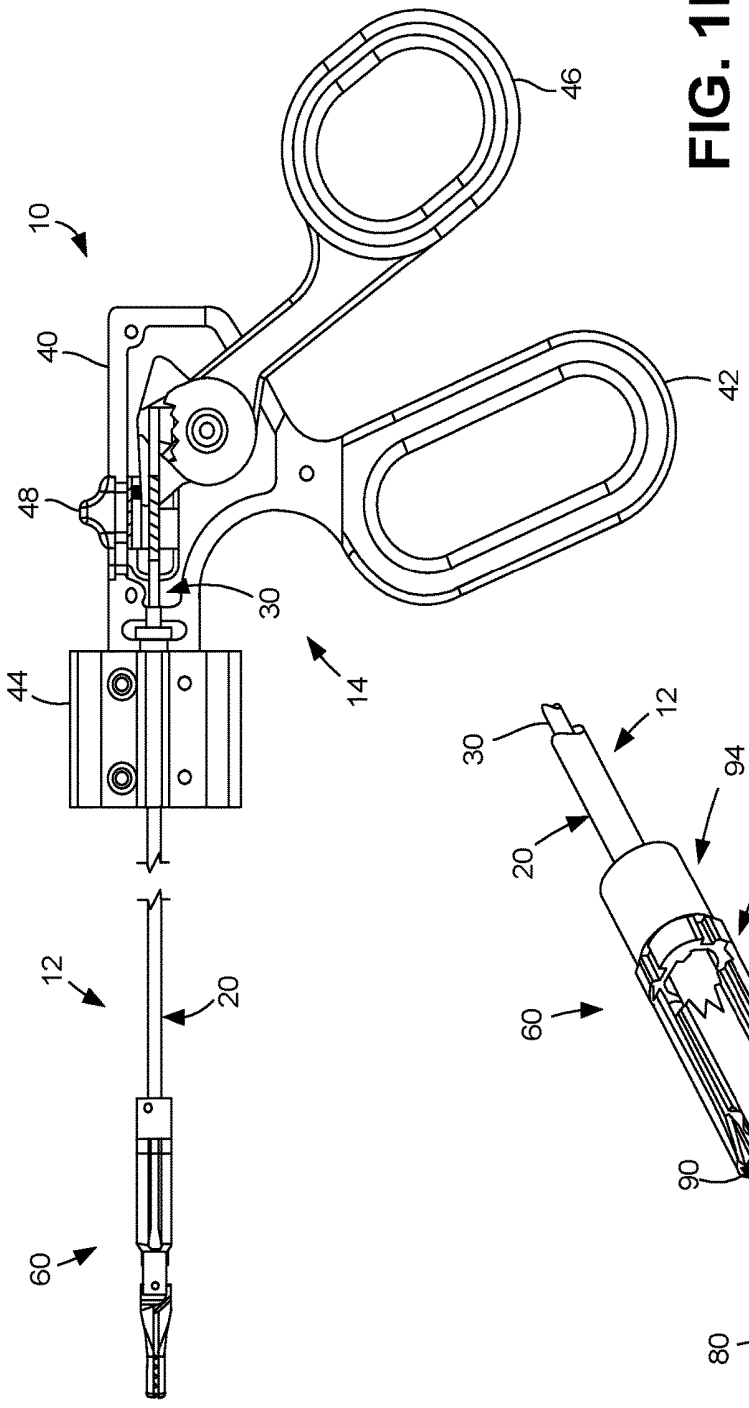


FIG. 1E

FIG. 1F

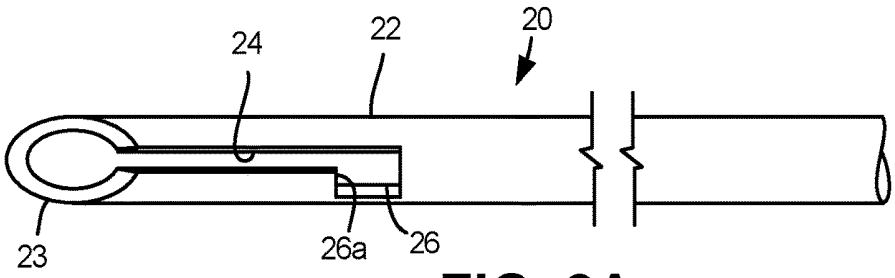


FIG. 2A

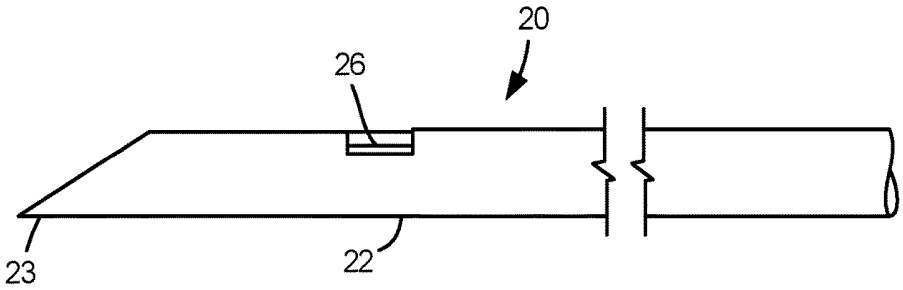


FIG. 2B

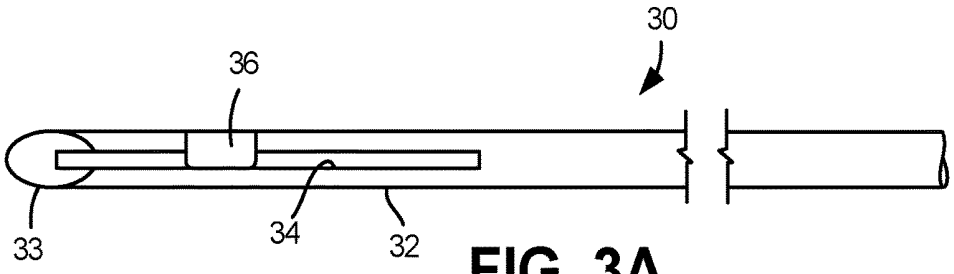


FIG. 3A

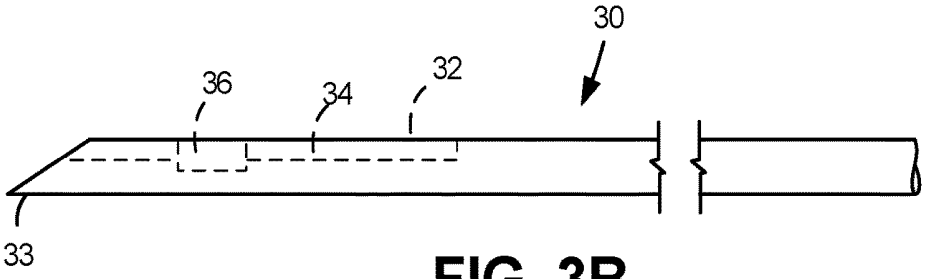


FIG. 3B

