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(54) **ARTICULATING SURGICAL STAPLING INSTRUMENT INCORPORATING A TWO-PIECE E-BEAM FIRING MECHANISM**

(71) Applicant: **Ethicon Endo-Surgery, LLC**, Guaynabo, PR (US)

(72) Inventors: **Frederick E. Shelton, IV**, Hillsboro, OH (US); **Michael E. Setser**, Burlington, KY (US); **Kevin R. Doll**, Mason, OH (US); **Jerome R. Morgan**, Cincinnati, OH (US)

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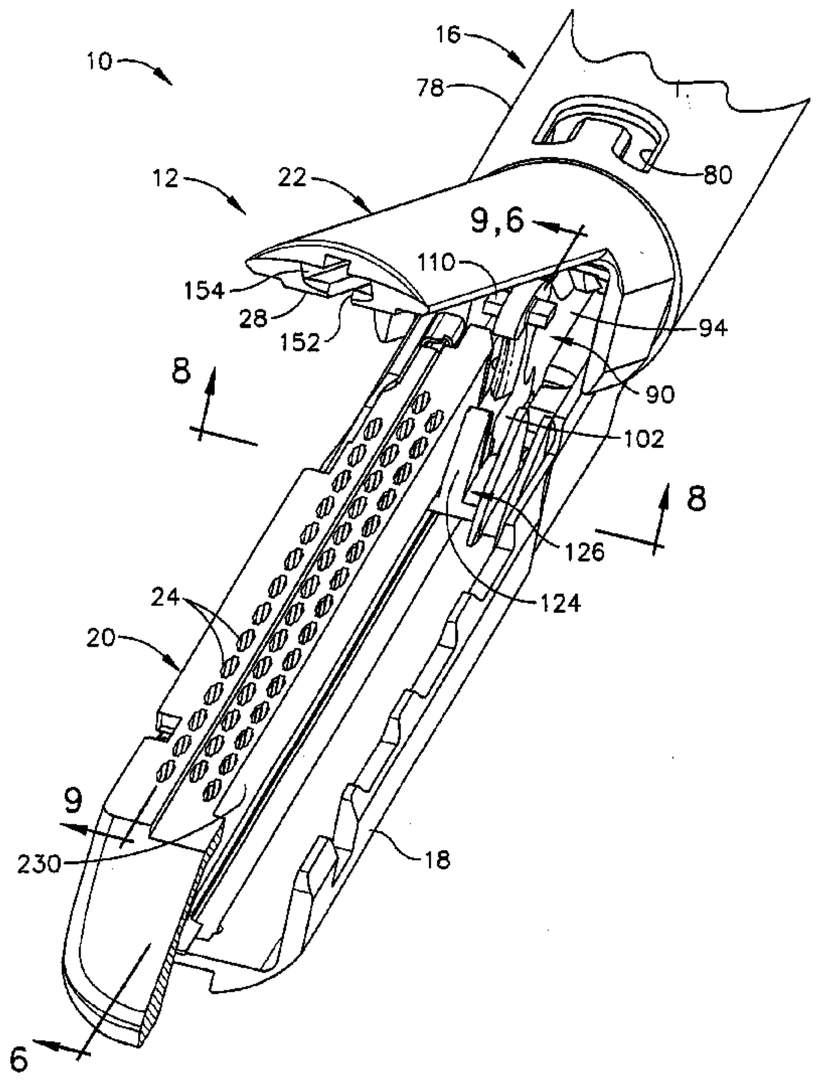
(57) **ABSTRACT**

A surgical severing and stapling instrument, suitable for laparoscopic and endoscopic clinical procedures, clamps tissue within an end effector of an elongate channel pivotally opposed by an anvil. An E-beam firing bar moves distally through the clamped end effector to sever tissue and to drive staples on each side of the cut. The E-beam firing bar affirmatively spaces the anvil from the elongate channel to assure properly formed closed staples, especially when an amount of tissue is clamped that is inadequate to space the end effector. In particular, an upper pin of the firing bar longitudinally moves through an anvil slot and a channel slot is captured between a lower cap and a middle pin of the firing bar to assure a minimum spacing. Forming the E-beam from a thickened distal portion and a thinned proximal strip enhances manufacturability and facilitates use in such articulating surgical instruments.



