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(54) **LAPAROSCOPIC SURGICAL INSTRUMENT FOR IN SITU TOOL EXCHANGE**

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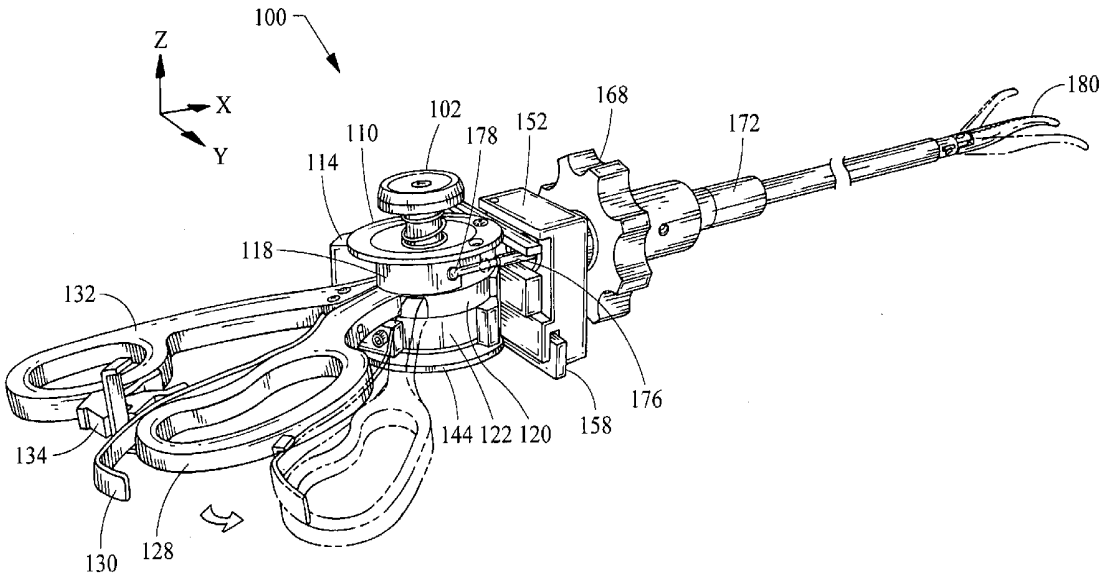
(57) **ABSTRACT**

A method is presented for replacing a tool through a sleeve of a laparoscopic instrument without removing the sleeve from a body. The method includes rotating a housing portion of the laparoscopic instrument to expose an end of a first tool to be removed, removing the first tool from the sleeve, and inserting a second tool into the sleeve without removing it from the body.



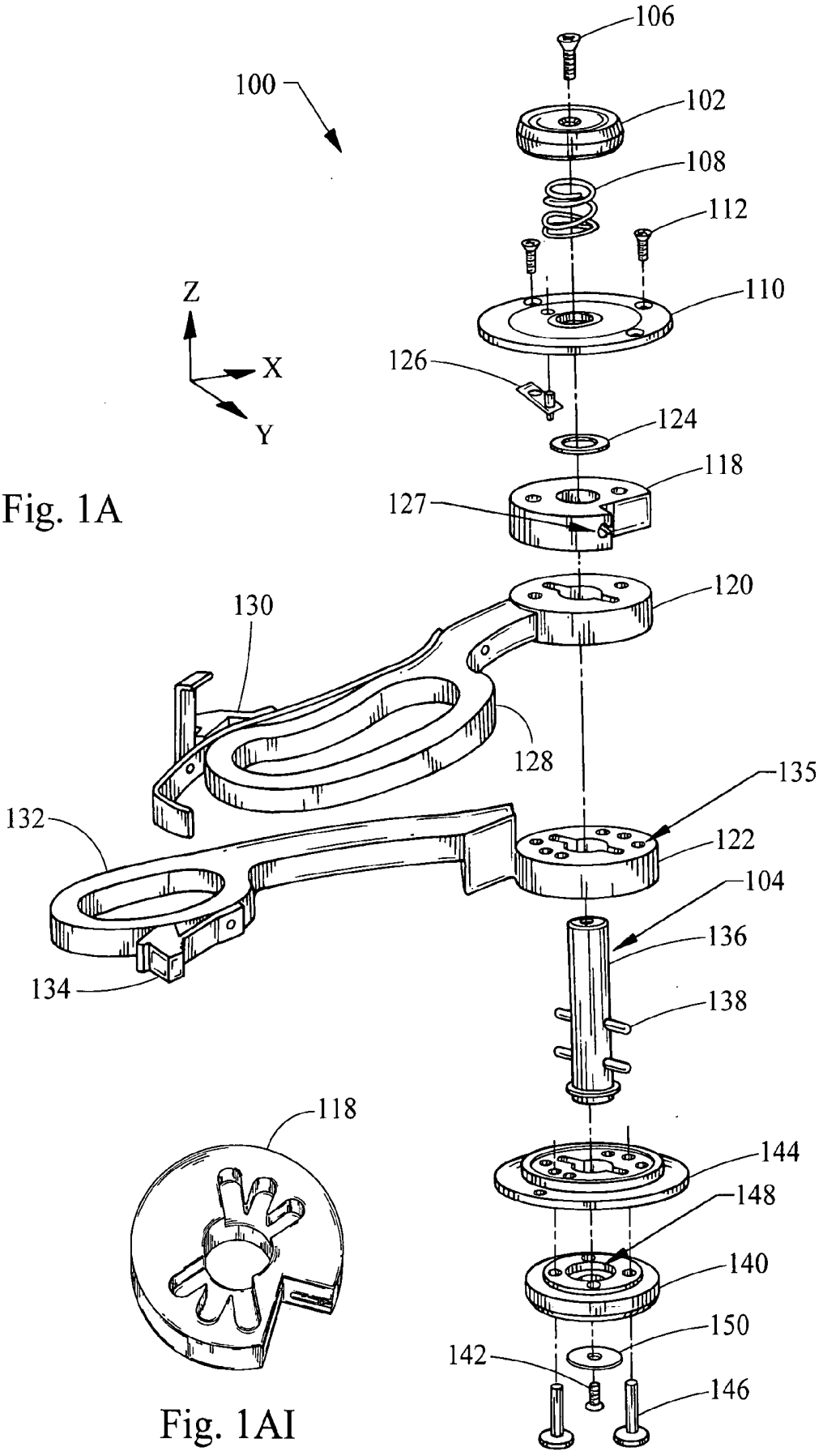


Fig. 1A

Fig. 1AI

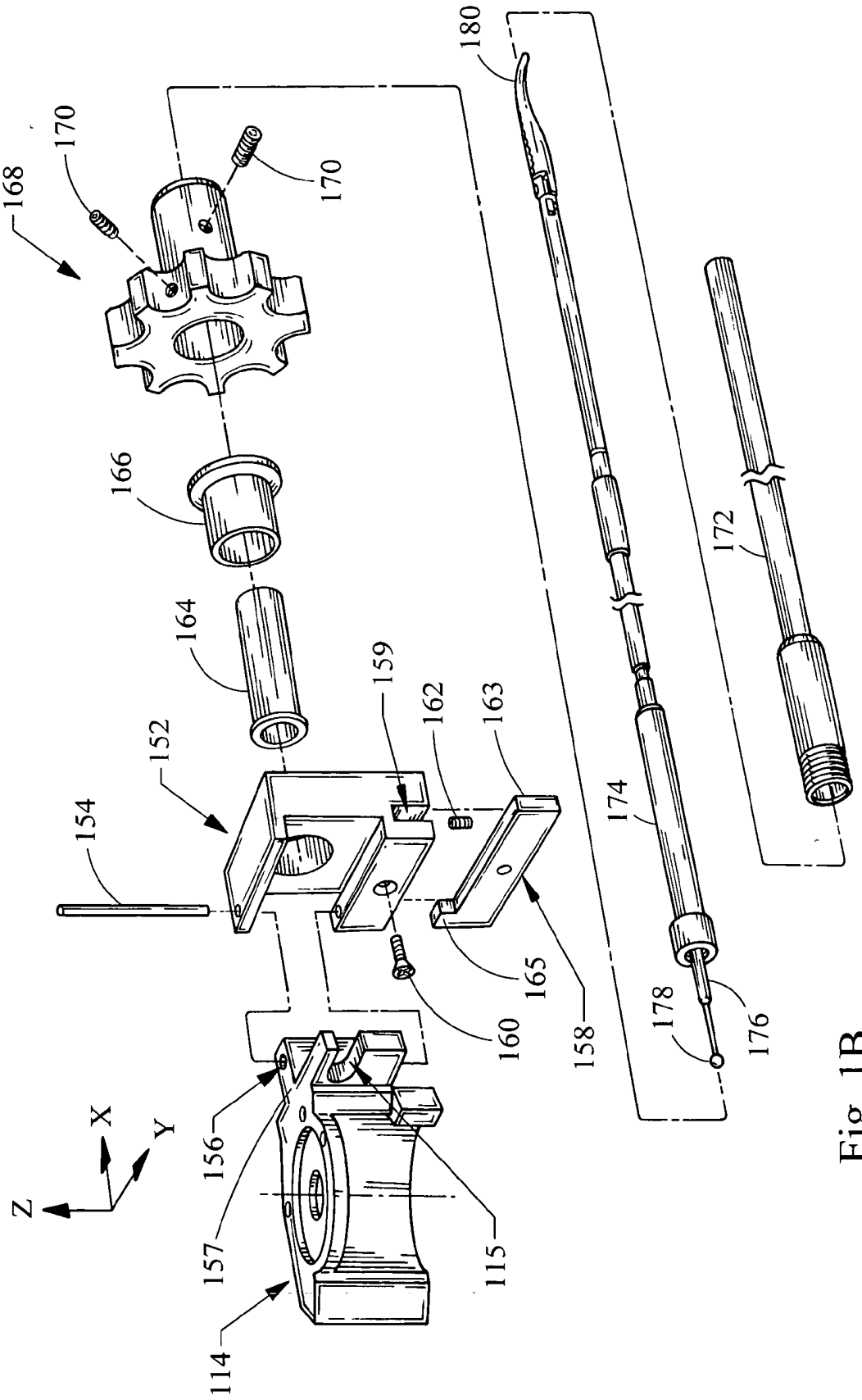

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Fig. 1B

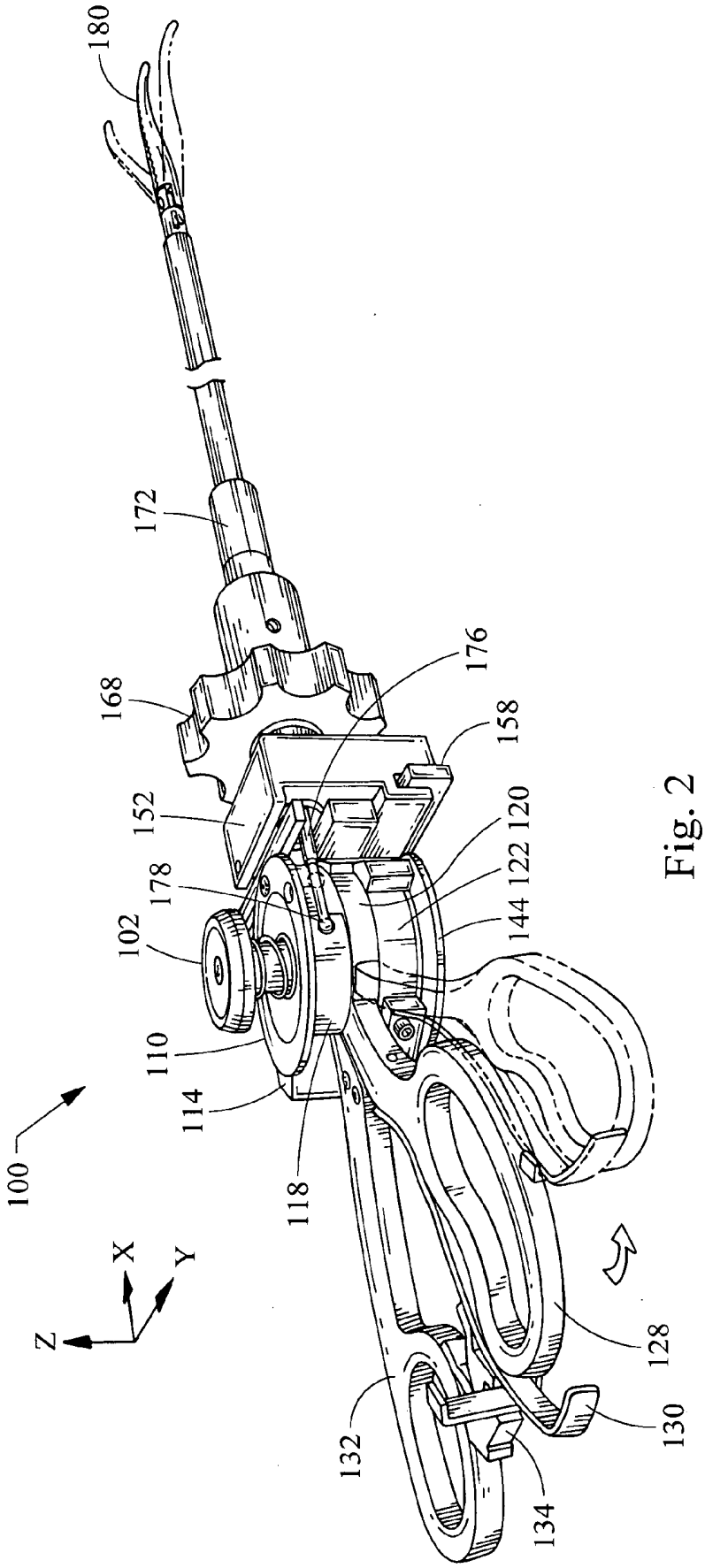
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Fig. 2