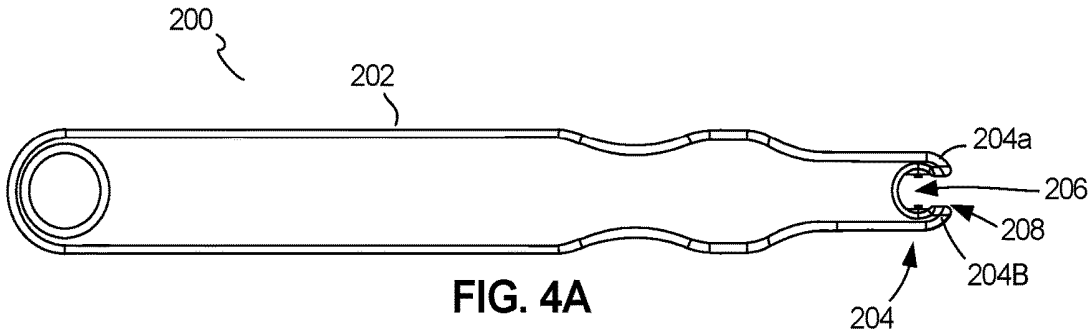


FIG. 4A

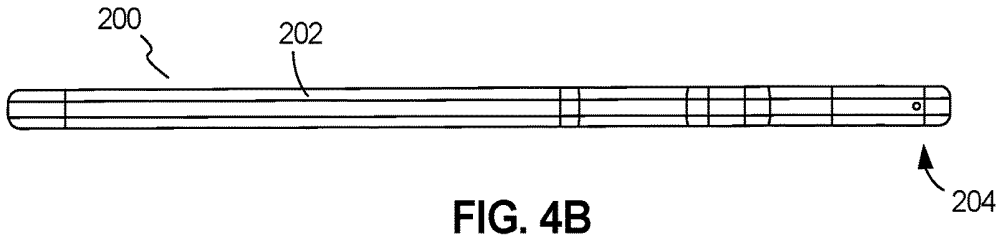


FIG. 4B

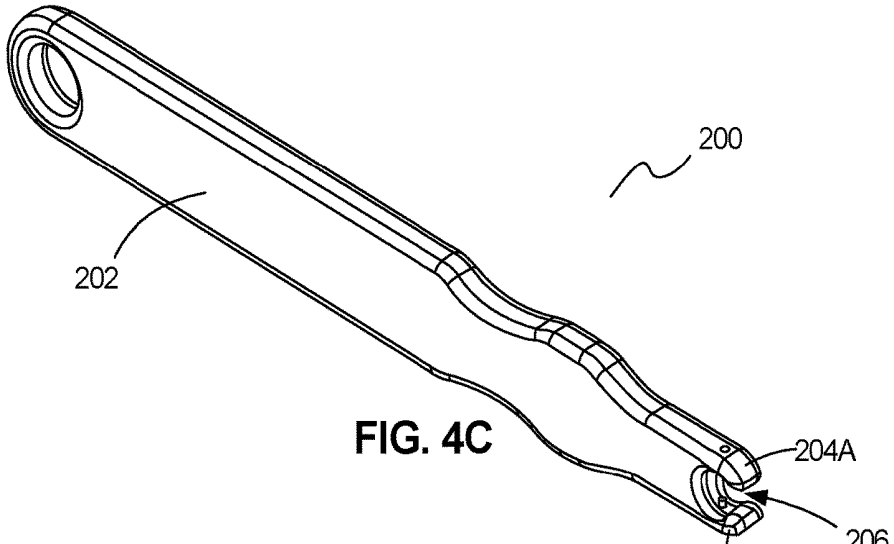


FIG. 4C

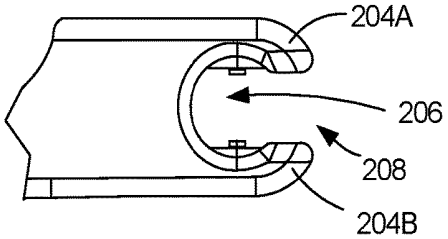


FIG. 4D

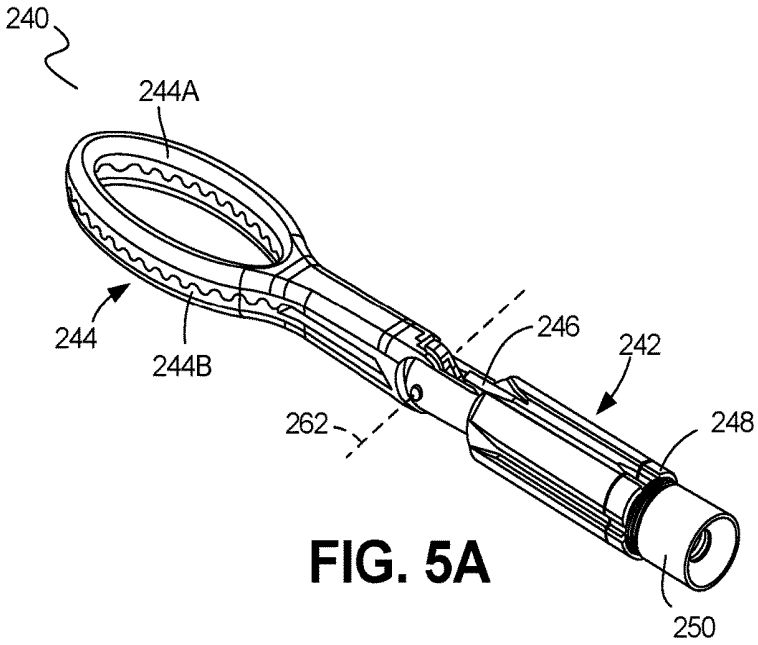
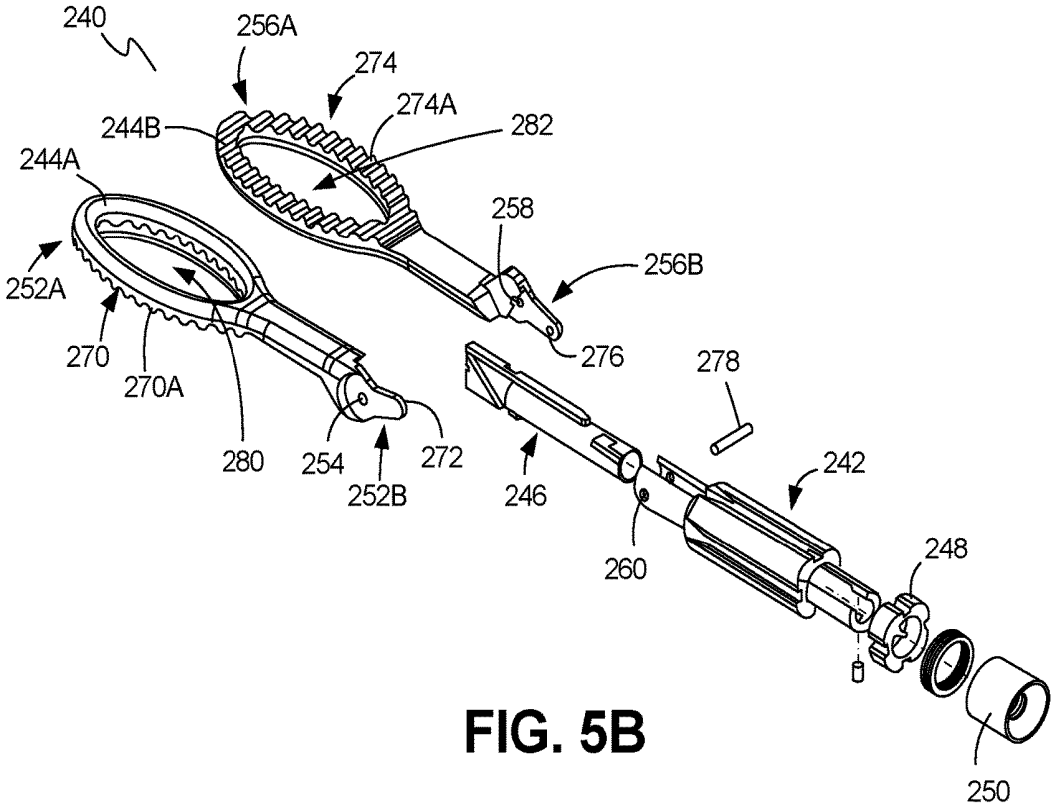