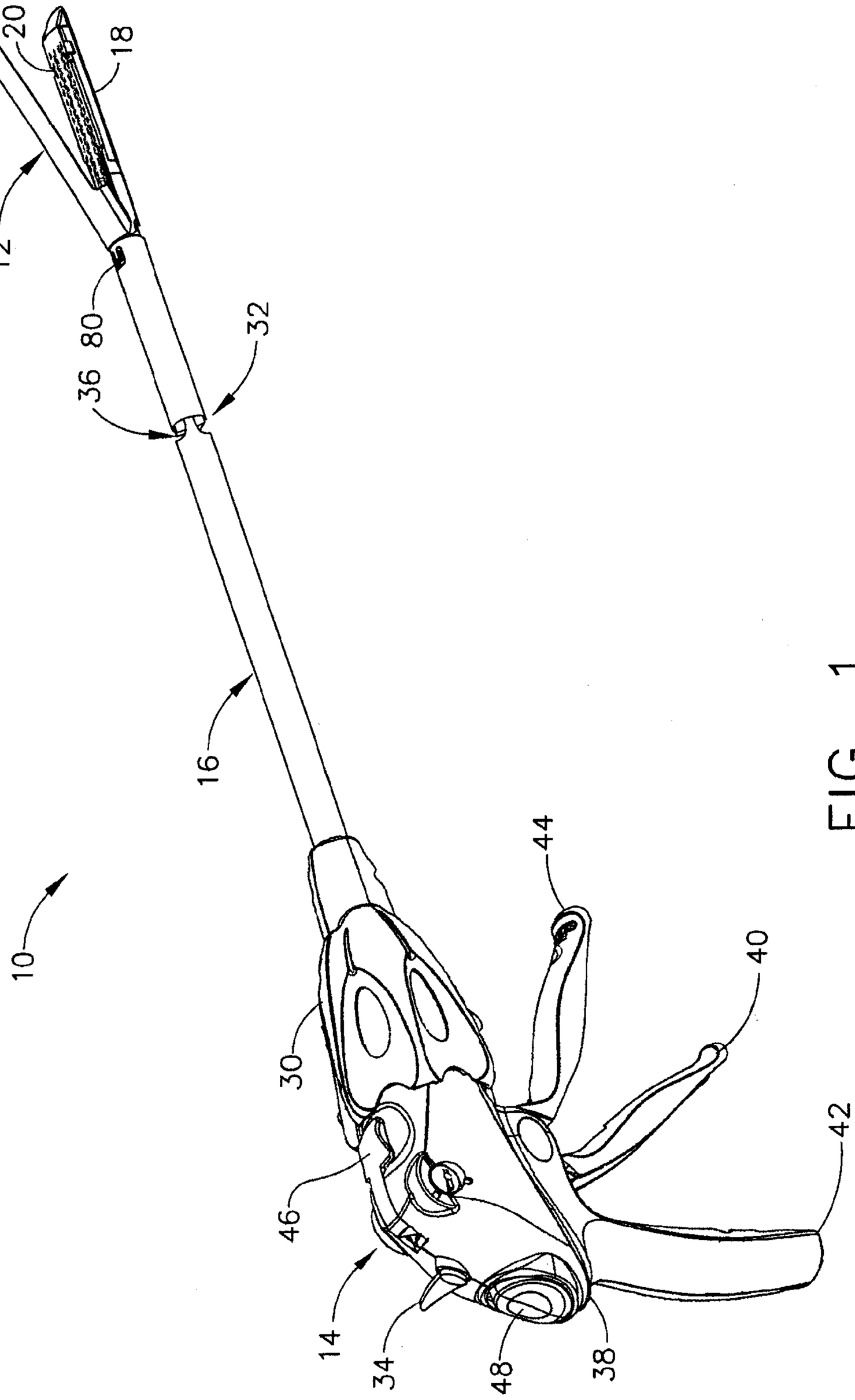


FIG. 1

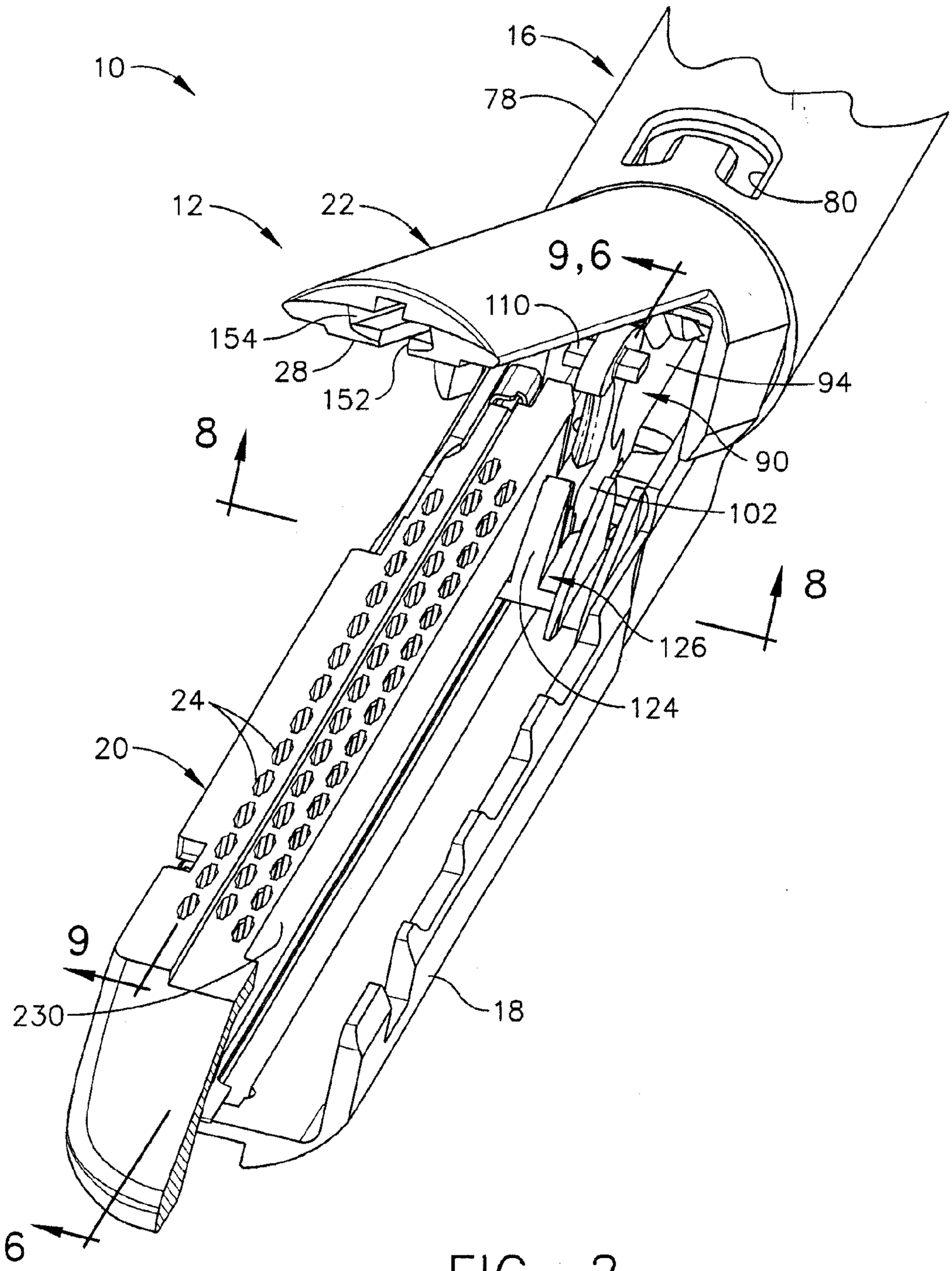