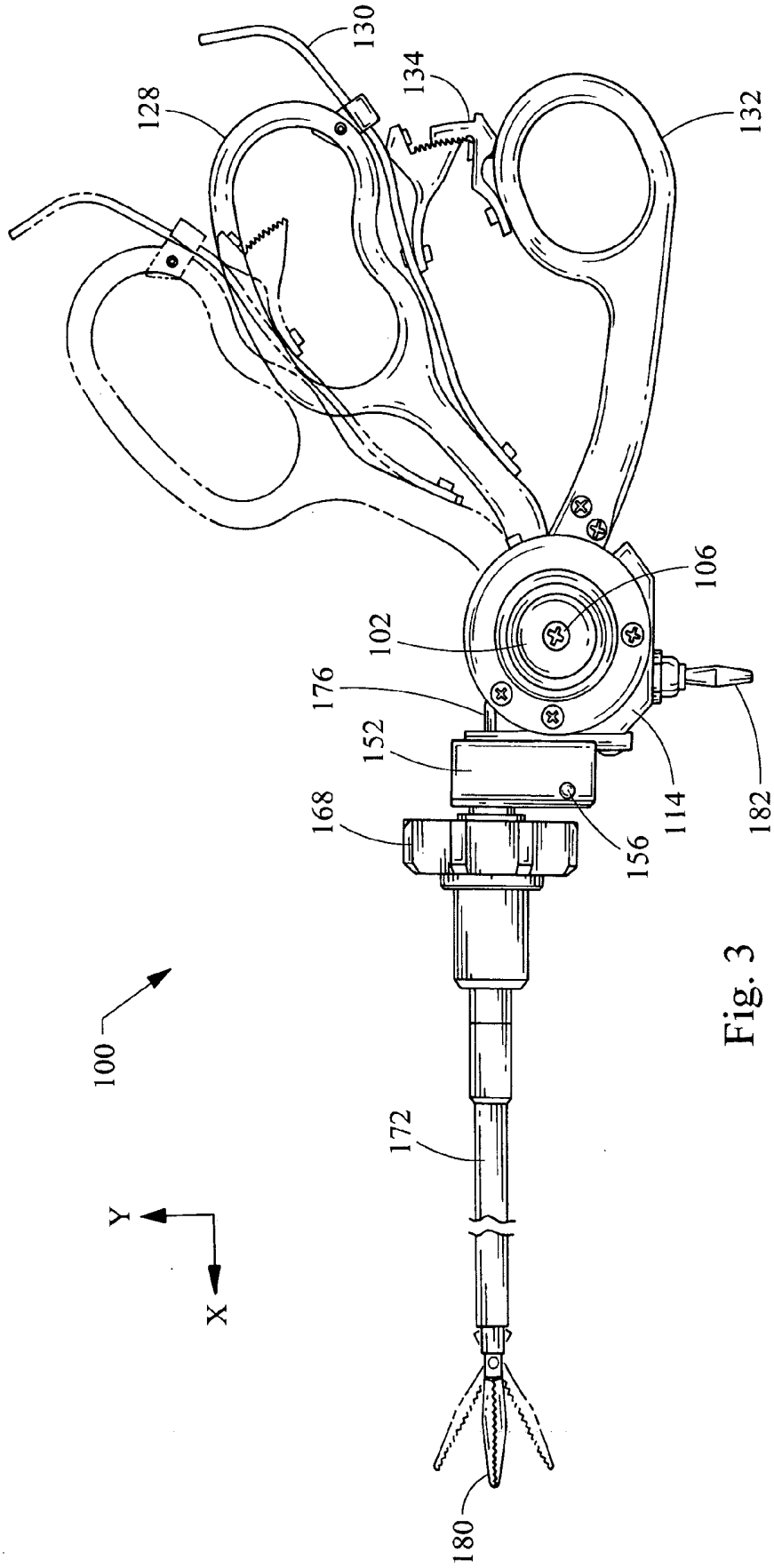

Fig. 3

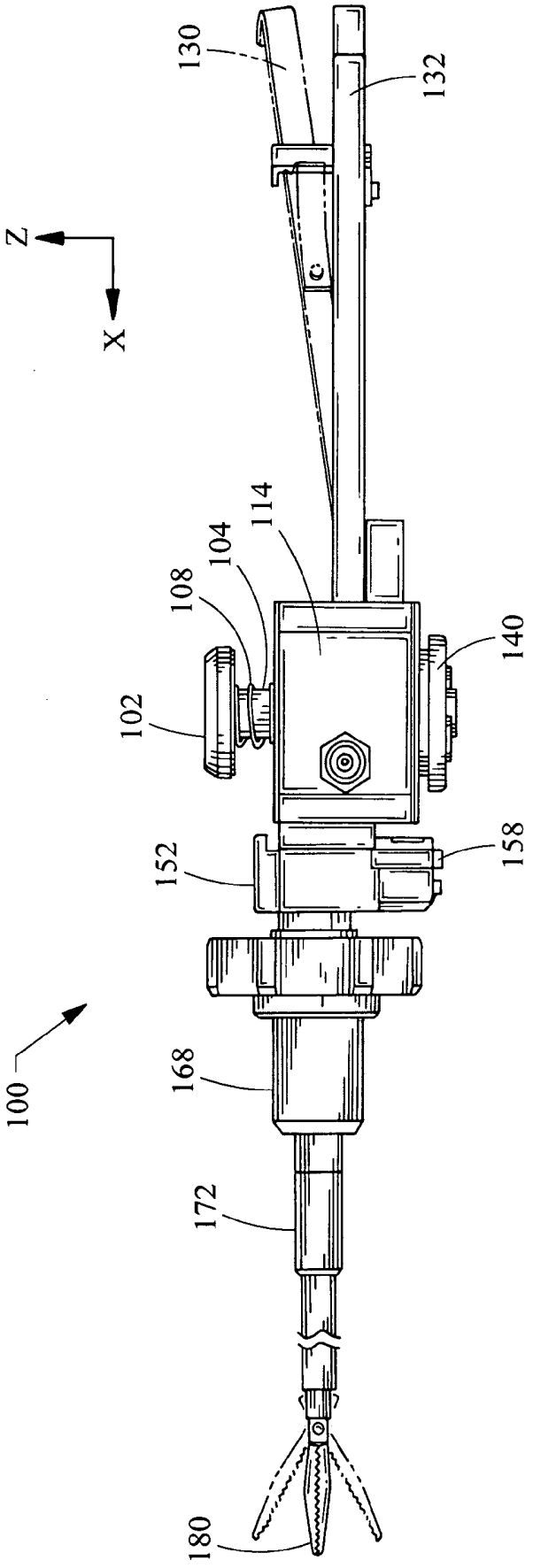

Fig. 4

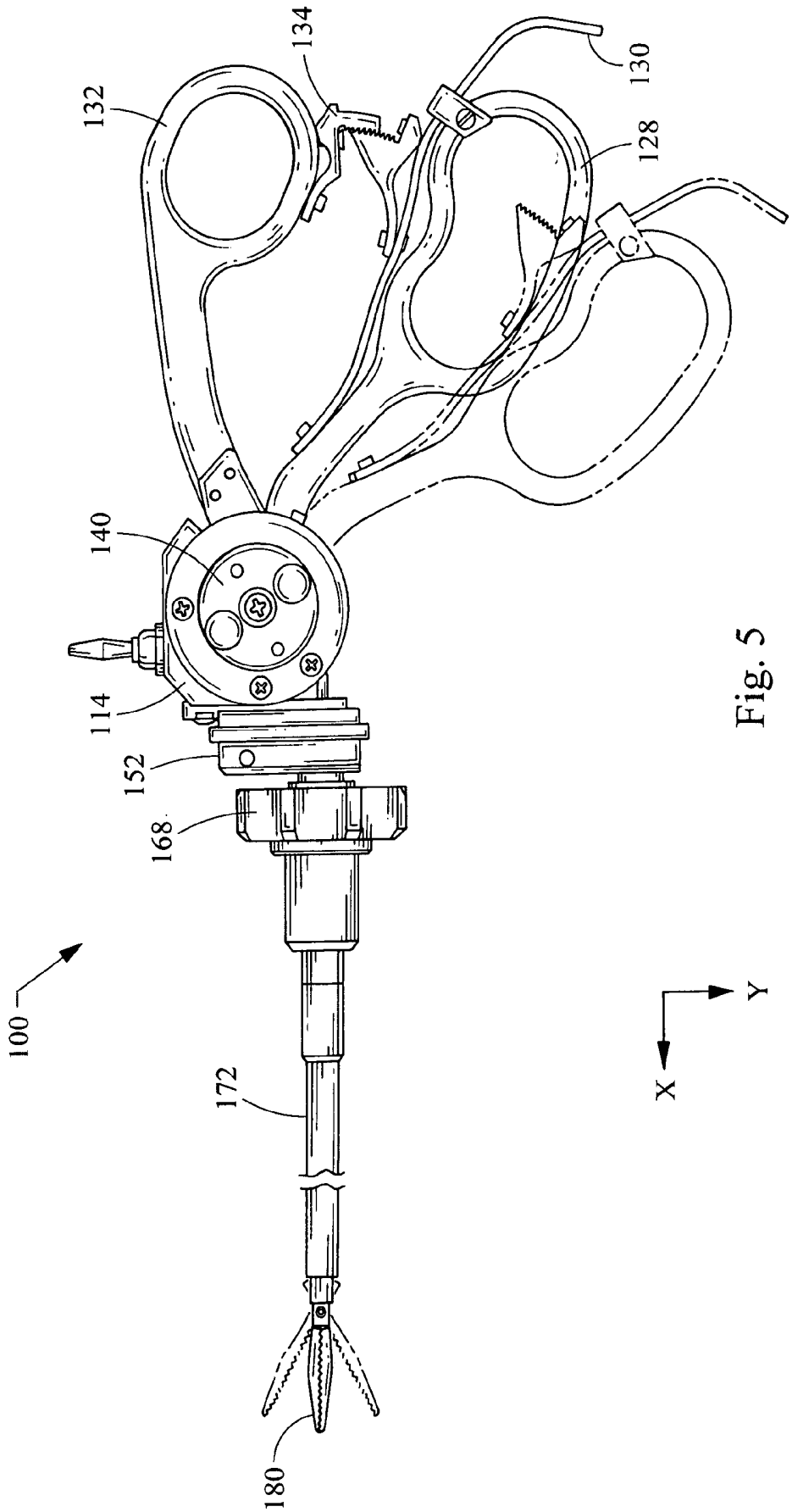

Fig. 5

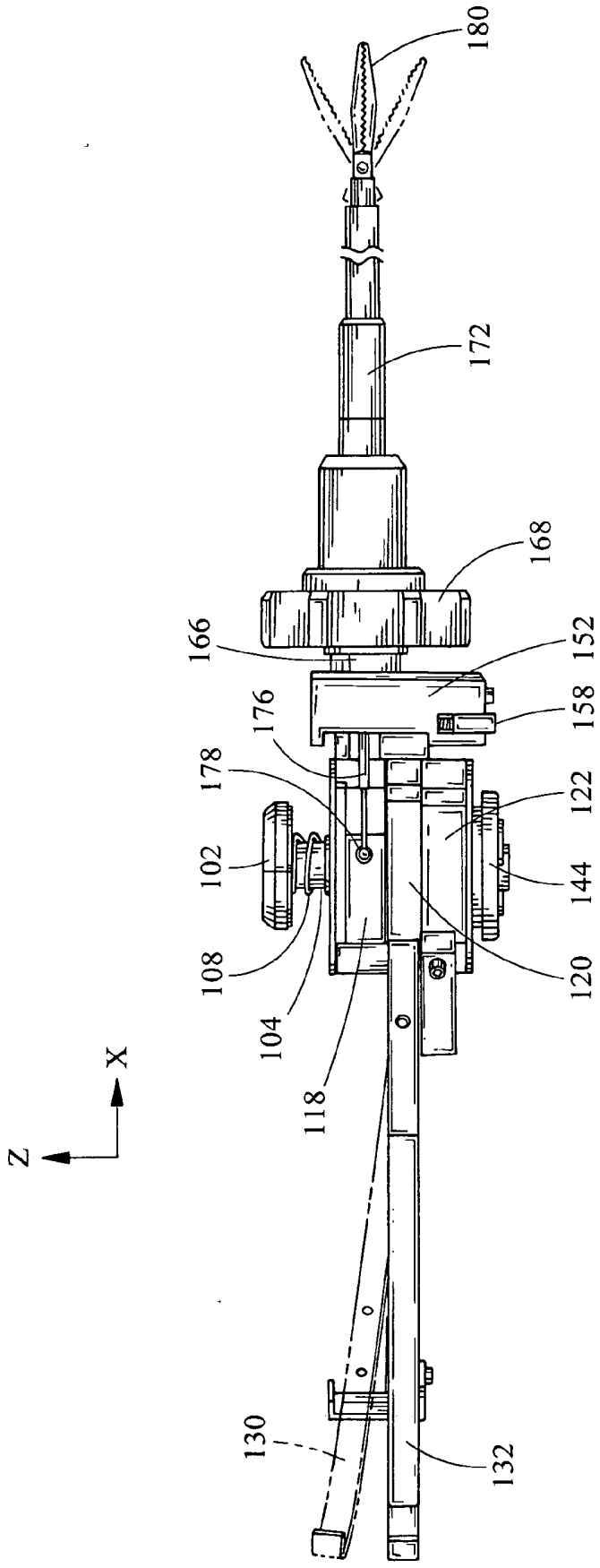
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Fig. 6

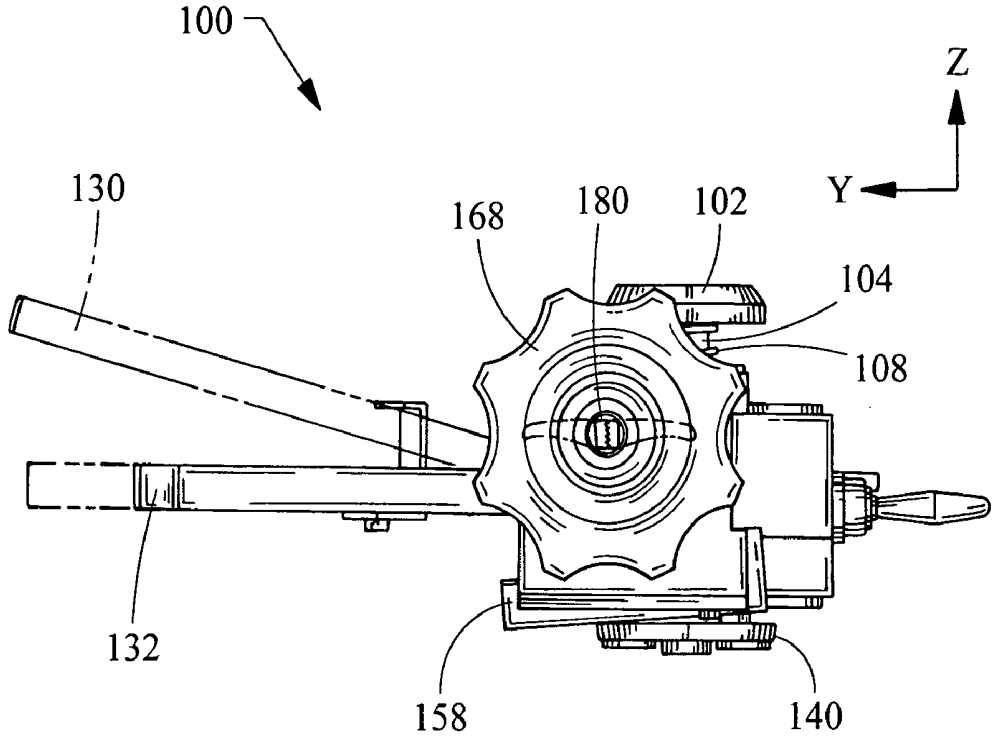
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Fig. 7

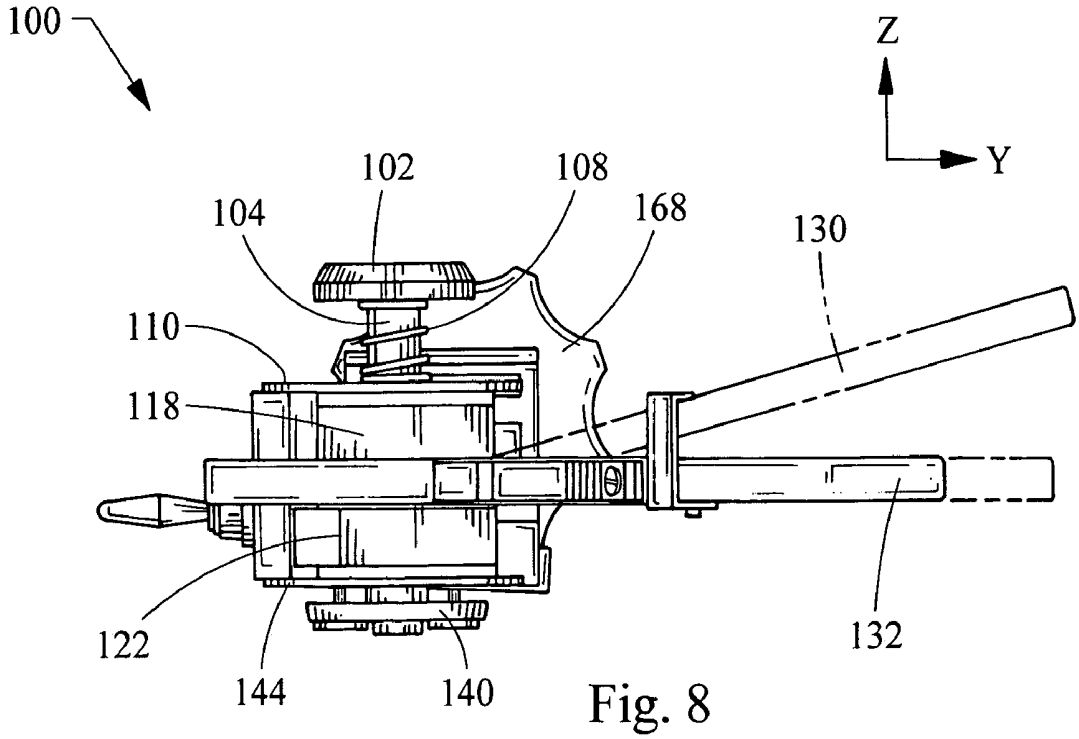
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Fig. 8