240
244A
244
244B
246
242
262
248
250

FIG. 5A


240
256A
274
274A
244B
282
244A
258
256B
252A
270
270A
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278
280
254
272
252B
246
242
260
248
250

FIG. 5B

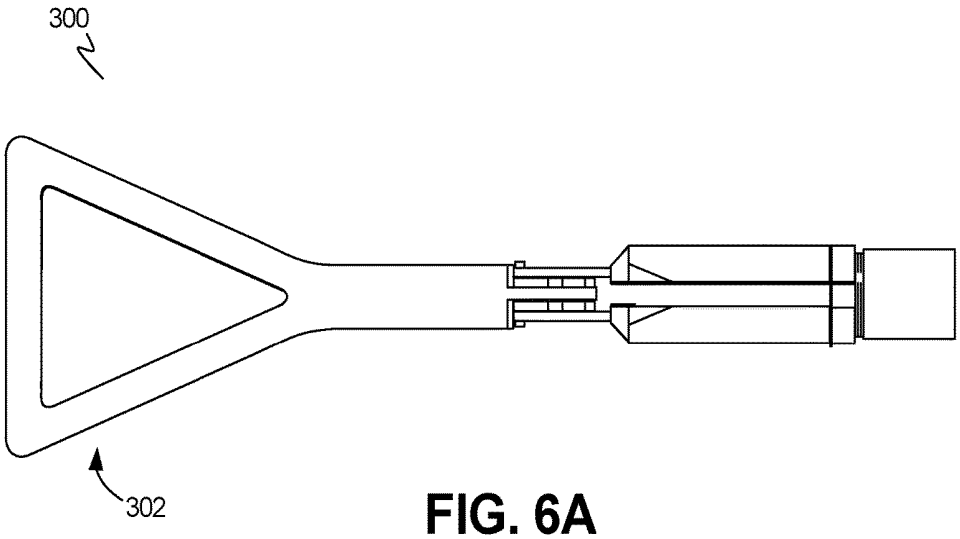

FIG. 6A

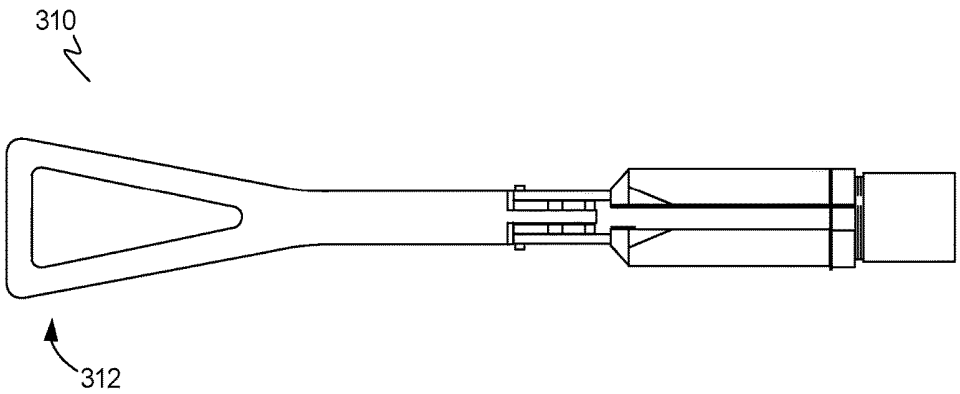

FIG. 6B

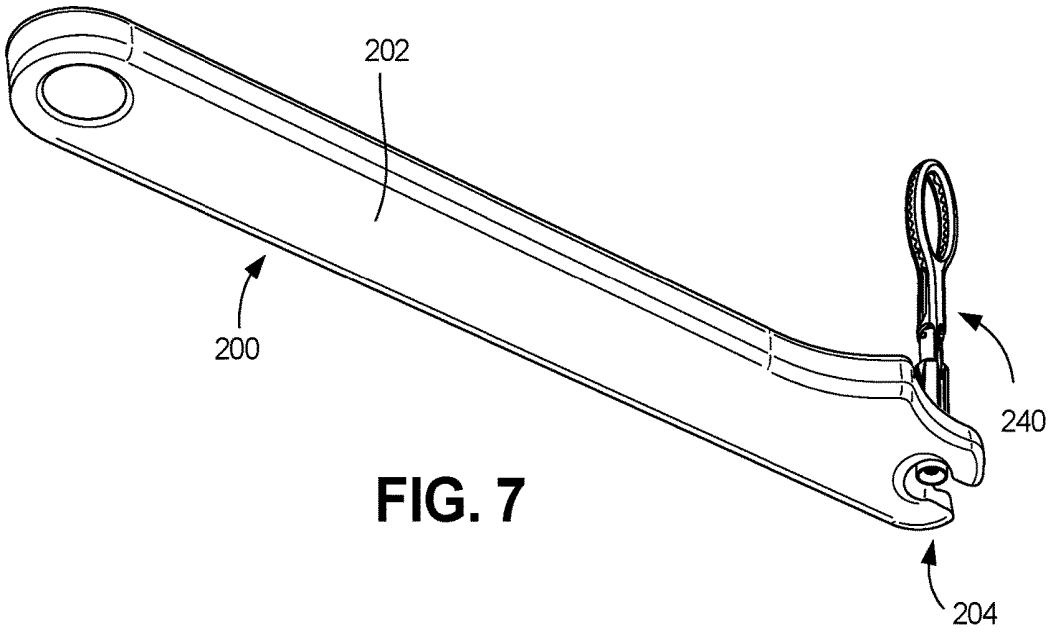

FIG. 7

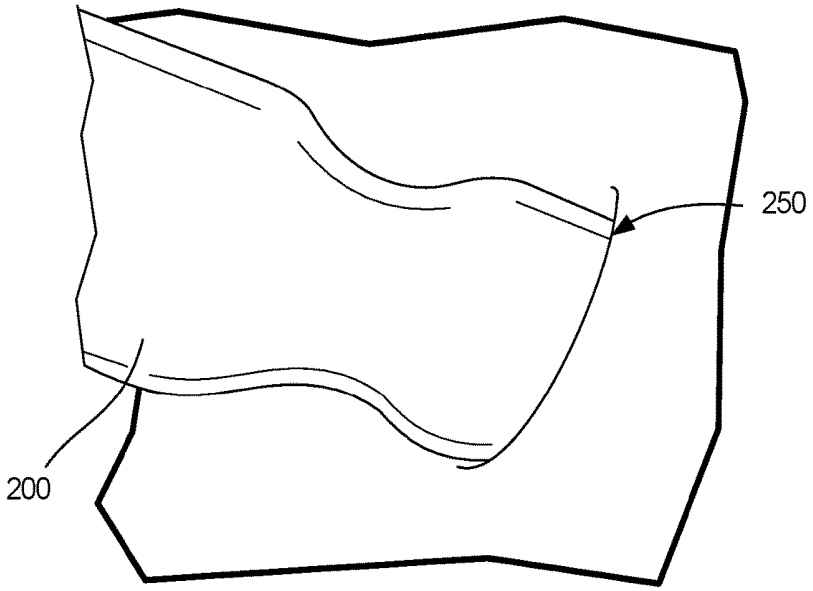

FIG. 8

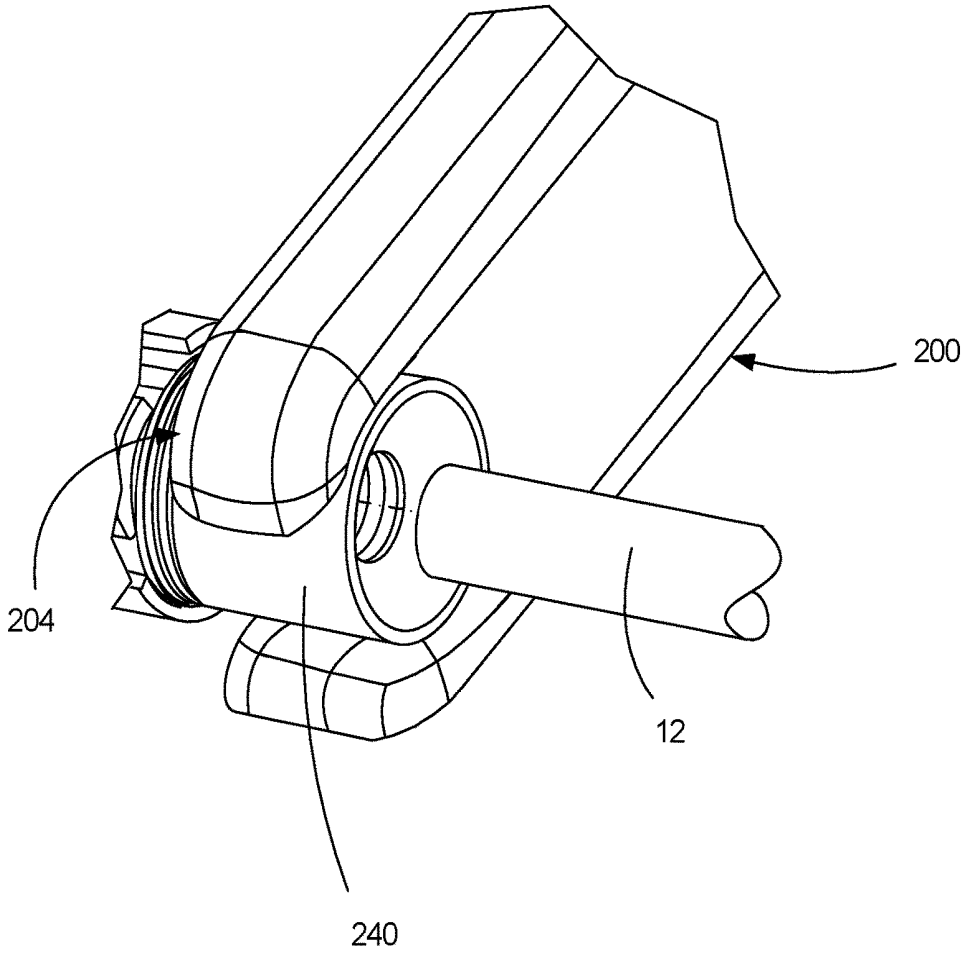

FIG. 9

LAPAROSCOPIC SURGICAL DEVICE AND RELATED SYSTEMS AND METHODS

FIELD OF THE INVENTION

[0001] The various embodiments herein relate generally to apparatus, systems, and methods for performing surgery, e.g., laparoscopic surgery, and more particularly, to laparoscopic surgical tools and to systems and methods including such tools.

BACKGROUND OF THE INVENTION

[0002] Surgery has become increasingly less invasive thanks to advances in medical technology. Laparoscopy is the dominant minimally invasive surgical (MIS) approach used today and has replaced many traditional "open" approaches. In laparoscopic surgery, trocars (typically 3-5) are placed at separate points in the surgical field. These trocars serve as ports into a body cavity or other surgical space (such as the abdomen) through which special long and thin instruments can be inserted. Manipulation of these tools from outside the body mechanically translates into motion within the body cavity. Depending on the tool head design, different instruments have different functions. The appropriate instrument is selected based on what the surgeon needs for that step of the procedure.

[0003] Minimally Invasive Surgery (MIS) offers several advantages compared to open surgical procedures including minimal trauma to the abdominal wall and hence less postoperative pain, fewer wound complications, earlier patient mobilization, and shorter length of stay. Laparoscopic access to the peritoneal space is the dominant MIS approach when performing minimally invasive abdominal operations.

[0004] Recent clinical studies show that further reduction of the size and/or number of incisions may offer added benefits such as faster recovery, less pain, reduced operative time, and improved cosmetic result. Such benefits may have physical and psychological impact. However, the size of the tool tips on conventional instruments used in laparoscopic procedures generally limit the ability to reduce the size of the incisions and trocars needed for such procedures.

[0005] Recent waves of scar-free techniques, including natural orifice trans-luminal endoscopic surgery ("NOTES") and single-port surgery, have emerged to meet the need to further reduce the incisions required for surgical procedures. Ample information explaining the details of these new approaches exists in the public domain. Of the two, single-port surgery is thought among the surgery community to be the more feasible approach given available technology today.