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FIG. 2

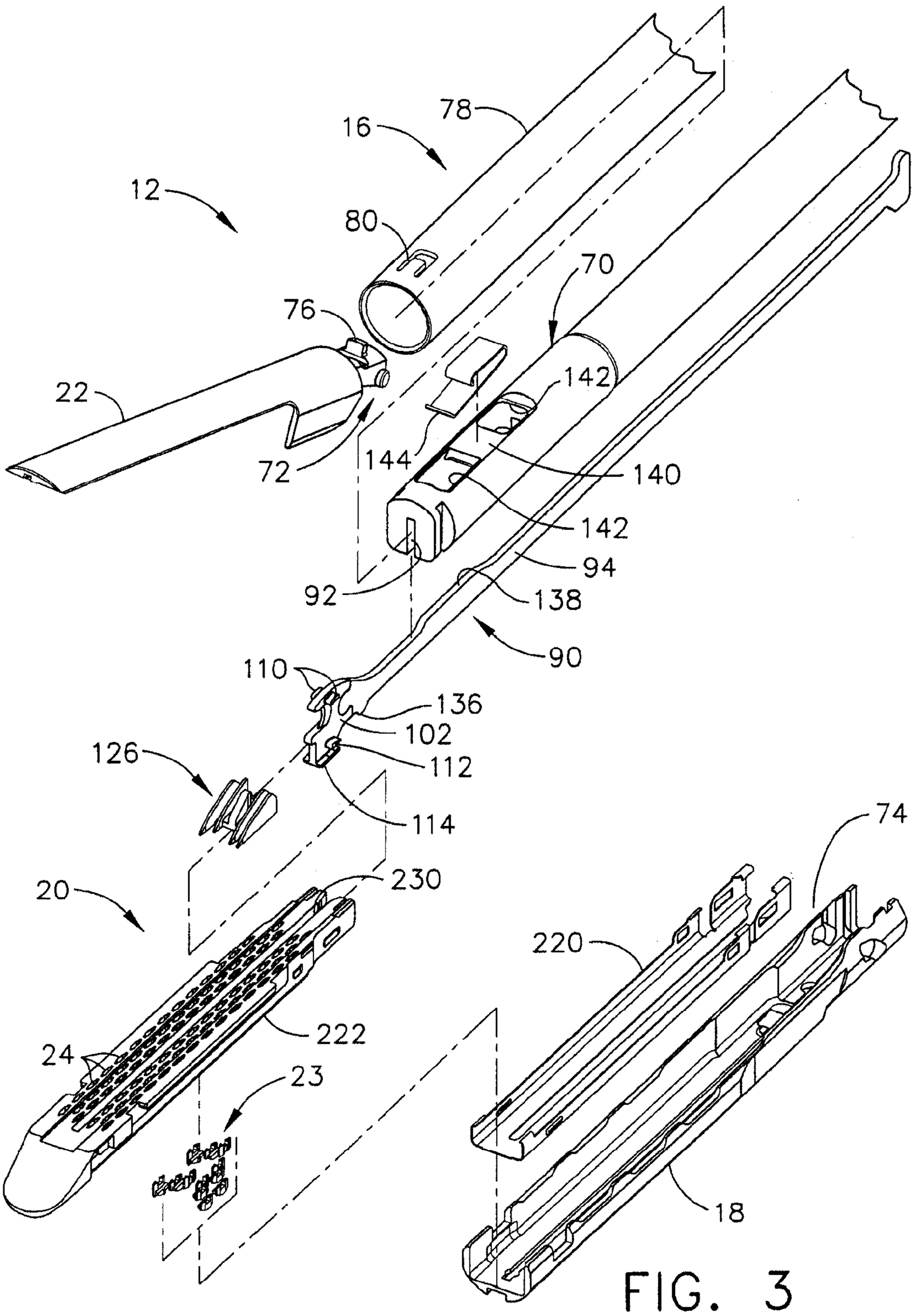
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FIG. 3