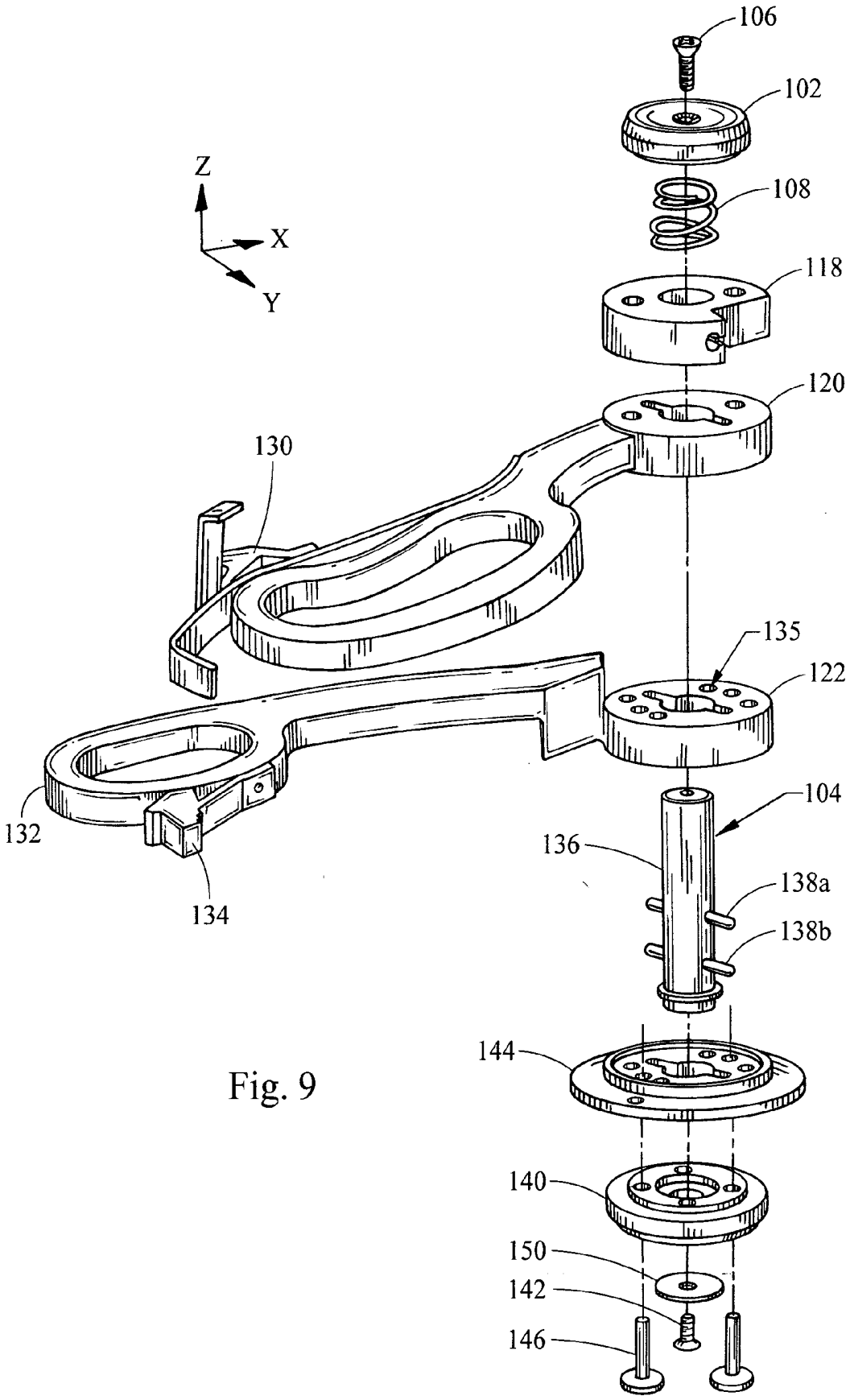
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Fig. 9

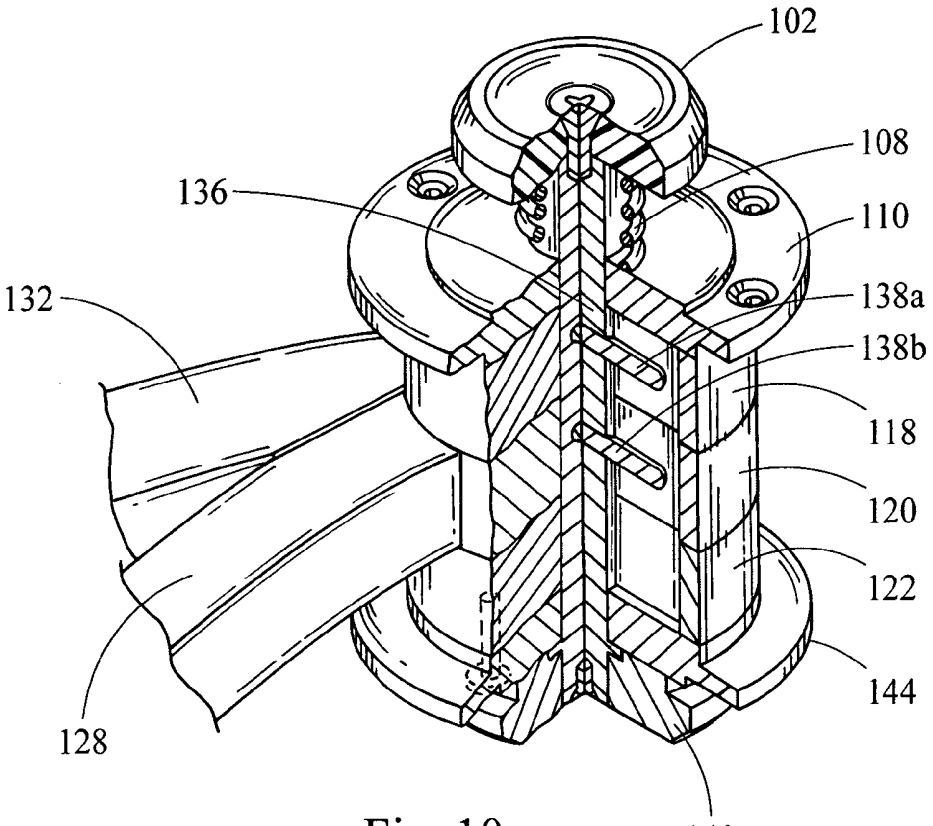
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Fig. 10

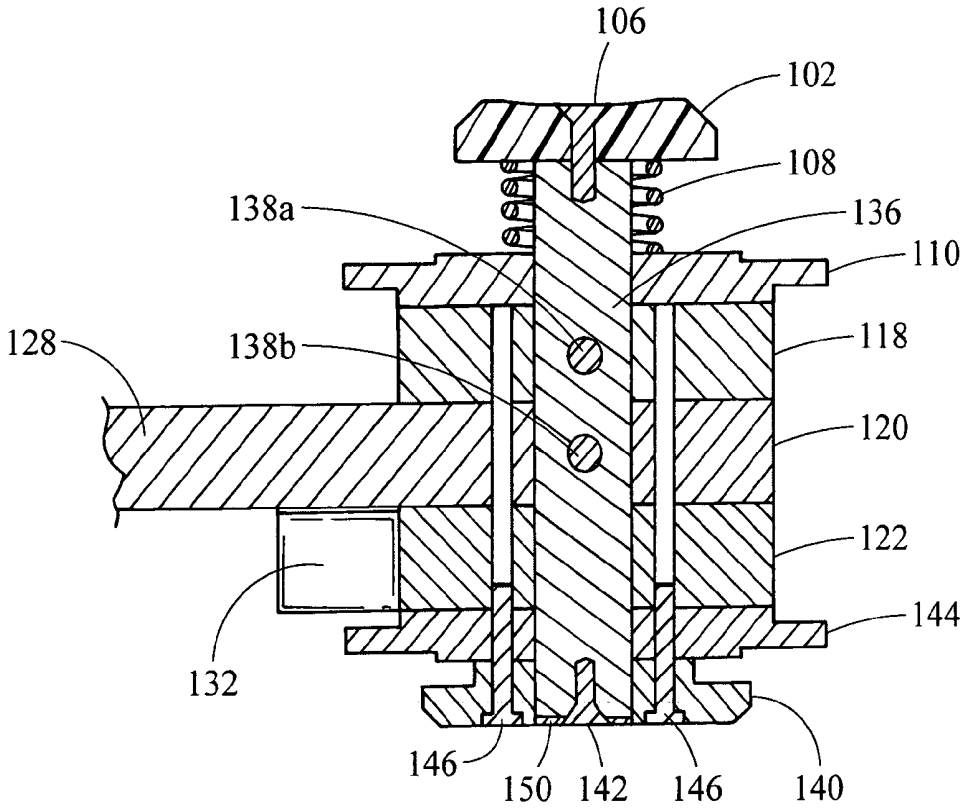
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Fig. 11