[0006] Single-port surgery involves a multi-channel port that is typically placed in the belly button. This results in hidden scar post operatively. Through these channels, standard laparoscopic tools can be inserted. However, manipulation is more challenging because the tight aperture of the belly button and strong connective tissue in the abdominal wall forces all the instruments to move dependent on one another. In addition, the surgeon's hands are crowded together because of these constraints. Triangulation is largely lost. This makes the procedure frustrating to perform compared to other approaches.

[0007] A number of commercially available tools have been designed to circumvent some of these limitations. Some are variations of standard laparoscopic instruments but have articulating tool heads. Such designs are intended for re-enabling triangulation. However, constraints of the belly button port may force these articulating tools to cross, thus reversing the left-right motion between what the surgeon does with his hands and what he sees on the video monitor. Also, the complex mechanics behind the articulation may drive the cost up significantly.

[0008] The need exists for a revised laparoscopic technique and tools that reduce surgery-induced trauma but preserve the ergonomics and visualization to which surgeons have become accustomed. Such a procedure and tools may be safer for patients. A scar-free or minimal scar result may also appeal more to young adults, and the potential health benefits of a less traumatic approach may be higher for children and the elderly.

[0009] The first step during a laparoscopic surgical procedure is to insufflate the body cavity with a harmless gas (such as carbon dioxide) to increase the working space for the tools. The trocars are inserted across the abdominal wall and are designed to prevent excessive leakage of the insufflation gas, which invariably happens with incisions greater than three millimeters (3 mm).

[0010] In endoscopic and laparoscopic surgical procedures, a trocar device is used to puncture the patient's body in order to provide an access port through the abdominal wall to allow for the introduction of surgical instruments. A typical trocar requires a one-centimeter incision. Typically, a first trocar is placed above the umbilicus to introduce a camera to allow the surgeons to view the surgical site. The camera view is projected on a screen outside the body, which the surgeon and his or her assistants watch in order to appropriately manipulate the instruments inside the body cavity. Additional trocars are used to introduce surgical instruments, such as grasping tools, scissors, clips, and electrosurgical instruments. Typically, the laparoscopic instruments extend toward the surgical target from either side of the video camera. This "triangulation" of the instruments provides the most ergonomic and intuitive set up for the surgeon.

[0011] Patients who undergo laparoscopic surgery may benefit from shorter hospital stays and reduced surgery-inflicted morbidity compared to those who undergo open surgery. But, the number of trocar ports used in an operation is trauma-limited. For many cases, surgeries requiring more than five to seven (5-7) ports may be better performed using an open approach. Surgeons often hesitate to place more ports, even if it would mean making the procedure easier to do, because of the increased risk of wound complications with each additional incision (such as infection, dehiscence, or hernia).

[0012] There is a need in the art for improved laparoscopic surgical devices.

BRIEF SUMMARY OF THE INVENTION

[0013] Discussed herein are various laparoscopic surgical tools and related systems and methods, all designed to facilitate surgery while minimizing the number and/or size of surgical access sites used and/or minimizing visible scars related thereto.

[0014] In Example 1, a surgical system comprises a surgical tool comprising a handle and a control shaft, a detachable tool head operably coupleable to the control shaft, and an introducer tool comprising an open coupler. The open

coupler comprises first and second jaws, a seat defined by inner walls of the first and second jaws, and an opening defined by a distal end of the first and second jaws.

[0015] Example 2 relates to the surgical system according to Example 1, wherein the detachable tool head comprises a tool head shaft and a tool head end effector operably coupled to the shaft, wherein the tool head end effector has a diameter greater than a diameter of the introducer tool.

[0016] Example 3 relates to the surgical system according to Example 2, wherein the detachable tool head is operably coupleable to the open coupler of the introducer tool.

[0017] Example 4 relates to the surgical system according to Example 3, wherein the tool head shaft is positionable within the seat of the open coupler via the opening, thereby resulting in the coupling of the detachable tool head to the open coupler.

[0018] Example 5 relates to the surgical system according to Example 3, wherein the detachable tool head is operably coupleable to the open coupler prior to introduction of the open coupler into a target cavity of a patient.

[0019] Example 6 relates to the surgical system according to Example 5, wherein the detachable tool head is operably coupleable to the open coupler prior to introduction of the open coupler into the target cavity via an incision or a port.

[0020] Example 7 relates to the surgical system according to Example 5, wherein the control shaft is positionable into the target cavity.

[0021] Example 8 relates to the surgical system according to Example 7, wherein the control shaft is configured to be coupled to the detachable tool head within the target cavity.

[0022] Example 9 relates to the surgical system according to Example 8, wherein the introducer tool is configured to be uncoupled from the detachable tool head and retracted from the target cavity.

[0023] In Example 10, a surgical system for assembly within the thoracic cavity comprises an introducer tool configured to inserted into the thoracic cavity via an incision or port, a detachable tool head configured to be operably coupled to the introducer tool prior to insertion into the thoracic cavity, and a surgical tool configured to be introduced into the thoracic cavity separately from the introducer tool. The introducer tool comprises an open coupler comprising first and second jaws, a seat defined by inner walls of the first and second jaws, and an opening defined by a distal end of the first and second jaws. The detachable tool head comprises a lung grasping end effector, wherein the end effector has a diameter greater than the introducer tool. The surgical tool comprises a handle and a control shaft, wherein the surgical tool is configured to be coupled to the detachable tool head within the thoracic cavity.

[0024] Example 11 relates to the surgical system according to Example 10, wherein the introducer tool is configured to be uncoupled from the detachable tool head after the surgical tool is coupled to the detachable tool head.

[0025] Example 12 relates to the surgical system according to Example 11, wherein the lung grasping end effector is configured to manipulate a lung within the thoracic cavity after the surgical tool is coupled to the detachable tool head.

[0026] Example 13 relates to the surgical system according to Example 11, wherein the introducer tool is configured to be removed from the thoracic cavity after the introducer tool is uncoupled from the detachable tool head.

[0027] While multiple embodiments are disclosed, still other embodiments of the present invention will become apparent to those skilled in the art from the following detailed description, which shows and describes illustrative embodiments of the invention. As will be realized, the invention is capable of modifications in various obvious aspects, all without departing from the spirit and scope of the present invention. Accordingly, the drawings and detailed description are to be regarded as illustrative in nature and not restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

[0028] FIG. **1**A is a side view of a surgical tool including a handle and control shaft with a modular tool head coupled to the shaft, showing an end effector of the tool head in the open position, according to one embodiment.

[0029] FIG. **1**B is a close-up perspective view of the tool head of FIG. **1**A, showing relative alignment of internal features of the tool head and control shaft.

[0030] FIG. **1**C is a side view of the surgical tool of FIG. **1**A, showing the end effector of the tool head in the fully closed position, according to one embodiment.

[0031] FIG. **1**D is a close-up perspective view of the tool head of FIG. **1**C, showing relative alignment of internal features of the tool head and control shaft.

[0032] FIG. **1**E is a side view of the surgical tool of FIG. **1**A with an actuator on the handle directed to an alignment position in which the tool head may be coupled or removed from the shaft.

[0033] FIG. **1**F is a close-up perspective view of the tool head of FIG. **1**E, showing relative alignment of internal features of the tool head and control shaft.

[0034] FIGS. **2**A and **2**B are top and side views, respectively, of an exemplary embodiment of an outer cannula tube that may included in the shaft of the surgical tool of FIGS. **1**A, **1**C, and **1**E.

[0035] FIGS. **3**A and **3**B are top and side views, respectively, of an exemplary embodiment of an inner "active" shaft tube that may included in the shaft of the surgical tool of FIGS. **1**A, **1**C, and **1**E.

[0036] FIG. **4**A is a top view of a tool carrier, according to one embodiment.

[0037] FIG. **4**B is a side view of the tool carrier of FIG. **4**A.

[0038] FIG. **4**C is a perspective view of the tool carrier of FIG. **4**A.

[0039] FIG. **4**D is a close-up top view of the coupler of the tool carrier of FIG. **4**A.

[0040] FIG. **5**A is a perspective view of a tool head, according to one embodiment.

[0041] FIG. **5**B is an exploded perspective view of the tool head of FIG. **5**A.

[0042] FIG. **6**A is a top view of a tool head, according to another embodiment.

[0043] FIG. **6**B is a top view of another tool head, according to a further embodiment.

[0044] FIG. **7** is a perspective view of a tool head coupled to a carrier, according to one embodiment.

[0045] FIG. **8** is a perspective view of a carrier disposed through an incision, according to one embodiment.

[0046] FIG. **9** is a perspective view of a shaft of a surgical tool being positioned adjacent to a tool head coupled to a carrier prior to assembly, according to one embodiment.

DETAILED DESCRIPTION

[0047] The various embodiments disclosed or contemplated herein are directed to devices, systems, and methods for performing surgery, e.g., laparoscopic surgery. More particularly, provided herein are laparoscopic surgical tools and to systems and methods including such tools, e.g., designed to facilitate surgery while minimizing the number and/or size of access sites used and/or minimizing visible scars.

[0048] For example, in one embodiment, a modular surgical instrument may be provided that enables standard laparoscopic techniques to be performed through relatively small puncture holes in the body wall of a patient used to access the surgical space. In an exemplary embodiment, the assembled modular instrument may include a handle, a relatively small diameter cannular shaft (e.g., less than or equal to about 2.5 millimeter diameter), and one or more interchangeable tool heads. The cannular shaft may include two coaxial shafts that move relative to one another, e.g., to actuate a tool head attached to the shaft in situ.

[0049] The tool head may be introduced into the surgical site independently of the cannular shaft, e.g., through separate trocar ports, punctures, or other access passages, e.g., located through the umbilicus and the like. For example, the tool head can be introduced using a tool carrier. The cannular shaft may be attached to the tool head within the surgical space inside the body. Once the modular instrument is fully assembled, the tool head may be manipulated through the puncture hole, e.g., using an actuator on the handle, to perform one or more procedures within the surgical space.

[0050] In an exemplary embodiment, a coaxial locking mechanism is provided between the cannular shaft and the tool head, e.g., that locks both an external shaft and an internal "active" shaft on the cannular shaft with respective elements on the tool head, e.g., as disclosed in International Publication No. WO 2010/114634, which is hereby incorporated herein by reference.

[0051] In accordance with another embodiment, an apparatus (also referred to herein as a "tool carrier") is provided for delivering a tool head into a surgical space within a patient's body being visualized by an endoscope introduced into the surgical space via an access port. Generally, the apparatus includes an elongate shaft including a proximal end and a distal end, the shaft connectable to a shaft of an endoscope such that the shaft is advanceable from a proximal position to a distal position, e.g., such that the distal end is within a field of view of the endoscope. An end effector may be provided on the distal end of the tool carrier for releasably engaging a tool head, and a handle may be provided on the proximal end of the shaft including an actuator for operating the end effector to engage and release a tool head.

[0052] In accordance with still another embodiment, a system or kit is provided for performing a procedure within a surgical space within a patient's body that includes a plurality of tool heads, and a tool head carrier including features for removably receiving one or more tool heads, the tool head carrier sized for introduction through a trocar or other port into a surgical space. The system or kit may also include a tool shaft introduceable into the surgical space and include features for securing a tool head to the tool. Each tool head may include a proximal end including a connector for coupling the tool head to a distal end of a tool shaft, and a distal end including an end effector for performing a surgical procedure.

[0053] In accordance with a further embodiment, a method is provided for performing a procedure within a surgical space within a patient's body that includes introducing a tool head into a surgical space through a trocar, other port, or an incision, and securing the tool head to a tool shaft for performing a procedure within the surgical space. The tool head may be introduced into the surgical space on a tool head carrier, which may carry one or more tool heads, e.g., along an endoscope.

[0054] Turning to FIGS. **1**A-**1**F, an exemplary embodiment of a surgical tool **10** is shown that includes a control shaft **12** and a handle **14**, and has a modular tool head **60** coupled to the control shaft **12**. Generally, similar to other embodiments described herein and in the references incorporated by reference herein, the control shaft **12** includes an outer cannular tube or shaft **20** and an inner "active" shaft **30** that are movable relative to one another, e.g., axially and/or rotationally, as described elsewhere herein. In addition, the outer and inner shafts **20**, **30** include features, e.g., on distal ends **22**, **32** as shown in FIGS. **2**A-**3**B, for engaging corresponding features on the tool head **60**, e.g., to couple the tool head **60** to the control shaft **12** and/or actuate an end effector **80** on the tool head **60**, also as described further below.

[0055] For example, as shown in FIGS. **2**A and **2**B, the distal end **22** of the outer cannular shaft **20** includes a longitudinal slot **24**, e.g., extending proximally from a distal tip **23** of the cannular shaft **20** to an angular pocket **26** that extends laterally from the slot **24** to provide a blunt distal edge **26***a*. As shown in FIGS. **3**A and **3**B, the inner shaft **30** also includes a longitudinal slot **34**, e.g., extending proximally from a distal tip **33** of the inner shaft **30**. An angular notch **36** is provided in the distal end **32** at an intermediate location along the slot **34**. Initially, the slots **24**, **34** may be aligned with one another, e.g., to accommodate receiving the tool head **60** onto the control shaft **12**, yet may be directed out of alignment with one another, e.g., by rotating the inner shaft **30** relative to the outer shaft **20**, to secure the tool head **60** to the control shaft **12**.