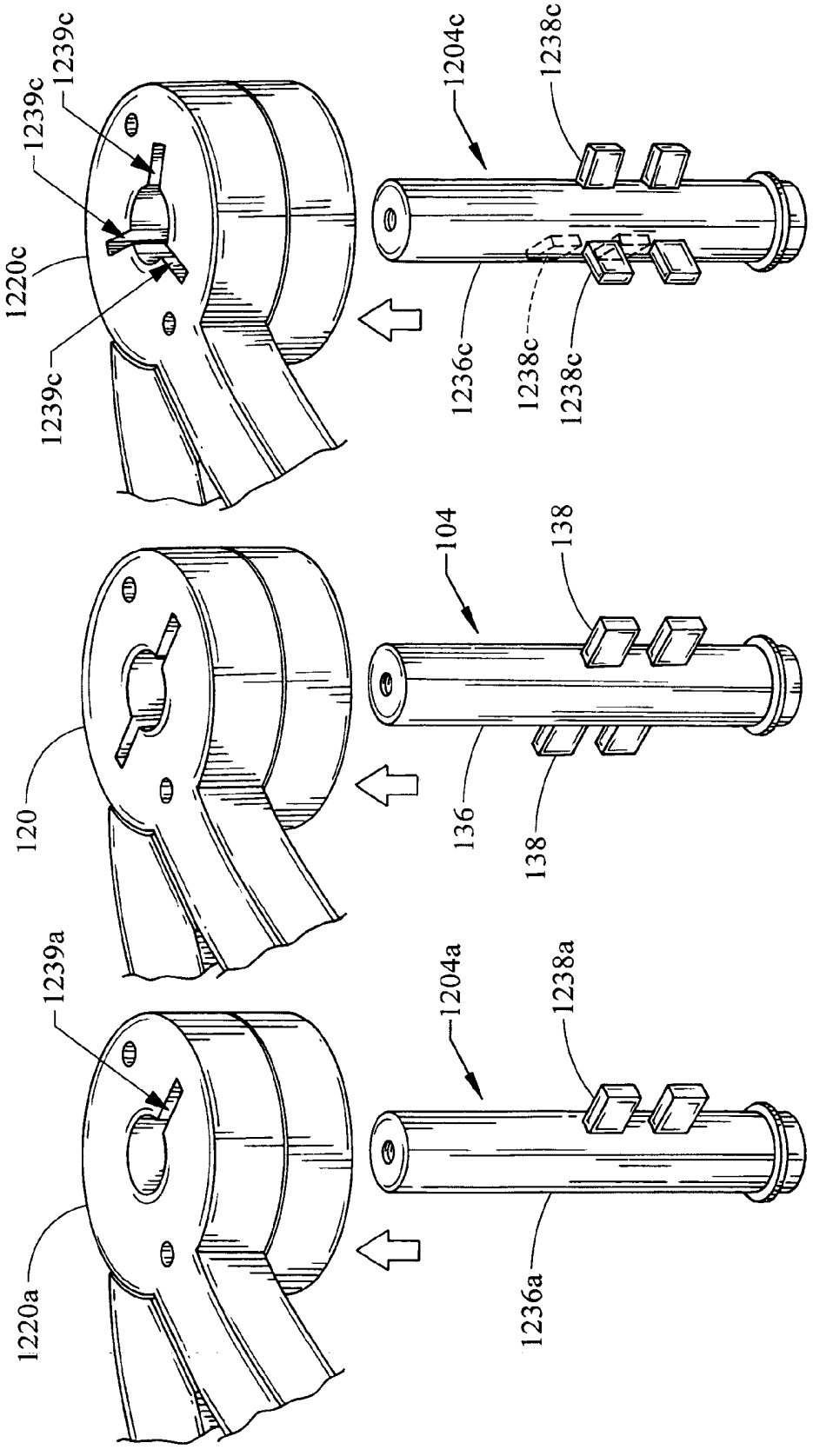


Fig. 12C

Fig. 12B

Fig. 12A

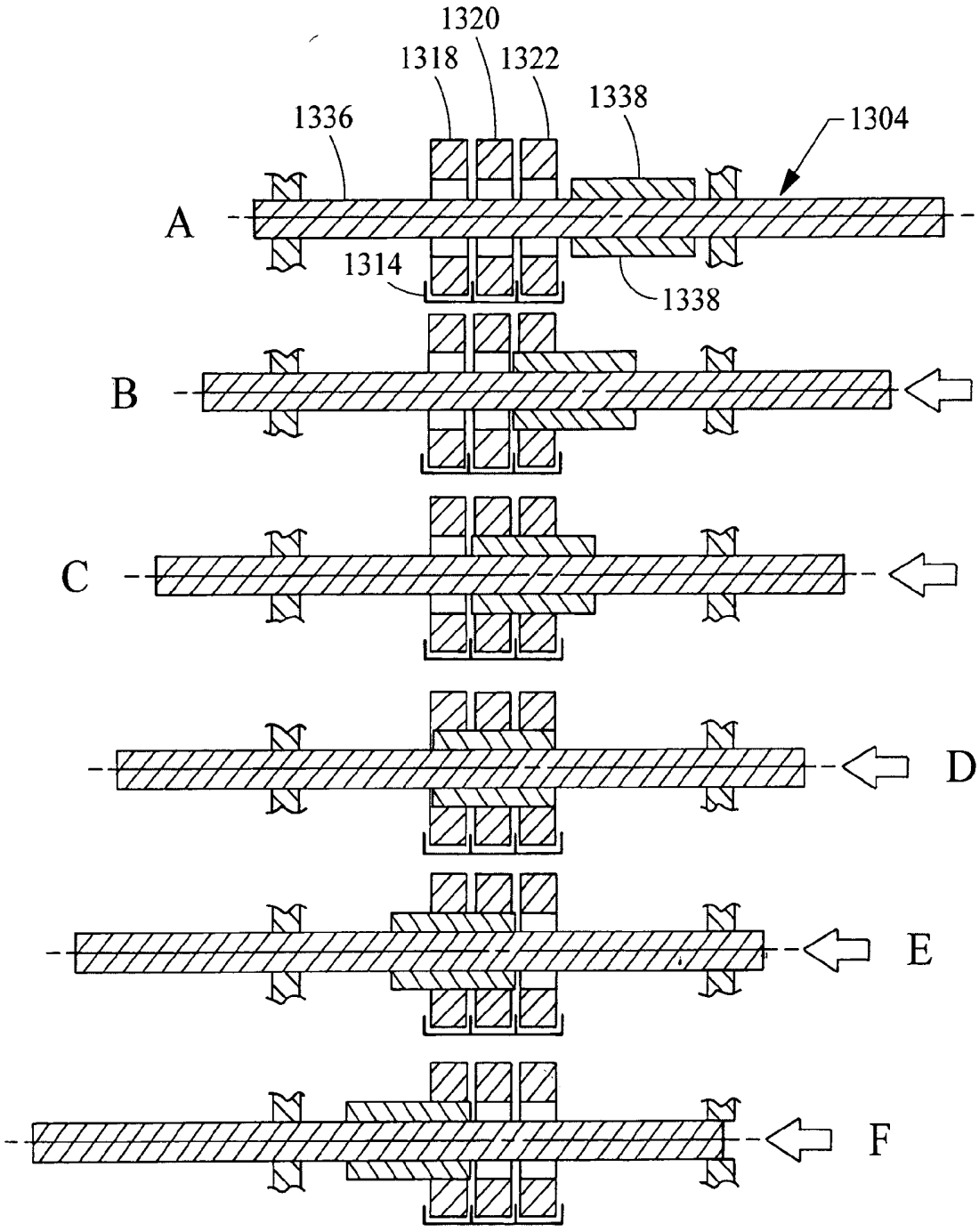


Fig. 13

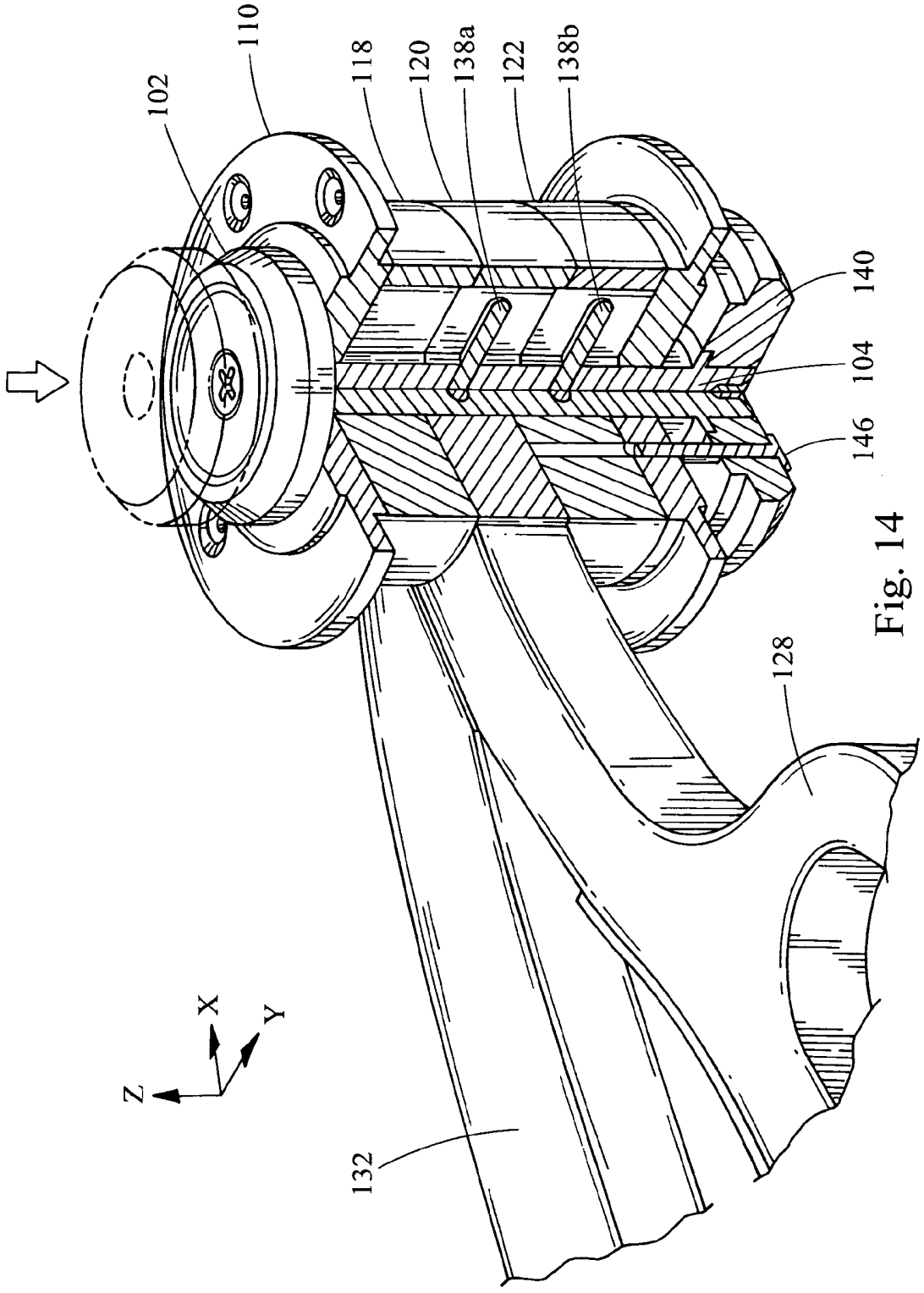
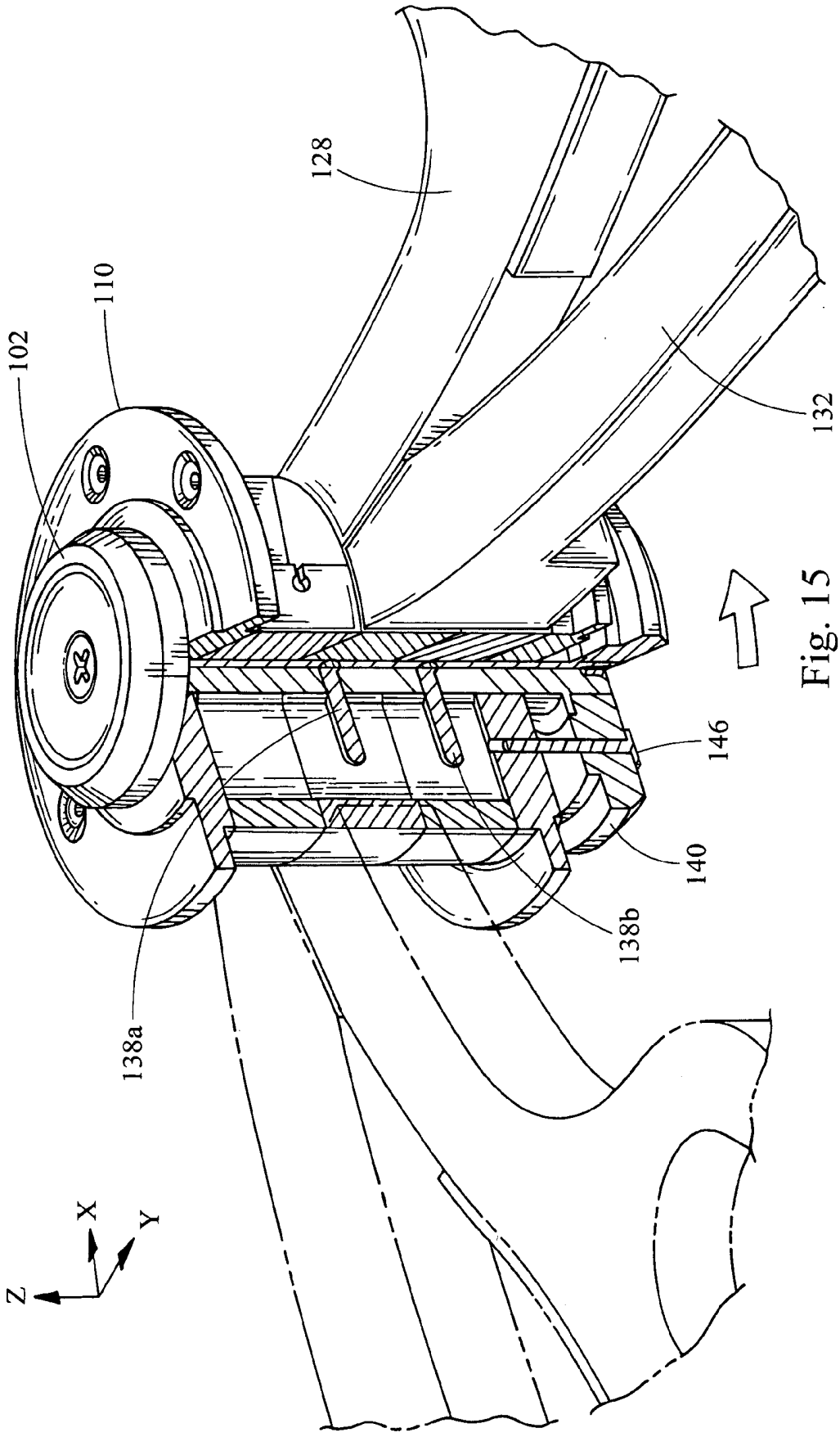


Fig. 14



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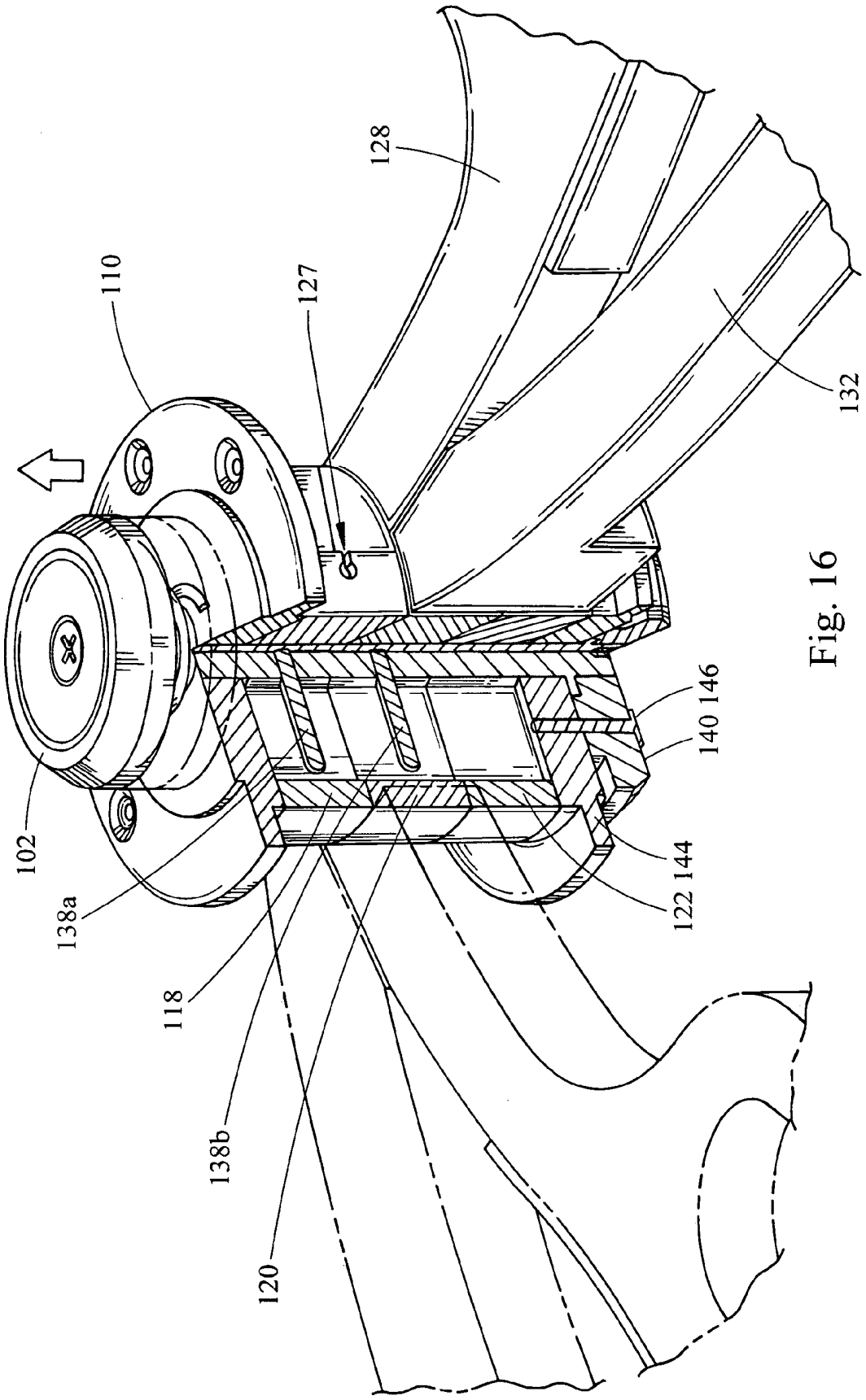

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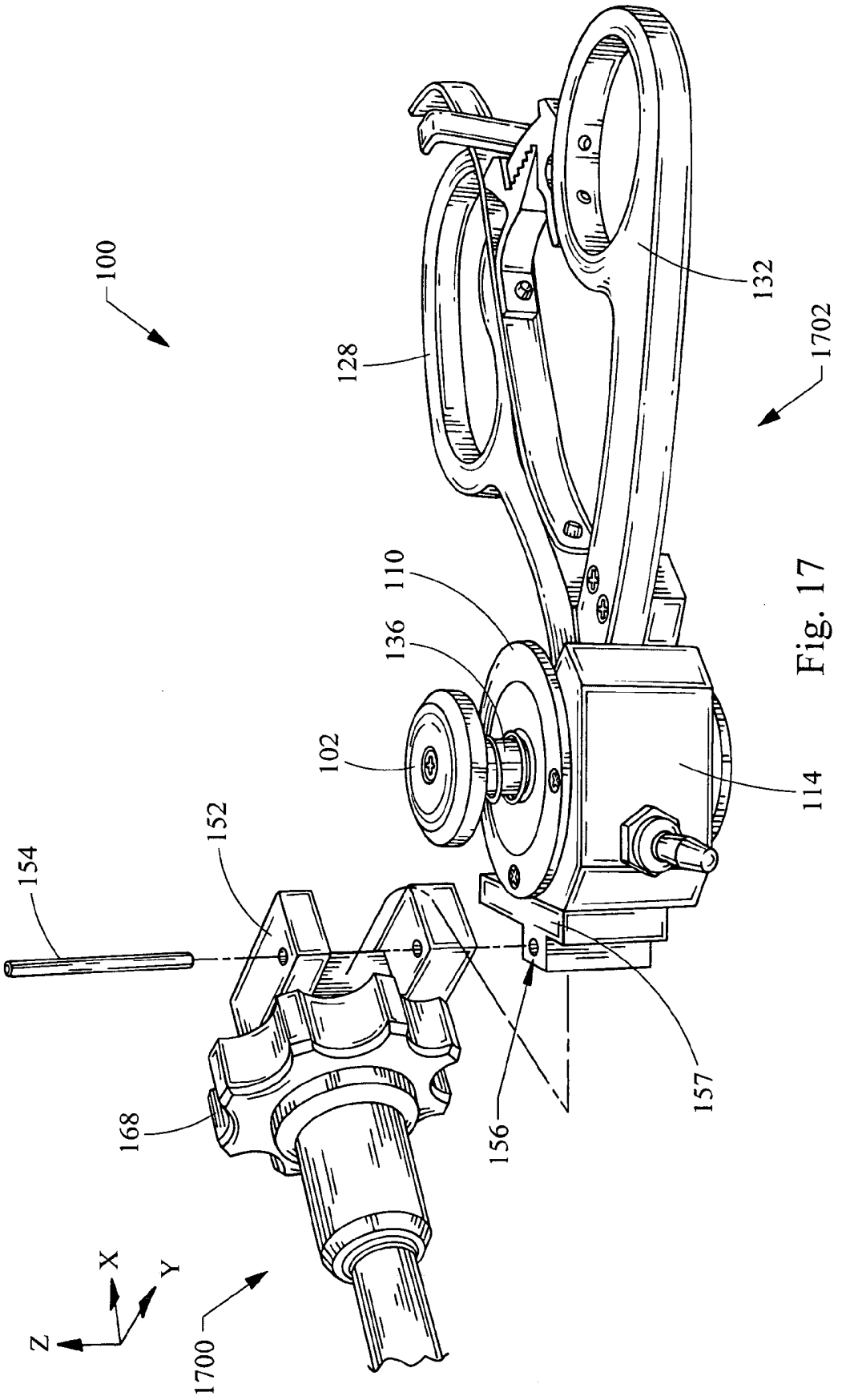

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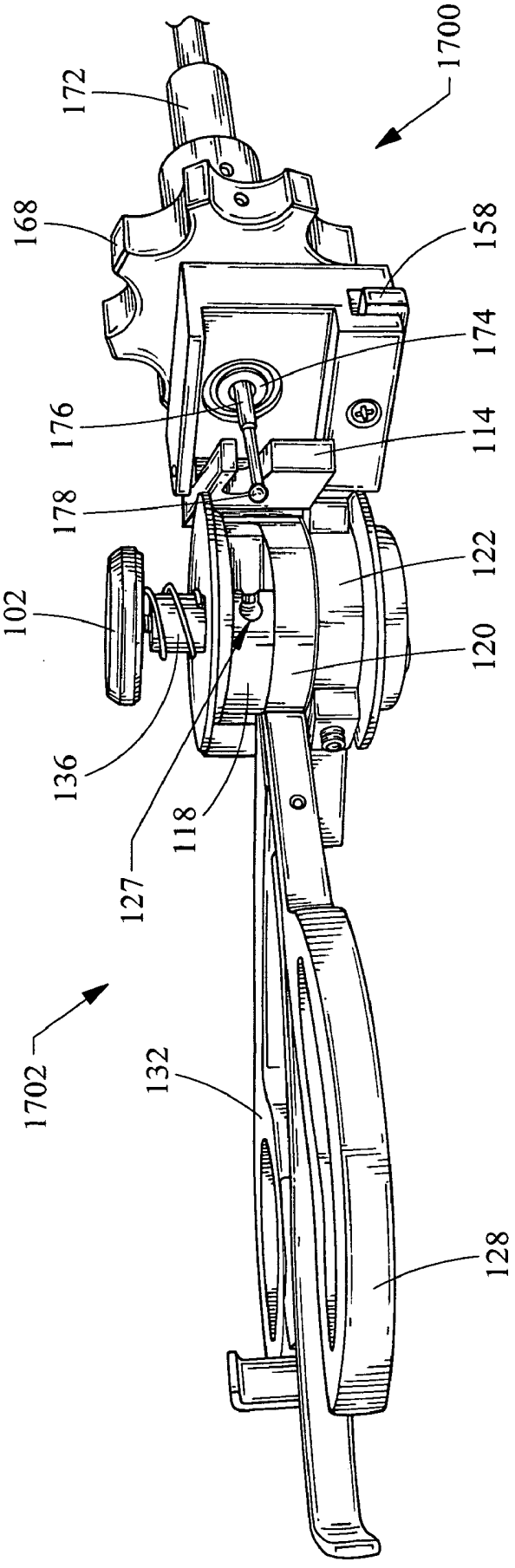
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Fig. 18

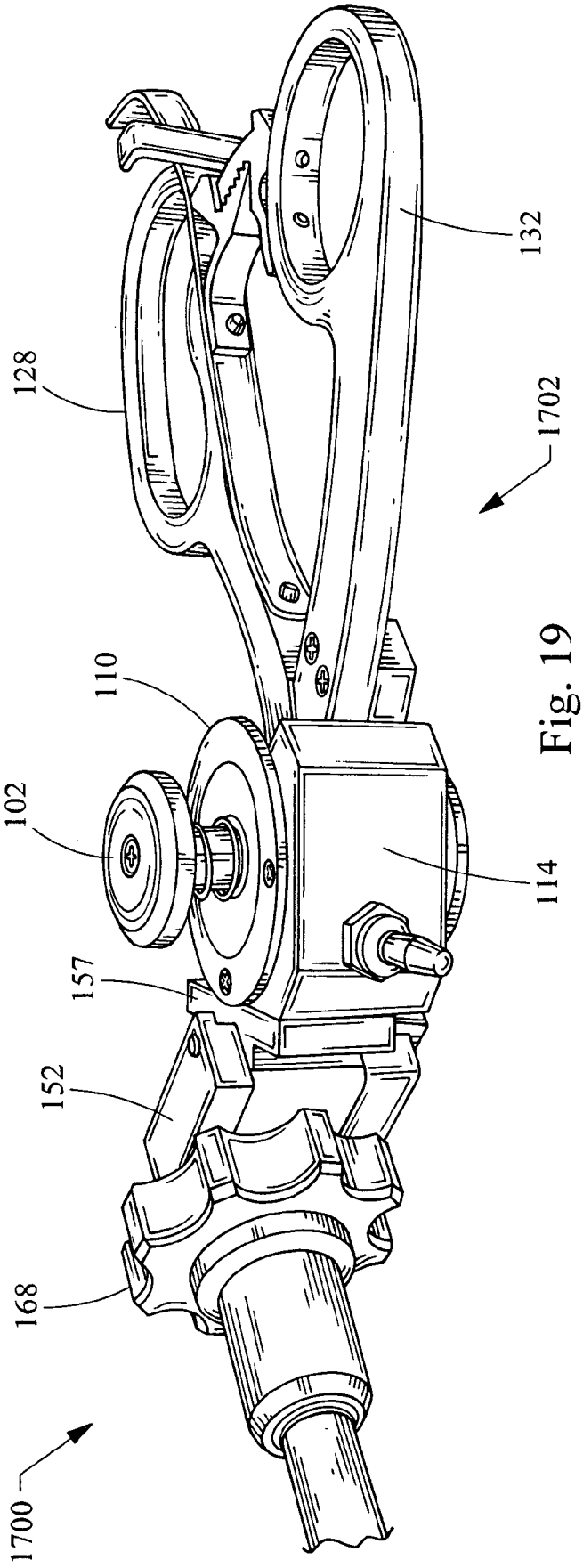

Fig. 19

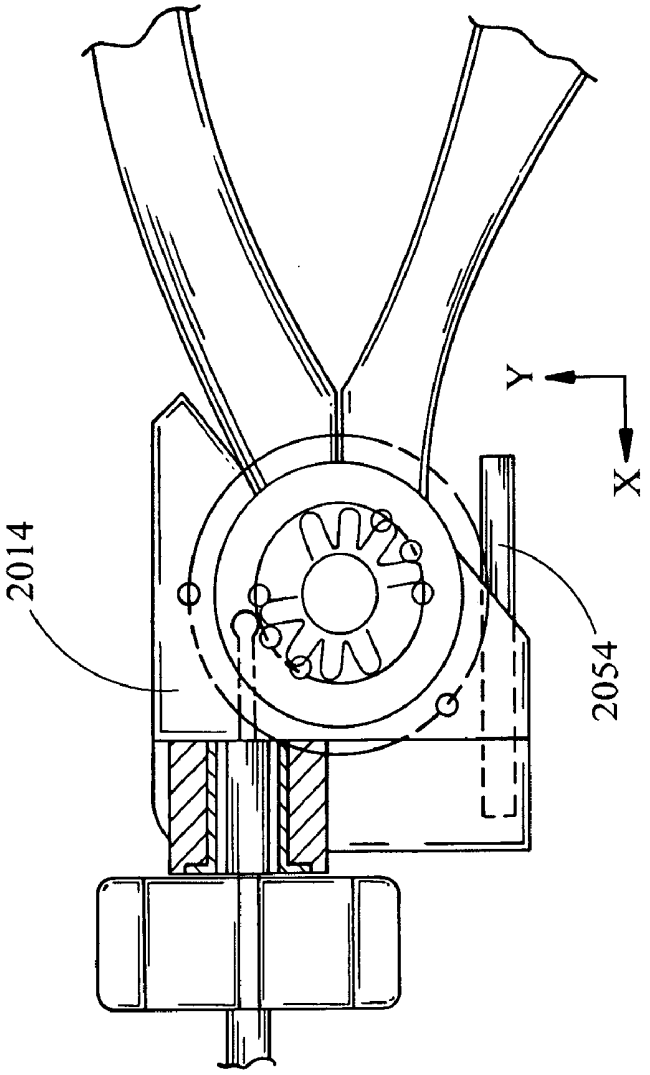

Fig. 20B

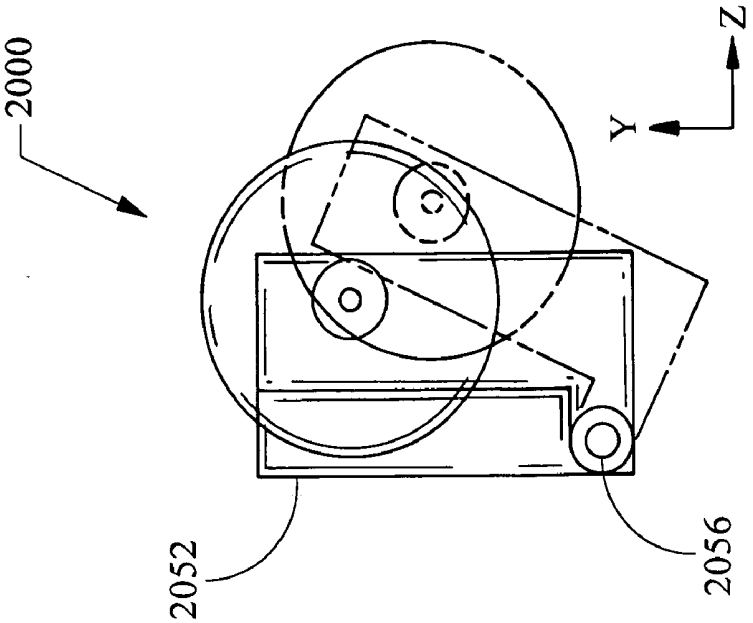

Fig. 20A

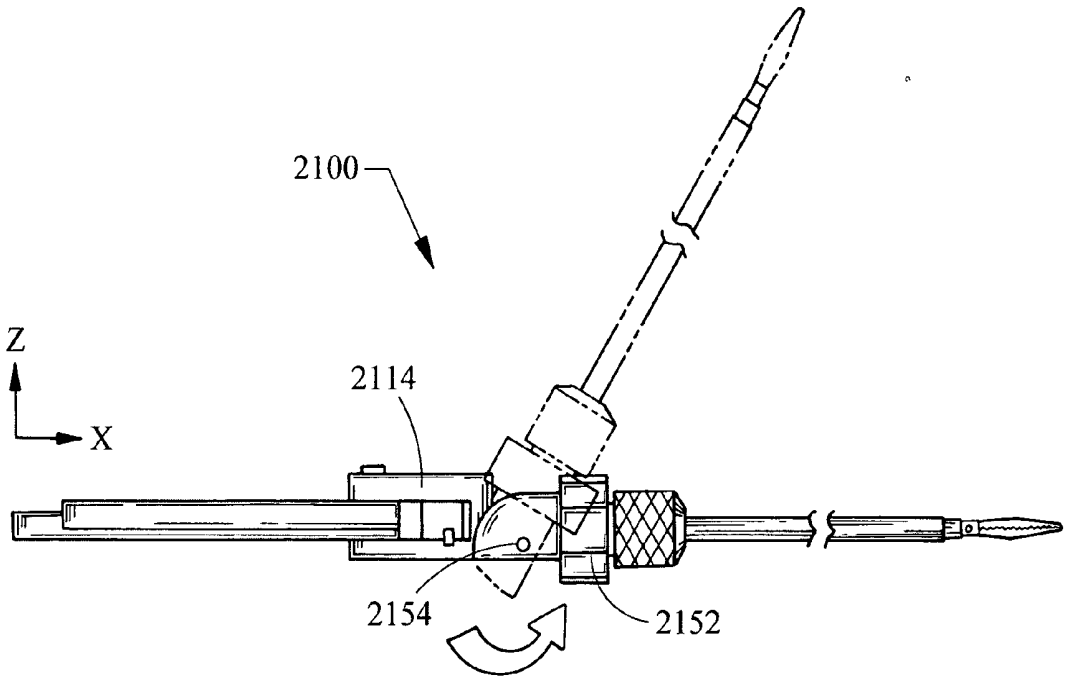

Fig. 21A

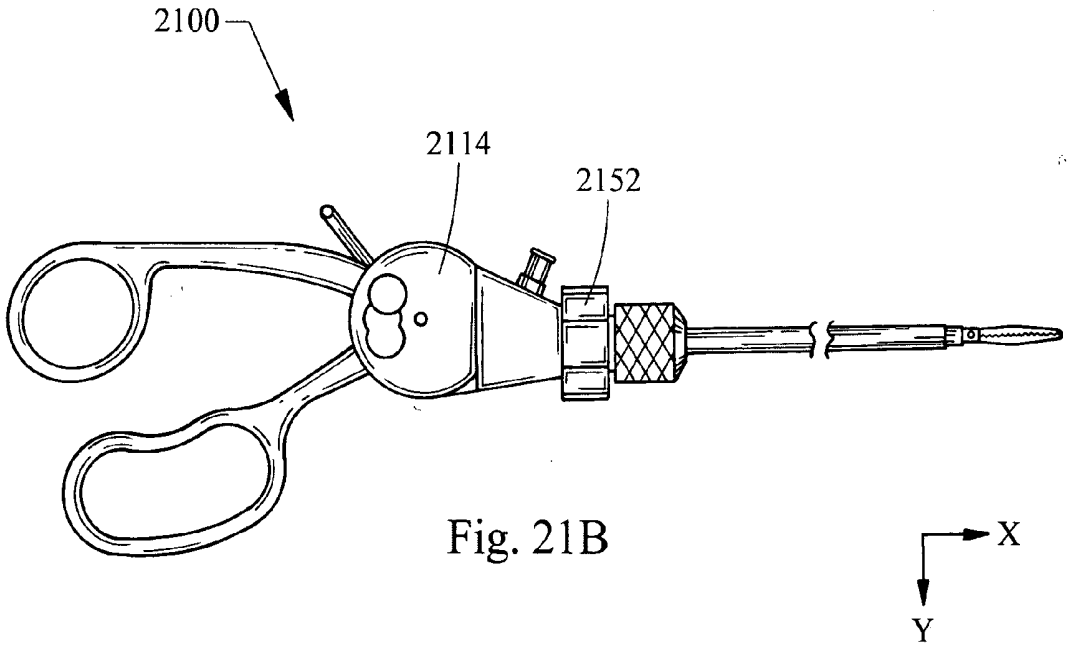

Fig. 21B

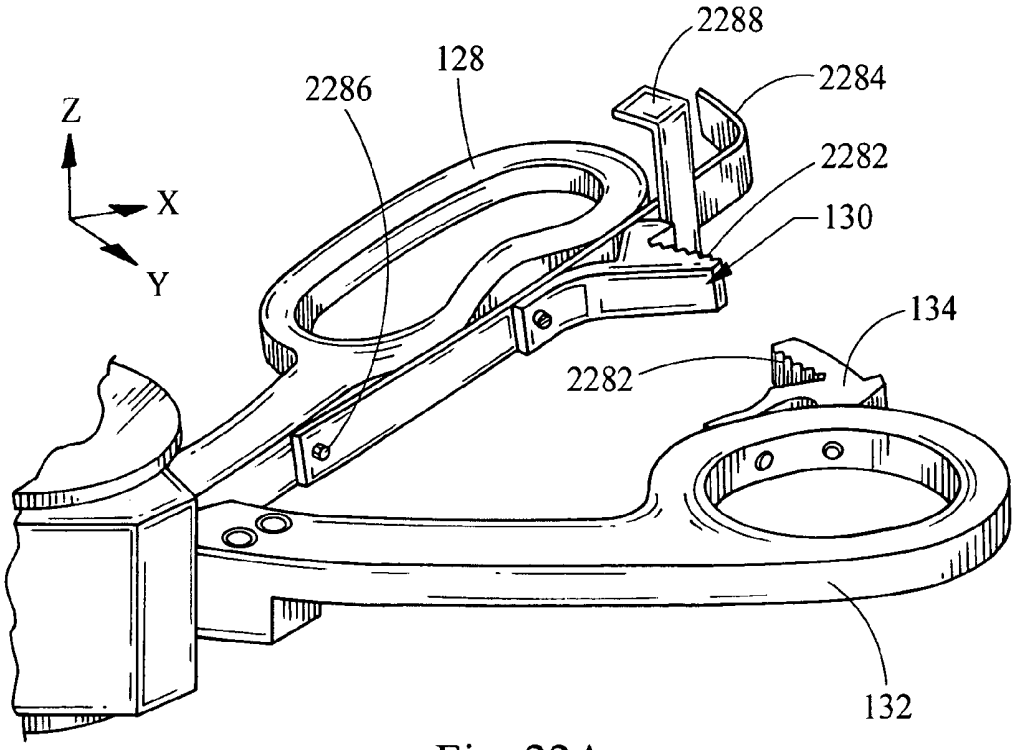

Fig. 22A

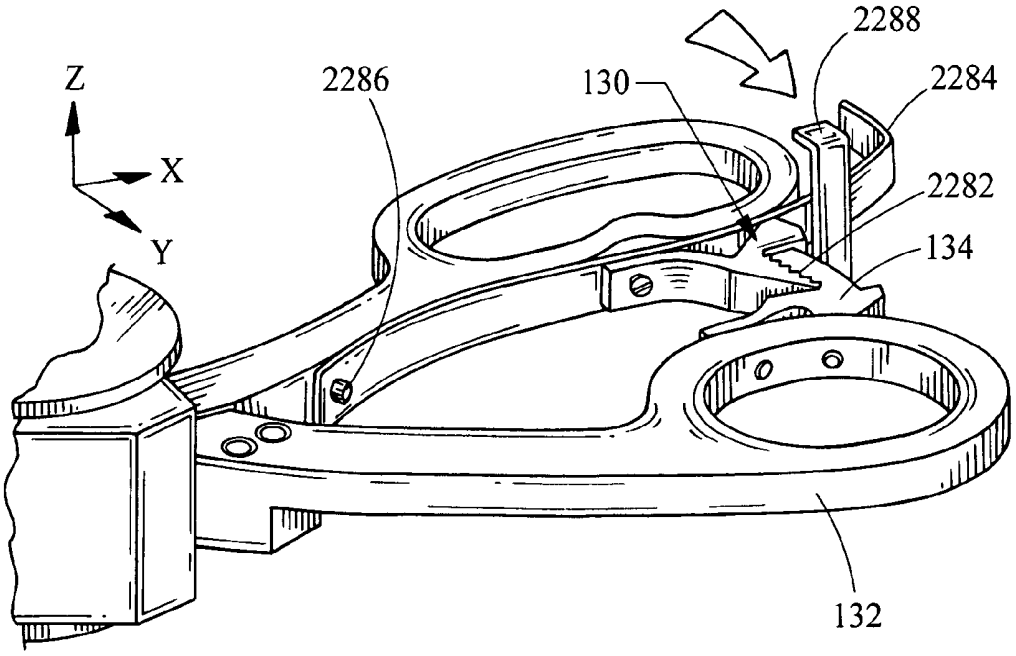

Fig. 22B

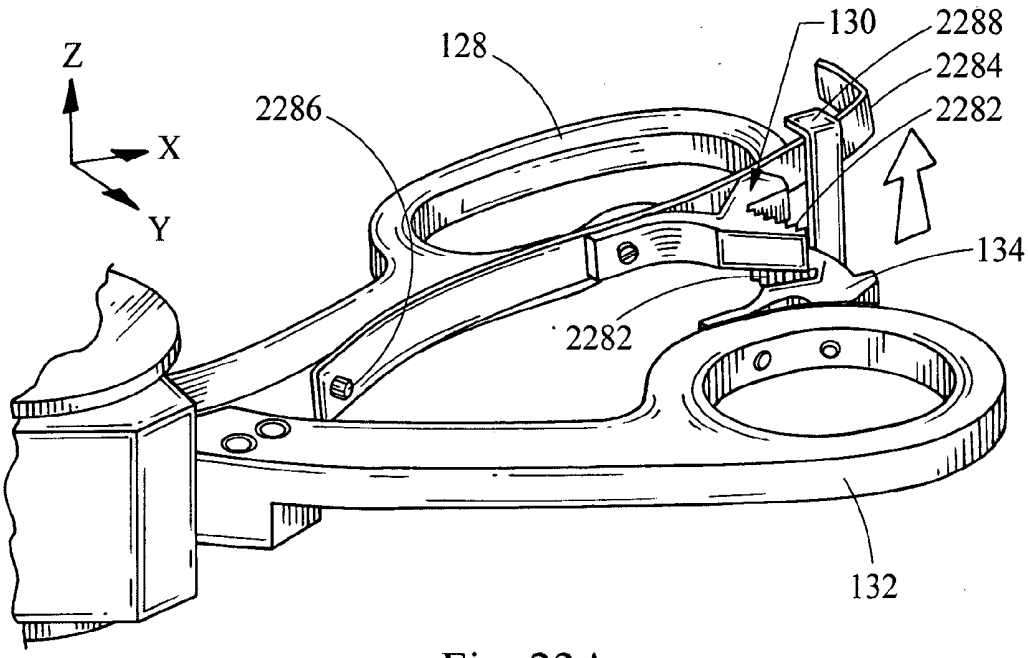

Fig. 23A

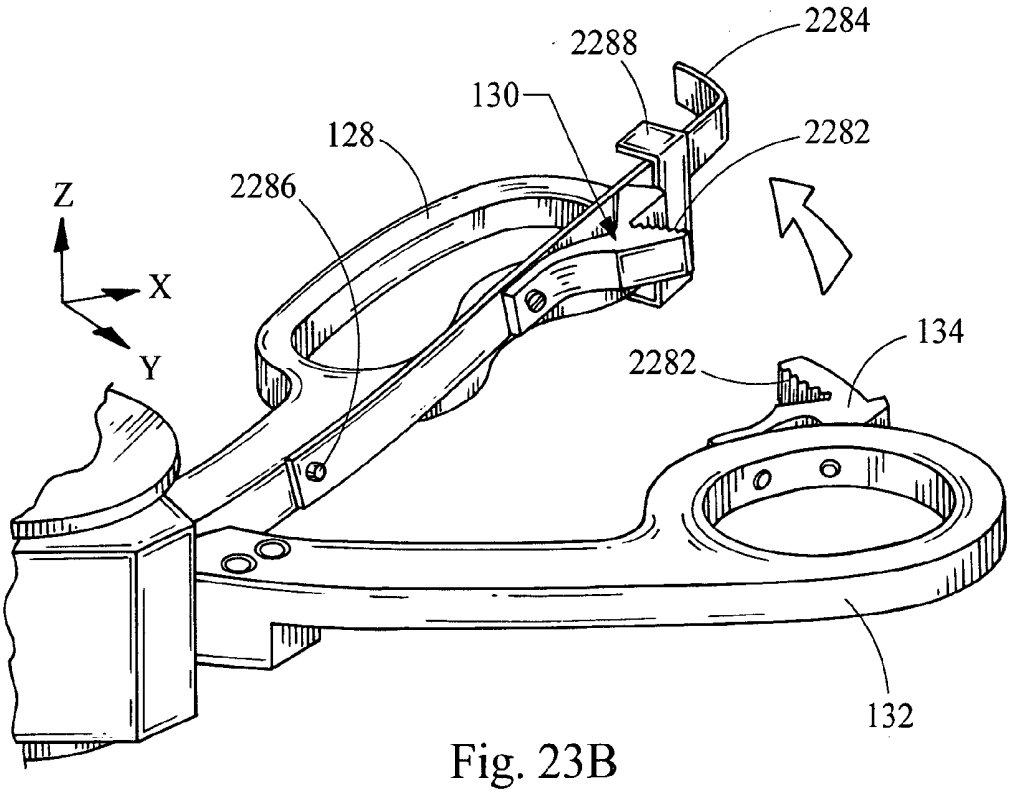

Fig. 23B

LAPAROSCOPIC SURGICAL INSTRUMENT FOR IN SITU TOOL EXCHANGE

RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application Ser. No. 60/690,968 filed Jun. 16, 2005, titled "Laparoscopic Tool Coupler," and U.S. Provisional Patent Application Ser. No. 60/711,347 filed Aug. 25, 2005, titled "Laparoscope's Tool With In Situ Tool Exchange," each of which is incorporated herein in its entirety.

FIELD OF THE INVENTION

[0002] The present invention relates generally to laparoscopic instruments and, more particularly, to a laparoscopic instrument for in situ tool exchange.

BACKGROUND OF THE INVENTION

[0003] Laparoscopic instruments are used during laparoscopy procedures, which are generally used to examine a patient and/or to perform minor surgery on the patient. For example, a laparoscopic instrument can be used to examine the patient's abdominal cavity for signs of disease or abnormality. In addition, fully invasive surgery may be avoided by using the laparoscopic instrument to perform relatively minor surgery. Similarly, in minimally invasive arthroscopic procedures, such as on a knee joint, an arthroscopic instrument is used to access joints or bones.

[0004] The laparoscopic (or arthroscopic) instrument generally includes a grasping end and an operating end that are connected by a flexible hollow cylindrical shaft. The laparoscopic instrument is introduced into the patient through a cannula/trocar unit. After the laparoscopic instrument is inserted into the patient through a cannula that is anchored to the body via a small incision, the surgeon may insert one of a plurality of laparoscopic tools into the laparoscopic instrument to perform a particular surgical procedure. For example, if a grasping procedure is required the surgeon will insert a grasping tool in the laparoscopic instrument. Similarly, if a cutting procedure is required the surgeon will insert a cutting tool in the laparoscopic instrument.

[0005] One problem associated with current laparoscopic instruments is that they may cause the surgeon to lose his or her "feel" when changing laparoscopic tools. During surgery, the surgeon develops a particular "feel" associated with the location and positioning of the laparoscopic instrument relative to the patient's internal cavities. Because the surgeon may be required to perform several procedures during a single surgery, each procedure requiring a different laparoscopic tool, the surgeon may lose the "feel" when changing the laparoscopic tools.

[0006] In one exemplary scenario, the surgeon uses an examination tool to find the best location for performing a cutting procedure. After finding the best location, the surgeon retrieves the laparoscopic instrument from within the patient, replaces the examination tool with a cutting tool, and reinserts the laparoscopic instrument inside the patient. It can be time consuming and frustrating for the surgeon to locate, for a second time, the best location for performing the cutting procedure.

[0007] Another problem associated with current laparoscopic instruments is that they have a fixed grasping end and, therefore, limit the ability and/or comfort of the surgeon in attaining desired positions within the patient's body. Depending on the surgical procedure, the surgeon must often change the position of the laparoscopic instrument or contort his or her body position to reach various parts of a patient's internal cavity. For example, the surgeon will often attempt to achieve the best cutting position before performing a delicate cutting procedure by rotating and/or moving the grasping end of the laparoscopic tool at various uncomfortable and awkward positions. Because the grasping end of the laparoscopic instrument is fixed, the surgeon must perform the cutting procedure by grasping the laparoscopic tool at an uncomfortable or awkward position that decreases the likelihood of a successful surgical procedure, or must contort his or her body to access a hard-to-reach area of the patient's internal cavity.

[0008] Yet another problem associated with current laparoscopic instruments is that the surgeon must clasp the operating end together in order to hold a grasping tool in a closed position. Prolonged clasping results in hand fatigue and also undesirably ties up one of the surgeon's hands to perform other tasks. If the surgeon removes or relaxes his hand from the grasping end, then the grasping tool may lose its grip on the internal body structure it was grasping.

[0009] Thus, there is a need to provide a laparoscopic tool that allows the surgeon to retain the "feel" developed during a surgical procedure by changing laparoscopic tools without having to remove the laparoscopic instrument from within the patient's body. There is also a need for an adjustable grasping end for a laparoscopic or arthroscopic instrument for attaining desired and/or comfortable operating positions. There is yet another need for a laparoscopic or arthroscopic instrument that can lock a grasping tool in a fixed position without requiring manual clasping by the surgeon. The present invention fulfills these and other needs.

SUMMARY OF THE INVENTION

[0010] In an aspect of the present invention, a method is presented for replacing a tool of a laparoscopic instrument without removing the laparoscopic instrument from a body. The method includes rotating a housing portion of the laparoscopic instrument to expose an end of the tool to be removed, removing the tool from the laparoscopic instrument without removing the laparoscopic instrument from the body, and inserting a second tool into a sleeve of the laparoscopic instrument. The method may further include registering the exposed end of the tool in at least one of a ball-receiving slot and a ball-receiving hole of the housing portion when the housing assembly portion is in a locked position or pressing a locking lever to unlock the housing assembly from a locked position. The rotating may include rotating the housing portion about an axis of the laparoscopic instrument selected from a group consisting of an X-axis, a Y-axis, and a Z-axis. The X-axis is any axis lying in the 3-dimensional space occupied by the laparoscopic instrument. Alternately, the rotating may include rotating the housing assembly about a hinge of the laparoscopic instrument, the housing assembly being pivotably coupled to the hinge via a hinge pin. The method may further include grasping a pair of handles when rotating the housing assembly. The pair of handles is attached to the housing assembly. The method may still further include linearly displacing the

tool when the housing assembly is in a locked position to manipulate a tool device located at an opposing end of the tool.