[0056] The distal tips **23**, **33** may be generally coextensive with one another, although the distal tip **33** of the inner shaft **30** may extend from or retract into the distal end **22** of the outer cannular shaft **20**, e.g., when the inner shaft **30** is directed axially relative to the outer cannular shaft **20**. As shown, the distal tips **23**, **33** are beveled, e.g., sharpened to facilitate penetration through tissue, if desired, and/or to facilitate insertion into the tool head **60**. Alternatively, the distal tips **23**, **33** may be blunt or have other configurations, as desired.

[0057] Returning to FIGS. **1**A-**1**F, the handle **14** includes a stationary housing **40** from which a hand rest **42** extends, e.g., configured to be held by a user. The outer cannular shaft **20** may be substantially fixed axially and rotationally relative to the housing **40**. The inner shaft **30** may be rotated relative to the housing **40**, for example, using actuator **44**, e.g., to rotate the inner shaft **30** relative to the cannular shaft **20** to lock or unlock the tool head **60** from the control shaft **12**. Alternatively, if desired, the actuator **44** may be coupled to the outer cannular shaft **20**, which may be rotatable to lock or unlock the tool head **60** from the control shaft **12**.

[0058] The handle **14** also includes a trigger or other actuator **46** coupled to the inner shaft **30**, e.g., for directing

the inner shaft **30** axially relative to the outer cannular shaft **20**. For example, with the tool head **60** coupled to the control shaft **12**, the trigger **46** may be activated to direct the inner shaft **30** axially to open and close an end effector **80** of the tool head **60**, as shown in FIGS. **1**A and **1**C.

[0059] Optionally, as shown, the handle **14** may include an alignment actuator **48** for directing the inner shaft **30** between first and second predetermined axial locations, e.g., with the trigger **46** in the closed position. For example, with the trigger **46** and the end effector **80** in the closed position shown in FIG. **1**C, the alignment actuator **48** may directed from an operational position (shown in FIG. **1**C) to a locked position in which components of the tool head **60** and control shaft **12** are aligned to allow the tool head **60** to be separated from (or coupled to) the control shaft **12**.

[0060] The tool head or end effector assembly **60**, according to one embodiment, may be selectively coupled to the shaft **12** of the surgical tool **10** of FIGS. **1**A-**1**F. The tool head **60** includes a housing **70**, an end effector **80**, an actuating link **90** movable axially relative to the housing **70** and coupled to the end effector **80**, a locking ring **92**, and a guide cap **94**.

[0061] Additional embodiments of surgical tools, including handles and tool heads, related methods, and additional details thereof, are described in further detail in U.S. Published Application 2013/0331646, entitled "Apparatus, Systems, and Methods for Performing Laparoscopic Surgery," and also in U.S. Published Application 2016/0015253, entitled "Surgical Devices, Systems, and Methods," both of which are hereby incorporated herein by reference in their entireties.

[0062] According to certain embodiments as discussed in further detail below, the tool head **60** can be introduced into a surgical space using a tool head carrier (such as tool head carrier **200** discussed below) and attached to the cannular shaft **20** for performing a surgical procedure within the surgical space.

[0063] According to one embodiment as shown in FIGS. **4**A-**4**D, the tool carrier **200** is an introducer tool **200** having an introducer body (also referred to as a "handle") **202** and a coupler (also referred to herein as a "u-shaped coupler," "open coupler," "open-ended coupler," "open-faced coupler," "coupling jaws," or "coupling component") **204**. The coupler **204** has two jaws **204**A, **204**B that define a seat **206** that is shaped to removably receive a tool head (such as tool head **60** discussed above, for example) such that the shaft of the tool head is disposed in the seat **206** and thereby coupled to the coupler **204**. The seat **206** is defined by the inner walls of the jaws **204**A, **204**B, and is accessible by a shaft of a tool head (such as tool head **60**) being moved through the opening **208** defined between the distal ends of the two jaws **204**A, **204**B and into the seat **206**. The tool head can then be removed or uncoupled from the coupler **204** by moving the shaft out of the seat **206** through the opening **208**.

[0064] In one embodiment, the open-ended coupler **204** of the tool carrier **200** (and any other tool carrier embodiment disclosed or contemplated herein) allows it to accommodate a tool head having jaws with a wider diameter than the diameter of the tool carrier **200**, because the seat **206** is sized to accommodate the shaft of the tool head. The open-ended coupler **204** allows for coupling the tool head shaft to the coupler **204** and subsequently uncoupling the shaft from the coupler **204** via the opening **208** defined at the distal end of the jaws **204**A, **204**B as discussed above without having to move the jaws of the tool head (such as tool head **60**) through the seat **206**. As such, the open-ended coupler **204** can be used to introduce any tool head having jaws or other end effector components with a diameter greater than the tool carrier **200**.

[0065] One such tool head **240** embodiment (with jaws having a diameter greater than that of the tool carrier **200**) is provided for use with the tool carrier **200** (or any other system disclosed or incorporated by reference), as shown in FIGS. **5**A and **5**B. In certain implementations, this tool head **240** has a graspers end effector **244** configured for use in grasping and manipulating lung tissue. As an example, the tool head **240** may be selectively coupled to the shaft **12** of the surgical tool **10** of FIGS. **1**A, **1**C, and **1**E. As shown in FIGS. **5**A-**5**B, the tool head **240** includes a shaft (or "housing") **242**, an actuating link **246** movable axially relative to the housing **242** and coupled to the end effector **244**, a locking ring **248**, and a guide cap **250**, generally similar to embodiments in the reference incorporated by reference herein. More specifically, it is understood that the actuating link **246**, the locking ring **248**, and the guide cap **250** operate in substantially the same way as described with respect to the tool head embodiments in U.S. Published Application 2013/0331646, which is incorporated above.

[0066] The end effector **244** includes a pair of grasper elements **244**A, **244**B. The first grasper element **244**A has first and second ends **252**A, **252**B on opposite sides of an aperture **254** extending through the end effector element **244**A. Similarly, the second grasper element **244**B has first and second ends **256**A, **256**B on opposite sides of an aperture **258** extending through the element **244**B. The two apertures **254**, **258** combine—along with the aperture **260** on the housing **242**—to provide a pivot axis **262**, as best shown in FIG. **5**A, via the pin **278** (as best shown in FIG. **5**B) disposed therethrough. In the first grasper element **244**A, the first end **252**A includes a paddle-shaped jaw element **270** having a plurality of teeth or other gripping features **270**A, while the second end **252**B includes a tab **272** that may be slidably engaged with the actuating link **246**, as described in further detail in the incorporated application. In the second grasper element **244**B, the first end **256**A includes a paddle-shaped jaw element **274** having a plurality of teeth or other gripping features **274**A, while the second end **256**B includes a tab **276** that may be slidably engaged with the actuating link **246**, as described in further detail in the incorporated application. Both jaw elements **270**, **274** have openings **280**, **282** defined therethrough as shown.