[0011] In another aspect of the present invention, a laparoscopic instrument includes a housing assembly that includes a pair of handles and a hinge portion. The hinge portion is pivotally connected to the housing portion and includes a tool knob extension for insertion into an incision of a body. The knob extension includes an open end and an elongated hollow shaft (sleeve) for receiving a first tool for insertion into the sleeve through the open end. The hinge portion is pivotable between a closed position and an open position and is positioned in the open position with the knob extension remaining in the body when changing the first tool with a second tool. The housing assembly may include a drum assembly having at least two drums connected to respective ones of the pair of handles. The drums rotate independently of one another to permit movement of the handles relative to one another. The drums also rotate together in a fixed relationship about an axis passing through the center of the drums to permit rotation of the handles in a fixed relationship about the axis. The hinge in the closed position may rotate around an axis perpendicular to an axis of the knob extension to achieve the open position. Alternately, the hinge portion in the closed position may rotate around an axis parallel to an axis of the knob extension to achieve the open position. The hinge portion may further include a locking lever for locking the hinge portion in at least the locked position and the open position. The housing assembly may include a ball-receiving slot for receiving a ball end of any of the first tool and the second tool when the hinge portion is in the closed position.

[0012] In yet another aspect of the present invention, a method of replacing a tool of a laparoscopic instrument includes inserting a laparoscopic instrument into an incision of a body having a first tool and a pair of handles coupled to the first tool. A housing assembly of the laparoscopic instrument is rotated from a locked position to an open position to expose an end of the first tool. The first tool is removed and a second tool is inserted without removing the laparoscopic instrument from the body. The housing assembly is rotated from the open position to the locked position to couple the second tool to the handles of the laparoscopic instrument. The method may further pressing a locking lever to release the housing assembly from the locked position or pressing the locking lever to release the housing assembly from the open position. The method may further rotating one of the handles to cause a linear movement of a tool device of the first tool or the second tool. The method may still further include rotating the housing assembly about any axis of the laparoscopic instrument lying in the 3-dimensional space occupied by the laparoscopic instrument.

[0013] In still another aspect of the present invention, a method of exchanging tools in a surgical instrument includes inserting a first tool through an elongated sleeve of the surgical instrument, moving part of the surgical instrument to permit removal of the first tool from the elongated sleeve, removing the first tool from the elongated sleeve, and inserting a second tool into the elongated sleeve. The surgical instrument can be a laparoscopic instrument or an arthroscopic instrument. The method may further include inserting the surgical instrument together with its elongated sleeve through a cannula into the body. The moving may include rotating a housing assembly of the surgical instrument to expose an end of the first tool to be removed.

[0014] The above summary of the present invention is not intended to represent each embodiment, or every aspect, of the present invention. Additional features and benefits of the present invention are apparent from the detailed description, figures, and claims set forth below.

BRIEF DESCRIPTION OF THE FIGURES

[0015] **FIG. 1A** is an exploded perspective view showing a first portion of a laparoscopic instrument according to one embodiment of the present invention.

[0016] **FIG. 1A**l is a perspective bottom view of the tool drum shown in **FIG. 1A** according to an embodiment of the present invention.

[0017] **FIG. 1B** is an exploded perspective view showing a second portion to the laparoscopic instrument shown in **FIG. 1A**.

[0018] **FIG. 2** is an assembly perspective view of the laparoscopic instrument of **FIGS. 1A and 1B**.

[0019] **FIG. 3** is a front view of the laparoscopic instrument of **FIGS. 1A and 1B**.

[0020] **FIG. 4** is a top view of the laparoscopic instrument of **FIGS. 1A and 1B**.

[0021] **FIG. 5** is a back view of the laparoscopic instrument of **FIGS. 1A and 1B**.

[0022] **FIG. 6** is a bottom view of the laparoscopic instrument of **FIGS. 1A and 1B**.

[0023] **FIG. 7** is a left-side view of the laparoscopic instrument of **FIGS. 1A and 1B**, showing a tool end of the laparoscopic instrument.

[0024] **FIG. 8** is a right-side view of the laparoscopic instrument of **FIGS. 1A and 1B**, showing a handle-end of the laparoscopic instrument.

[0025] **FIG. 9** is an exploded perspective view showing a drum subassembly of the laparoscopic instrument of **FIGS. 1A and 1B**.

[0026] **FIG. 10** is an assembly perspective view showing interior details of the drum subassembly of **FIG. 9**.

[0027] **FIG. 11** is a planar cross-sectional view of the drum subassembly of **FIG. 9**.

[0028] **FIGS. 12A-12C** are perspective views of an assembly comprising a winged shaft and a handle drum according to three alternative embodiments of the present invention, respectively.

[0029] **FIG. 13** is a cross-sectional view representing the interaction between a winged shaft and a drum subassembly according to an embodiment of the present invention.

[0030] **FIG. 14** is a perspective cross-sectional view of the drum subassembly of **FIG. 9** showing a push-button in a fully depressed position and a pair of handles in a first position.

[0031] **FIG. 15** is a perspective cross-sectional view showing the push-button of **FIG. 14** in the fully depressed position and the pair of handles in a second position.

[0032] **FIG. 16** is a perspective cross-sectional view showing the push-button of **FIG. 14** in an un-depressed position and the pair of handles in the second position.

[0033] **FIG. 17** is a partial exploded perspective view showing a shotgun subassembly of the laparoscopic instrument of **FIGS. 1A and 1B** in an open breech position.

[0034] **FIG. 18** is a perspective view of the shotgun subassembly of **FIG. 17** in an open breech position exposing an insertion end of a laparoscopic tool.

[0035] **FIG. 19** is a perspective view of the shotgun subassembly of **FIG. 17** showing an assembled shotgun subassembly in an open breech position.

[0036] **FIG. 20A** is a representative diagrammatic front view showing an alternative embodiment of a shotgun subassembly rotating about an X-axis of a laparoscopic instrument.

[0037] **FIG. 20B** is a representative side view of **FIG. 20A**.

[0038] **FIG. 21A** is a representative top view showing another alternative embodiment of a shotgun subassembly rotating about a Y-axis of a laparoscopic instrument.

[0039] **FIG. 21B** is a representative front view of **FIG. 22A**.

[0040] **FIG. 22A** is a perspective view of a pair of handles of the laparoscopic instrument of **FIGS. 1A and 1B** in an open aligned position.

[0041] **FIG. 22B** is a perspective view of the pair of handles of **FIG. 22A** in a locked position.

[0042] **FIG. 23A** is a perspective view of the pair of handles of **FIG. 22A** in a closed offset position.

[0043] **FIG. 23B** is a perspective view of the pair of handles of **FIG. 22A** in an open offset position.