[0067] It will be appreciated that other cooperating elements may be provided instead of the grasper elements **244**A, **244**B on the tool head **240**, e.g., curved and/or tapered elements (not shown) instead of the substantially flat elements shown, as described elsewhere in the reference incorporated by reference herein. Thus, according to certain alternative embodiments as best shown in FIG. **6**A, the end effector **300** is a pair of grasper elements **302** having a substantially triangular shape. In a further alternative, as best shown in FIG. **6**B, the end effector **310** is a pair of grasper elements **312** having a substantially triangular shape that is narrower than the pair of grasper elements **302** in FIG. **6**A.

[0068] In accordance with one embodiment, one method of introducing tool head **240** (or any of tool heads **300**, **310**, for example, or any other tool head disclosed or contemplated herein) into a surgical space and attaching the tool head **240** to the cannular shaft **12** of surgical tool **10** (or any

cannular shaft of any such surgical tool as disclosed or contemplated herein) for performing a surgical procedure within the surgical space can include the following steps.

[0069] As shown in FIG. **7**, the tool head **240** can be coupled or attached to the tool carrier **200** by inserting the tool head **240** into the coupler **204** via the opening **208** such that the shaft **242** of the tool head **240** is positioned in the seat **206** and thus coupled to the carrier **200**. Once the tool head **240** is attached to the carrier **200**, the carrier **200** (with the attached head **240**) can be inserted into the body as shown in FIG. **8**. More specifically, the carrier **200** with the tool head **240** is inserted through an incision **250** as shown such that the coupler **204** with the tool head **240** attached is disposed within the patient's body while the handle **202** of the carrier is disposed through the incision **250** such that a proximal end of the handle **202** extends out of the patient's body. Alternatively, the carrier **200** can be inserted through a port.

[0070] According to one implementation, at the same time as, prior to, or after the tool head **240** is introduced into the target surgical space of the patient with the carrier **200**, the cannular shaft **12** of the surgical tool **10** can be inserted into the target cavity via an incision as well (or through a trocar or another port). In one embodiment, the incision through which the shaft **12** is inserted is different from the incision **250** through which the tool head **240** and carrier **200** are inserted.

[0071] Once both the surgical tool shaft **12** and the carrier **200** with the tool head **240** are disposed in the patient's cavity, the carrier **200** and/or the shaft **12** can be positioned such that the tool head **240** is accessible for coupling with the distal end of the surgical tool shaft **12** as shown in FIG. **9**, according to one embodiment. The shaft **12** is then inserted into the tool head **240**, thereby coupling the tool head **240** to the shaft **12** (and thus the surgical tool **10**). This coupling of the tool head **240** and the shaft **12** can be accomplished via camera visualization or direct visualization.

[0072] The carrier **200** is then uncoupled from the tool head **240** by simply pulling the handle **202** in a proximal direction such that the tool head **240** uncouples from the coupler **204** via the opening **208** in the coupler **204**. The carrier **200** is then retracted from the body cavity via the incision **250** while the tool head **240** remains coupled to the surgical tool **10**. At that point, the surgical tool **10** can be operated with the tool head **240** coupled thereto to perform the desired surgical procedure within the target cavity of the patient.

[0073] Optionally, another tool head may be introduced and coupled to the cannular shaft **12** in a similar manner. Thus, one or more tool heads may be introduced sequentially into a surgical space to perform a series of steps or procedures, as desired. Once the desired procedure(s) is completed, the carrier tool **200**, cannular shaft **12**, any endoscope (not shown) used in the procedure, and/or any other devices may be removed from the patient's body using conventional methods.

[0074] According to one implementation, the various embodiments disclosed or contemplated herein can be used to perform a thoracic surgical procedure across the rib cage of a patient. In certain of these implementations, the tool head **240** can be introduced via the carrier **200** to be coupled to the shaft **12** inside the thoracic cavity and used for the procedure, which includes grasping and manipulating lung tissue.

[0075] Although the present invention has been described with reference to preferred embodiments, persons skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention.

What is claimed is:

1. A surgical system comprising:
(a) a surgical tool comprising a handle and a control shaft;
(b) a detachable tool head operably coupleable to the control shaft; and
(c) an introducer tool comprising an open coupler comprising:
(i) first and second jaws;
(ii) a seat defined by inner walls of the first and second jaws; and
(iii) an opening defined by a distal end of the first and second jaws.

2. The surgical system of claim **1**, wherein the detachable tool head comprises:
(a) a tool head shaft; and
(b) a tool head end effector operably coupled to the shaft, wherein the tool head end effector has a diameter greater than a diameter of the introducer tool.

3. The surgical system of claim **2**, wherein the detachable tool head is operably coupleable to the open coupler of the introducer tool.

4. The surgical system of claim **3**, wherein the tool head shaft is positionable within the seat of the open coupler via the opening, thereby resulting in the coupling of the detachable tool head to the open coupler.

5. The surgical system of claim **3**, wherein the detachable tool head is operably coupleable to the open coupler prior to introduction of the open coupler into a target cavity of a patient.

6. The surgical system of claim **5**, wherein the detachable tool head is operably coupleable to the open coupler prior to introduction of the open coupler into the target cavity via an incision or a port.

7. The surgical system of claim **5**, wherein the control shaft is positionable into the target cavity.

8. The surgical system of claim **7**, wherein the control shaft is configured to be coupled to the detachable tool head within the target cavity.

9. The surgical system of claim **8**, wherein the introducer tool is configured to be uncoupled from the detachable tool head and retracted from the target cavity.

10. A surgical system for assembly within the thoracic cavity, the system comprising:
(a) an introducer tool configured to inserted into the thoracic cavity via an incision or port, the introducer tool comprising an open coupler comprising:
(i) first and second jaws;
(ii) a seat defined by inner walls of the first and second jaws; and
(iii) an opening defined by a distal end of the first and second jaws;
(b) a detachable tool head configured to be operably coupled to the introducer tool prior to insertion into the thoracic cavity, the detachable tool head comprising a lung grasping end effector, wherein the end effector has a diameter greater than the introducer tool; and

(c) a surgical tool configured to be introduced into the thoracic cavity separately from the introducer tool, the surgical tool comprising a handle and a control shaft, wherein the surgical tool is configured to be coupled to the detachable tool head within the thoracic cavity.

11. The surgical system of claim **10**, wherein the introducer tool is configured to be uncoupled from the detachable tool head after the surgical tool is coupled to the detachable tool head.

12. The surgical system of claim **11**, wherein the lung grasping end effector is configured to manipulate a lung within the thoracic cavity after the surgical tool is coupled to the detachable tool head.

13. The surgical system of claim **11**, wherein the introducer tool is configured to be removed from the thoracic cavity after the introducer tool is uncoupled from the detachable tool head.

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摘要(译)

本文的各种实施例涉及具有手术工具，可拆卸工具头和导引器工具的手术系统。各种系统可用于微创腹腔镜外科手术。