[0044] While the invention is susceptible to various modifications and alternative forms, specific embodiments are shown by way of example in the drawings and are described in detail herein. It should be understood, however, that the invention is not intended to be limited to the particular forms disclosed. Rather, the invention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE ILLUSTRATED EMBODIMENTS

[0045] Referring to **FIGS. 1A and 1B**, a general description of the parts associated with a laparoscopic instrument **100** is provided according to an embodiment of the present invention. A more detailed description of the parts and their associated movements is provided in subsequent drawings. The laparoscopic instrument **100** includes a push button **102** that has a generally cylindrical disk shape. The push button **102** is connected to a winged shaft **104** via a push-button screw **106**, which is inserted through a central hole of the push button **102**. The push button **102** is adjacent to a spring **108**, which includes one end that is in contact with the push button **102** and another end that is in contact with a tool cover **110**.

[0046] The tool cover **110** is a generally cylindrical plate that includes a central hole and a plurality of tapped periphery holes. The winged shaft **104** protrudes through the central hole of the tool cover **110** toward the push button **102**. Two connecting screws **112** connect the tool cover **110** to a housing **114**.

[0047] The housing **114** includes a drum receiving portion **116** for accommodating at least in part a tool drum **118**, a trigger drum **120**, and a fixing drum **122**, each of which is located adjacent to one another as shown. The housing **114** further includes a ball-receiving slot **115** for allowing pivoting movement of the housing **114**, as described in more detail below in reference to **FIGS. 17-19**.

[0048] Referring to **FIG. 1A**l, the tool drum **118** is illustrated as being generally cylindrical, having a central through-hole, which is cylindrically shaped, and including a plurality of slots through which the winged shaft **104** protrudes. Although the plurality of slots is shown having three slots, alternatively, any number of slots may be used. The slot height extends only through part of the tool drum **118** (i.e., the slots are not through-slots). For example, the slot height is half the height of the tool drum **118**. In alternative embodiments, the slot height extends through the entire tool drum **118**. In yet other alternative embodiments, the central hole can have any other three-dimensional shape, e.g., a partial toroid, for receiving the winged shaft **104** therethrough. As explained in more detail below, the slots of the tool drum **118** engage the winged shaft **104** for securing the tool drum **118** to the fixing drum **122** in any one of a plurality of positions.

[0049] A drum washer **124** and a plug **126** is located between the tool drum **118** and the housing **114**. The tool drum **118** includes a ball-receiving hole **127** along its periphery as shown.

[0050] The trigger drum **120** is generally cylindrical and is attached to a trigger handle **128** that includes a latching mechanism **130**. The trigger drum **120** is attached to the trigger handle **128** directly or through a mechanical linkage. The trigger drum **120** includes a central slotted hole having substantially the same shape and dimensions as the slotted hole of the tool drum **118** through which the winged shaft **104** protrudes. The fixing drum **122** is generally cylindrical and is attached to a fixing handle **132** that includes a locking part **134** for the latching mechanism **130**. The fixing drum **122** is attached to the fixing handle **132** directly or through a mechanical linkage. The fixing drum **122** includes a central slotted hole having substantially the same shape and dimensions as the slotted holes of the tool drum **118** and the trigger drum **120** through which the winged shaft **104** protrudes. The fixing drum **122** further includes a plurality of fixing holes **135** for securing the fixing drum **122** as described in more detail below.

[0051] The winged shaft **104** includes a generally cylindrical shaft **136** and a plurality of winglets **138**, which are arranged in two symmetrical pairs along the shaft **136**. The winglet end of the winged shaft **104** is attached to a locking plate **140** via a locking screw **142**. In alternate embodiments, the winglets **138** can be splines or parts thereof, keys, or pins.

[0052] A fixing cover **144** is located along the winged shaft **104**, between the locking plate **140** and the fixing drum

122. The fixing cover **144** includes a central slotted hole having substantially the same shape and dimensions as the slotted holes of the tool drum **118**, the trigger drum **120**, and the fixing drum **122** through which the winged shaft **104** protrudes. In addition, the fixing cover **144** includes a plurality of push-pin receiving holes through which corresponding push pins **146** are inserted. The push pins **146** protrude through the locking plate **140**, the fixing cover **144**, and the fixing holes **135** to secure the fixing drum **122** to the locking plate **140**.

[0053] The locking plate **140** includes a recessed groove **148** for receiving the winged shaft **104** and a plurality of push-pin receiving holes through which corresponding push pins **146** are inserted. A locking washer **150** is inserted between the head of the locking screw **142** and the locking plate **140**.

[0054] Turning now to **FIG. 1B**, the housing **114** is pivotably connected to a hinge **152** via a hinge pin **154**, which is inserted through a plurality of hinge pivot holes **156**. The housing **114** is attached to the hinge **152** at a housing pivoting portion **157**, which is inserted in a hinge slotted area of the hinge **152**.

[0055] The hinge **152** includes a locking lever **158**, which is attached to the hinge **152** via a lever screw **160**. The locking lever **158** is inserted in a lever slot **159**, which is located at a bottom end of the hinge **152**. A lever spring **162** is positioned within the lever slot **159** for maintaining the locking lever **158** in a closed position. The locking lever **158** includes an actuating end **163** and a locking end **165**. The actuating end **163** is actuated by urging the locking lever **158** toward the lever spring **162** to unlock the hinge **152** from a closed position to an open position, as described in more detail below in reference to FIGS. **17-19**. When the locking lever **158** is pressed, it rotates around the axis of the lever screw **160** such that the locking end **165** causes the hinge **152** to pivot about the axis of the hinge pin **154** (the Z-axis).

[0056] A long bearing **164** and a short bearing **166** are used to rotatably attach a knob **168** to the hinge **152**. A plurality of set-screws **170** are screwed into the knob **168** for retaining the long bearing **165** and the short bearing **166** relative to the knob **168**.

[0057] A knob extension or sleeve **172** is attached to the knob **168** using a threaded end of the knob extension **172**. The knob extension **172** is a hollow shaft (or sleeve) that is used for accommodating a tool holder **174**, which is inserted into the hollow of the knob extension **172**. The tool holder **174** is a hollow shaft that accommodates a tool **176**, which includes a ball **178** at an insertion end and a scissors device **180** at an operating end. The tool **176** is inserted into the tool holder **174**, as shown. According to the shown embodiment, the scissors device **180** is a three-member claw device. The outer surface of the sleeve **172** may be composed of or coated with an insulating material, such as Teflon, to electrically insulate the operator of the instrument **100** from the sleeve **172** when using an electric tool such as a cauterizing tool. For example, the sleeve **172** is wrapped with a Teflon shrink tube.

[0058] **FIGS. 2-8** show various views of the laparoscopic instrument **100** in an assembled form and depict representative movements of the trigger handle **128**. The tool drum **118**, the trigger drum **120**, and the fixing drum **122** are assembled together with the housing **114**. The trigger handle **128** and the fixing handle **132** are shown in a locked position, which is described in more detail below. The housing **114** and the hinge **152** are shown in a closed position, and the ball **178** is received by the ball-receiving hole **127** of the tool drum **118**.

[0059] As represented by the phantom lines, the trigger handle **128** is rotated relative to the fixing handle **132** in a counter clock-wise direction (from the locked position) to open the scissors device **180** at the operating end of the tool **176**. In general, the rotation of the trigger handle **128** causes the rotation of the tool drum **118**, which in turn causes the linear movement of the tool **176**. The linear movement of the tool **176** causes an opening/closing movement for the scissors device **180**. The relationship between the three drums **118**, **120**, **122** (also referred to as the drum sandwich assembly) is described in more detail below.

[0060] In addition, as best seen in **FIG. 3**, the position of the shaft **136** (represented by the push-button screw **106**) can be aligned with the hinge pivot hole **156** or can be different than the position of the hinge pivot hole **156**. For example, the center of the shaft **136** can be at the same distance in the Y-axis direction from the X-axis of the tool **176** as the hinge pivot hole **156**. Alternatively, the distance between the center of the shaft **136** and the X-axis of the tool **176** can be smaller or greater than the distance between the hinge pivot hole **156** and the X-axis of the tool **176**.

[0061] An electrical probe **182** is protruding from and is attached to the housing **114**. The electrical probe **182** is electrically coupled to the tool **176** (such as a cauterizing tool) to supply electrical current from an external power supply. For example, electrical current is supplied via the electrical probe **182** to an electrocautery tool **176** for cauterizing organ tissue during a surgical procedure. Alternatively, a hole or plug is formed in the housing **114** for receiving an electrode therein.

[0062] Referring to **FIGS. 9-11**, the tool drum **118**, the trigger drum **120**, and the fixing drum **122** are sandwiched between the tool cover **110** (located at the top, adjacent to the tool drum **118**) and the fixing cover **144** (located at the bottom, adjacent to the fixing drum **122**). The push button **102** is located at the top of the drum sandwich assembly—near the tool cover **110**—and the locking plate **140** is located at the bottom of the drum sandwich assembly—near the fixing cover **144**. The shaft **136** protrudes through each of the fixing cover **144**, the fixing drum **122**, the trigger drum **120**, the tool drum **118**, and the tool cover **110**. The shaft **136** is attached via the locking screw **142** to the locking plate **140** and via the push-button screw **106** to the push button **102**. The shaft **136** also protrudes through the spring **108**.

[0063] The winglets **138** attached to the shaft **136** are adapted to protrude only through corresponding slots of the tool drum **118**, the trigger drum **120**, the fixing drum **122**, and the fixing cover **144**. Depending on whether the push button **102** is in a depressed or un-depressed position, the winglets **138** protrude through only some of the tool drum **118**, the trigger drum **120**, the fixing drum **122**, and the fixing cover **144**. Depending on the position of the winglets **138**, the rotatable movement of the trigger drum **120** is locked with respect to either the tool drum **118** or the fixing drum **122**.

[0064] The winglets **138** include a pair of top winglets **138***a* and a pair of bottom winglets **138***b*. As shown in **FIGS.**

10-11, the push button **102** is in an un-depressed position in which the top winglets **138***a* protrude through the tool drum **118** and the trigger drum **120**. In the un-depressed position, the rotatable movement of the trigger drum **120** is fixed with respect to the tool drum **118**. If the push button **102** is in a depressed position, the top winglets **138***a* rotate within the trigger drum **120** (where the bottom winglets **138***b* are located in the un-depressed position), and the bottom winglets **138***b* rotate within the fixing drum **122**. In the depressed position, the rotatable movement of the trigger drum **120** is fixed with respect to the fixing drum **122**. The novel arrangement according to the present invention allows the handles **128**, **132** to be rotated regardless of the position of the trigger drum **120** relative to the tool drum **118**. This aspect advantageously allows the surgeon to manipulate the handles **128**, **132** in any drum position. According to the present invention, instead of having to twist or contort the surgeon's body in order to access a hard-to-reach area of a patient's inner cavity, the surgeon simply rotates the drum to achieve a new position and can continue to manipulate the handles **128**, **132**, which control the tool **176** inside the patient's body. It is advantageous for the handles **128**, **132** to be manipulatable even as they are rotated together around the shaft **136**.

[**0065**] Referring to **FIGS. 12A-12C**, alternative embodiments of the winged shaft **136** of **FIGS. 1-11** are shown depicting three different winglet combinations. For ease of understanding, **FIG. 12B** shows the winged shaft **104** of **FIGS. 1-11**, including the shaft **136** and the two sets of winglets **138**. In an alternative embodiment, shown in **FIG. 12A**, a winged shaft **1204***a* includes a shaft **1236***a* and a single set of winglets **1238***a*. To accommodate the single set of winglets **1238***a*, the holes through which the winged shaft **1204***a* protrudes (e.g., slotted hole of a trigger drum **1220***a*) are modified to include a single slot **1239***a*. Each winglet in the set of winglets **1238***a* is spaced to lock at most any two drums together when rotated.

[**0066**] In another alternative embodiment, shown in **FIG. 12C**, a winged shaft **1204***c* includes a shaft **1236***c* and three sets of winglets **1238***c* approximately 120 degrees apart. To accommodate the three sets of winglets **1238***c*, the holes through which the winged shaft **1204***c* protrudes (e.g., slotted hole of a trigger drum **1220***c*) are modified to include three slots **1239***c*.

[**0067**] Referring to **FIG. 13**, a schematic cross-sectional representation illustrates the relationship between a winged shaft **1304** and a plurality of drums, a tool drum **1318**, a trigger drum **1320**, and a fixing drum **1322**, and various positions of the winged shaft **1304** relative to the drums **1318**, **1320**, **1322**. The winged shaft **1304** includes a shaft **1336** and a set of two winglets **1338**. From left to right, the drums include the tool drum **1318**, the trigger drum **1320**, and the fixing drum **1322**. The drums **1318**, **1320**, **1322** are housed within a housing **1314** such that each drum can rotate freely unless fixed in place by the winglets **1338**. The drums **1318**, **1320**, **1322** are fixed from rotational movement when the winglets **1338** protrude through corresponding drum slots. Movement of the winged shaft **1304** interlocks one or more of the drums **1318**, **1320**, **1322** with respect to each other to achieve a desired rotational combination. For example, as described below, movement of the winged shaft **1304** in any of a plurality of positions A-F achieves any desired rotational combination for the drums **1318**, **1320**, **1322**. As shown in **FIG. 13**, the winglet and drum combinations can be used to provide a sort of "binary logic" for mechanical devices, such as gears and clutches. The versatility of using the winglets and the drums in accordance with the present invention allows any combination of drum movements to be realized. The concepts of **FIG. 13** and related embodiments can be implemented in any mechanical system, including laparoscopic instruments. The present invention expressly contemplates that the lock-and-release embodiments shown and described herein is not limited to laparoscopic instruments.

[**0068**] At position A, the winglets **1338** are positioned to the right of the fixing drum **1322**. In this position, each of the drums **1318**, **1320**, **1322** is free to rotate with respect to each other.

[**0069**] At position B, the winged shaft **1304** is moved toward the drums **1318**, **1320**, **1322** such that the winglets **1338** are positioned within the fixing drum **1322** only. Accordingly, in this position the fixing drum **1322** is fixed from rotational movement, while the tool drum **1318** and the trigger drum **1320** are free to rotate.

[**0070**] At position C, the winged shaft **1304** is moved further toward the drums **1318**, **1320**, **1322** such that the winglets **1338** are positioned within both the trigger drum **1320** and the fixing drum **1322**. Accordingly, in this position the trigger drum **1320** and the fixing drum **1322** are fixed from rotational movement, while the tool drum **1318** is free to rotate.

[**0071**] At position D, the winged shaft **1304** is moved further toward the drums **1318**, **1320**, **1322** such that the winglets **1338** are positioned within all three drums. Accordingly, in this position each of the drums **1318**, **1320**, **1322** is fixed from rotational movement.

[**0072**] At position E, the winged shaft **1304** is moved further toward the drums **1318**, **1320**, **1322** such that the winglets **1338** are positioned within the tool drum **1318** and the trigger drum **1320**. Accordingly, in this position the tool drum **1318** and the trigger drum **1320** are fixed from rotational movement, while the fixing drum **1322** is free to rotate.

[**0073**] At position F, the winged shaft **1304** is moved further toward the drums **1318**, **1320**, **1322** such that the winglets **1338** are positioned within the tool drum **1318** only. Accordingly, in this position the tool drum **1318** is fixed from rotational movement, while the trigger drum **1320** and the fixing drum **1322** are free to rotate.

[**0074**] Referring to **FIGS. 14-16**, a cut-away perspective view of the drums **118**, **120**, **122** is shown revealing the winged shaft **104** in various positions together with the winglets **138**. With reference to these figures, the movement of the winged shaft **104** and of the handles **128**, **132** will now be described in more detail. In **FIG. 14**, the push button **102** is shown in a depressed position, and the handles **128**, **132** are shown in a first position. Depressing the push button **102** causes the winged shaft **104** to slide in a direction away from the movement of the push button **102** until the top winglets **138***a* are located within the trigger drum **120** and the bottom winglets **138***b* are located within the fixing drum **122**. In this configuration, the trigger drum **120** and the fixing drum **122** are fixed or locked together, which in turn locks the handles **128**, **132** together. In addition, the locking plate **140** and the

push pins **146** are correspondingly urged away from the fixing drum **122**, which is now disengaged from the locking plate **140** and the push pins **146**.

[**0075**] Accordingly, in the depressed position the trigger drum **120** and the fixing drum **122** are locked with respect to each other. Further, because the fixing drum **122** is now disengaged from the locking plate **140** and the push pins **146**, the combination of the trigger drum **120** and the fixing drum **122** is free to rotate around the Z-axis (the axis of the winged shaft **104**).

[**0076**] In **FIG. 15**, the push button **102** remains in the depressed position. However, the handles **128**, **132** have been rotated counter clock-wise from the first position to a second position. Thus, the only two components that change their position from the first position to the second position are the trigger handle **128** and the fixing handle **132**. For example, the position of the tool drum **118** remains unchanged. By rotating the handles **128**, **132** to a new position, while maintaining the position of the tool drum **118**, a surgeon using the laparoscopic instrument **100** may be able to achieve a better grasping position for the handles **128**, **132** without changing the position of the tool **176** inside a patient and without contorting or twisting the surgeon's body to maintain a comfortable and firm grasp.

[**0077**] As can be seen in **FIGS. 1A and 9**, the fixing handle **132** is secured to the locking plate **140** by inserting the push pins **146** through the fixing holes **135**. Three pairs of fixing holes **135** are shown, and each fixing hole pair represents a different handle position (up to three different positions in the embodiment shown in **FIG. 1A**). When the push button **102** is depressed, the push pins **146** disengage the fixing holes **135**, allowing the fixing drum **122** to freely rotate. The force exerted by the spring **108** allows the surgeon to rotate the fixing drum **122** (and thereby the fixing handle **132**) until the push pins **146**"click" into alignment with a different set of fixing holes **135**. Although three pairs of fixing holes **135** are shown allowing the fixing handle **132** to be rotated among one of three different positions, fewer or additional fixing holes are contemplated in other embodiments to allow the fixing handle **132** to be rotated among a corresponding number of positions. For example, if four positions are desired, four pairs of fixing holes **135** are formed in the fixing drum **122** and spaced according to each desired position. Although two push pins **146** are shown in **FIG. 1A**, in other embodiments, a different number of push pins is used instead.

[**0078**] In **FIG. 16**, the push button **102** is shown in the un-depressed position to engage the fixing drum **122** to the locking plate **140** and the trigger drum **120** to the tool drum **118**. The winglets **138** are now located within the tool drum **118** and the trigger drum **120** to secure the tool drum **118** and the trigger drum **120** to each other. The push pins **146** engage the fixing drum **122**, fixing the handles **128**, **132** in a second position. When the tool drum **118** and the trigger drum **120** are fixed relative to each other, i.e., in the un-depressed position, the trigger handle **128** may be partially rotated. The rotation of the trigger handle **128** causes the rotation of the tool drum **118**, which in turn causes the linear movement of the tool **176**. The linear movement of the tool **176** allows the surgeon to use the operating end of the tool **176**. For example, a counter clock-wise movement of the trigger handle **128** causes the opening of the scissors device **180**, while a clock-wise movement of the trigger handle **128** causes the closing of the scissors device **180**.

[**0079**] Referring to **FIGS. 17-19**, there is shown a shotgun subassembly of the laparoscopic instrument **100** in an open "breech" position. The term "shotgun" subassembly refers to the resemblance of the laparoscopic instrument **100** to the breech of a shotgun, which allows the surgeon to replace the laparoscopic tool without removing the instrument **100** from the patient's body. While the instrument **100** is inserted into the patient's body, the shotgun subassembly can be opened and closed like a shotgun to expose one end of the tool for removal and reinsertion. The laparoscopic instrument **100** includes a hinge portion **1700** and a housing portion **1702**, which together form the shotgun subassembly having a "breech" that is pivotable about a hinge **152**. The hinge portion **1700** generally includes the hinge **152**, the tool **176**, and the scissors device **180**. The housing portion **1702** generally includes the housing **114**, the handles **128**, **132**, and the drums **118**, **120**, **122**. The pivoting of the hinge **152** with respect to the housing **114** of the laparoscopic instrument **100** is described in more detail in connection with **FIGS. 18 and 19**. In **FIG. 17**, the hinge **152** is assembled to the housing pivoting portion **157** using the hinge pin **154**. The housing **114** pivots about the hinge pin **154** in the Z-axis to provide the opening and/or closing movement of the housing portion **1702** with respect to the hinge portion **1700**.

[**0080**] In **FIGS. 18 and 19**, the hinge portion **1700** is shown in an open position, having been pivoted in a counter clock-wise direction about the Z-axis from the closed position. As the hinge portion **1700** is urged toward the open position, the ball **178**—along with the tool **176**—is retracted from the ball-receiving hole **127** of the tool drum **118**. To open the hinge portion **1700**, the locking lever **158** is pressed in a direction toward the tool **176** (as described earlier in reference to **FIG. 1B**) such that the locking end **165** (shown in **FIG. 1B**) releases the housing pivoting portion **157**. As the hinge portion **1700** is urged toward the open position, the ball **178** passes through the ball-receiving slot **115** formed in the housing **114** until the ball **178** exits the ball-receiving slot **115**. After moving the hinge portion **1700** into the open position, the surgeon can remove the tool **176** from within the hinge portion **1700** and replace it with another laparoscopic tool without removing any other part of the instrument **100** from the patient's body. Thus, during the tool replacement, the knob extension or sleeve **172** remains inside the patient in a fixed position. In other words, in contrast to prior art laparoscopic instruments, the surgeon is not required to remove the instrument **100** from within the patient in order to replace the tool **176** with another tool. Maintaining the instrument **100** inside the patient while exchanging tools advantageously eliminates the need for the surgeon to search for and find a previously located body part or position.

[**0081**] The location of the ball-receiving hole **127** is found by drawing a circle about the hinge pin **154**, whose radius extends to the end of the ball **178** (when the tool **176** is fully inserted into the knob extension **172**). Where the circle intersects the tool drum **118** is where the manufacturer should form the ball-receiving hole **127**.

[**0082**] In an alternate embodiment, instead of adapting the hinge portion **1700** to swing open, the hinge portion **1700** is adapted to slide open. For example, instead of having the

housing **114** rotatable with respect to the hinge **152**, the housing **114** slides open with respect to the hinge **152** in, for example, a direction of the Z-axis, to allow the removal and/or insertion of the tool **176**.

[**0083**] Referring to **FIGS. 20A and 20B**, an alternative embodiment of the present invention shows a laparoscopic instrument **2000** that includes a housing **2014** and a hinge **2052**. The hinge **2052** pivots around an X-axis of the laparoscopic instrument **2000**. Specifically, the hinge **2052** pivots around a hinge pin **2052**, which is inserted through a hinge pivot hole **2056**, with respect to the housing **2014**.

[**0084**] Referring to **FIGS. 21A and 21B**, an alternative embodiment of the present invention shows a laparoscopic instrument **2100** that includes a housing **2114** and a hinge **2152**. The hinge **2152** pivots around a Y-axis of the laparoscopic instrument **2100**. Specifically, the hinge **2152** pivots around a hinge pin **2152** with respect to the housing **2114**. Slots in the housing **2014** and **2114**, respectively, and respective drums will enable the exposed part of each respective shaft and ball to travel into each respective drum.

[**0085**] Referring to **FIGS. 22A-23B**, the locking of the trigger handle **128** with respect to the fixing handle **132** will be described in more detail. In **FIG. 22A**, the handles **128**, **132** are in an open and aligned position relative to one another. In the open position there is no contact between the latching mechanism **130** of the trigger handle **128** and the locking part **134** of the fixing handle **132**. The latching mechanism **130** and the locking part **134** include a plurality of corresponding teeth **2282** that are biased so as to lock the handles **128**, **132** to each other, as described in more detail below in reference to **FIG. 22B**.

[**0086**] The trigger handle **128** further includes a latching lever **2284**, which is pivotally connected to the trigger handle **128** at a pivoting point **2286**, and a lever limiter **2288**. The lever limiter **2288** limits the rotational movement of the latching lever **2284** to a distance that is sufficient for disengaging engaged ones of the teeth **2282**. A reason for limiting the rotational movement of the latching lever **2284** is to prevent the latching lever **2284** from interfering with the operation of the laparoscopic instrument **100**. The latching mechanism **130** is mounted on the latching lever **2284** such that the latching mechanism **130** moves whenever the latching lever **2284** is moved. The aligned position shows the latching lever **2284** parallel to the fixing handle **132** in the X-Y plane.

[**0087**] In **FIG. 22B**, the handles **128**, **132** are shown in a locked position, and the handles **128**, **132** are correspondingly in a closed and aligned position. The latching mechanism **130** and the locking part **134** are interlocked via the plurality of corresponding teeth **2282**, which are included in each of the latching mechanism **130** and the locking part **134**. To lock the handles **128**, **132**, at least one of the handles **128**, **132** is rotated around the Z-axis toward the other one of the handles **128**, **132**. For example, the trigger handle **128** is rotated in a clockwise direction toward the fixing handle **132**. Corresponding ones of the teeth **2282** are engaged via frictional forces to prevent movement of the handles **128**, **132** toward an open position. The teeth **2282** are biased to encourage movement of the handles **128**, **132** toward one another but to resist movement of the handles **128**, **132** away from one another. The ability to lock the handles **128**, **132** during surgery advantageously frees the surgeon's hand to carry out other tasks, while leaving the instrument **100** inside the patient's body. It further permits the surgeon to relax the hand gripping the instrument **100** to minimize hand fatigue that can be caused by prolonged grasping and manipulation of the handles **128**, **132**. Still further, without locking handles, if the surgeon's hand that is grasping the handles **128**, **132** were to momentarily relax or lose its grip, the tool **176** may slip or dislodge from a desired position inside the patient's body cavity. When the handles **128**, **132** are in the locked position, the tool **176** can be reliably maintained inside the patient. With the handles locked, the surgeon may also rotate them together in accordance with the present invention to a better position without disturbing the position of the tool **176** inside the body cavity.

[**0088**] In **FIG. 23A**, the handles **128**, **132** are shown in a closed and offset position. The handles **128**, **132** are fixed with respect to the Z-axis as the latching lever **2284** is urged in the Z-axis direction to unlock the latching mechanism **130** from the locking part **134**. When the latching mechanism **130** is moved in the Z-axis direction away from the locking part **134**, via movement of the latching lever **2284**, engaged ones of the teeth **2282** disengage, causing the trigger handle **128** to unlock from the fixing handle **132**.

[**0089**] In **FIG. 23B**, the handles **128**, **132** are shown in an open and offset position. After the trigger handle **128** is moved in the Z-axis direction (as shown in **FIG. 23A**) away from the fixing handle **132**, the trigger handle **128** is rotated in a counter-clockwise direction around the Z-axis. To position the latching lever **2284** in the initial open and aligned position of **FIG. 22A**, the latching lever **2284** must be urged in the Z-axis direction toward the trigger handle **128** in order to position the latching lever **2284** in the same X-Y plane as the fixing handle **132**. Now, the trigger handle **128** is ready to be locked relative to the fixing handle **132**.

[**0090**] Preferably, the latching lever **2284** is positioned to be manipulatable by the surgeon with a single finger, such as with the pinky finger of the hand grasping the handles **128**, **132**. In this respect, the surgeon is not required to remove the hand from the handles **128**, **132** in order to lock or unlock them. In operation, the surgeon simply moves the latching lever **2284** with the pinky finger, which is typically not positioned within the handle **128** as are the ring and middle fingers.

[**0091**] At least some of the parts described above in reference to **FIGS. 1A-23B** are injection-molded parts, which are precision molded with hot-oil or water molds using high-strength, graphite-, glass-, or carbon-filled plastics such as PEEK™ (polyetheretherketone), Ultem® (polyetherimide), Grivory®, or RADEL® R (polyphenylsulfone). The injection-molded parts include single cavity molds and family molds. For example, some of the molded parts can be cold runner molds.

[**0092**] Although the foregoing embodiments have been described in connection with a laparoscopic instrument **100**, the present invention is equally applicable to an arthroscopic instrument.

[**0093**] While the invention is susceptible to various modifications and alternative forms, specific embodiments thereof have been shown by way of example in the drawings and herein described in detail. It should be understood, however, that it is not intended to limit the invention to the

particular forms disclosed, but on the contrary, the intention is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

What is claimed is:

1. A method of replacing a tool from a sleeve of a laparoscopic instrument without removing the sleeve from a body, comprising:

rotating a housing assembly of the laparoscopic instrument to expose an end of the tool to be removed;

removing the tool from the sleeve of the laparoscopic instrument without removing the sleeve from the body; and

inserting a second tool into the laparoscopic instrument.

2. The method of claim 1, further comprising registering the exposed end of the tool in at least one of a ball-receiving slot and a ball-receiving hole of the housing portion when the housing assembly portion is in a locked position.

3. The method of claim 2, wherein the ball-receiving slot is included in a housing of the housing assembly.

4. The method of claim 2, wherein the ball-receiving hole is included in a drum of the housing assembly.

5. The method of claim 1, pressing a locking lever to unlock the housing assembly from a locked position.

6. The method of claim 1, wherein the rotating includes rotating the housing portion about an axis of the laparoscopic instrument selected from a group consisting of an X-axis, a Y-axis, and a Z-axis, wherein the X-axis is any axis lying in the 3-dimensional space occupied by the laparoscopic instrument.

7. The method of claim 1, wherein the rotating includes rotating the housing assembly about a hinge of the laparoscopic instrument, the housing assembly being pivotably coupled to the hinge via a hinge pin.

8. The method of claim 1, further comprising grasping a pair of handles when rotating the housing assembly, the pair of handles being attached to the housing assembly.

9. The method of claim 1, further comprising linearly displacing the tool when the housing assembly is in a locked position to manipulate a tool device located at an opposing end of the tool.

10. A laparoscopic instrument comprising:

a housing assembly including a pair of handles; and

a hinge portion pivotally connected to the housing portion and including a tool knob extension for insertion into an incision of a body, the knob extension having an open end and an elongated hollow shaft for receiving a first tool for insertion into the hollow shaft through the open end, the hinge portion being pivotable between a closed position and an open position, the hinge portion being positioned in the open position with the knob extension remaining in the body when changing the first tool with a second tool.

11. The laparoscopic instrument of claim 10, wherein the housing assembly includes a drum assembly having at least two drums connected to respective ones of the pair of handles, the drums rotating independently of one another to permit movement of the handles relative to one another, the drums also rotating together in a fixed relationship about an axis passing through the center of the drums to permit rotation of the handles in a fixed relationship about the axis.

12. The laparoscopic instrument of claim 10, wherein the. hinge in the closed position rotates around an axis perpendicular to an axis of the knob extension to achieve the open position.

13. The laparoscopic instrument of claim 10, wherein the hinge portion in the closed position rotates around an axis parallel to an axis of the knob extension to achieve the open position.

14. The laparoscopic instrument of claim 10, wherein the hinge portion further includes a locking lever for locking the hinge portion in at least the locked position and the open position.

15. The laparoscopic instrument of claim 10, wherein the housing assembly includes a ball-receiving slot for receiving a ball end of any of the first tool and the second tool when the hinge portion is in the closed position.

16. A method of replacing a tool of a laparoscopic instrument, comprising:

inserting a laparoscopic instrument into an incision of a body, the laparoscopic instrument having a first tool and a pair of handles coupled to the first tool;

rotating a housing assembly of the laparoscopic instrument from a locked position to an open position to expose an end of the first tool;

removing the first tool from a sleeve of the laparoscopic instrument and inserting a second tool without removing the sleeve from the body; and

rotating the housing assembly from the open position to the locked position to couple the second tool to the handles of the laparoscopic instrument.

17. The method of claim 16, further comprising pressing a locking lever to release the housing assembly from the locked position.

18. The method of claim 16, further comprising pressing the locking lever to release the housing assembly from the open position.

19. The method of claim 16, further comprising rotating one of the handles to cause a linear movement of a tool device of the first tool or the second tool.

20. The method of claim 16, further comprising rotating the housing assembly about any axis of the laparoscopic instrument lying in the 3-dimensional space occupied by the laparoscopic instrument.

21. A method of exchanging tools in a surgical instrument, comprising:

inserting a first tool through an elongated sleeve of the surgical instrument;

moving part of the surgical instrument to permit removal of the first tool from the elongated sleeve;

removing the first tool from the elongated sleeve; and

inserting a second tool into the elongated sleeve.

22. The method of claim 21, wherein the surgical instrument is a laparoscopic instrument or an arthroscopic instrument.

23. The method of claim 21, further comprising inserting the surgical instrument together with its elongated sleeve through a cannula into the body.

24. The method of claim 21, wherein the moving includes rotating a housing assembly of the surgical instrument to expose an end of the first tool to be removed.

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专利名称(译)	腹腔镜手术器械用于原位工具交换		
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[标]申请(专利权)人(译)	培林ALFRED		
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摘要(译)

提出了一种用于通过腹腔镜器械的套管替换工具而无需从套体移除套管的方法。该方法包括旋转腹腔镜器械的壳体部分以暴露待移除的第一工具的端部，从套管移除第一工具，以及将第二工具插入套管中而不将其从主体移除。