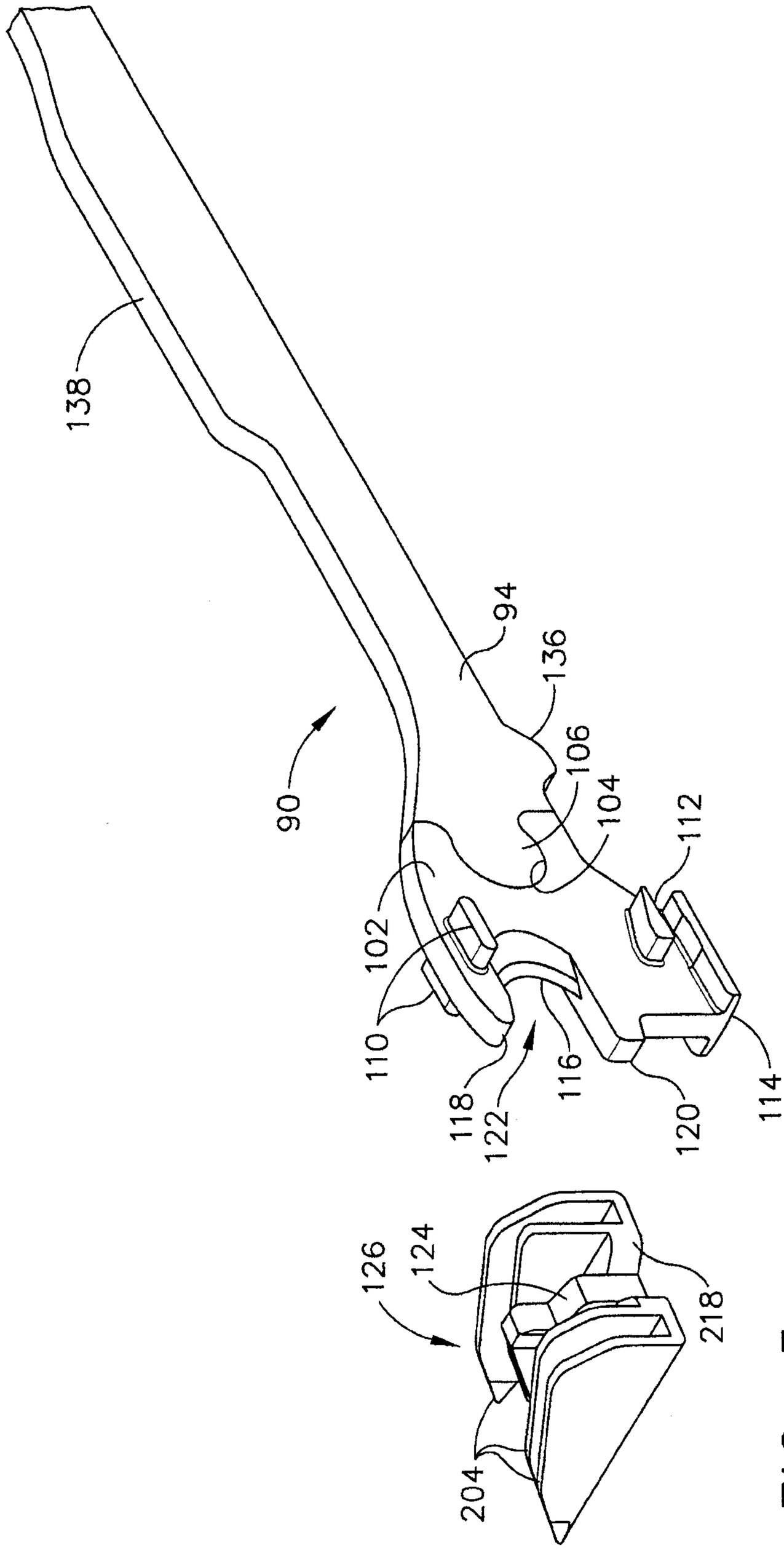
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FIG. 4

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FIG. 5

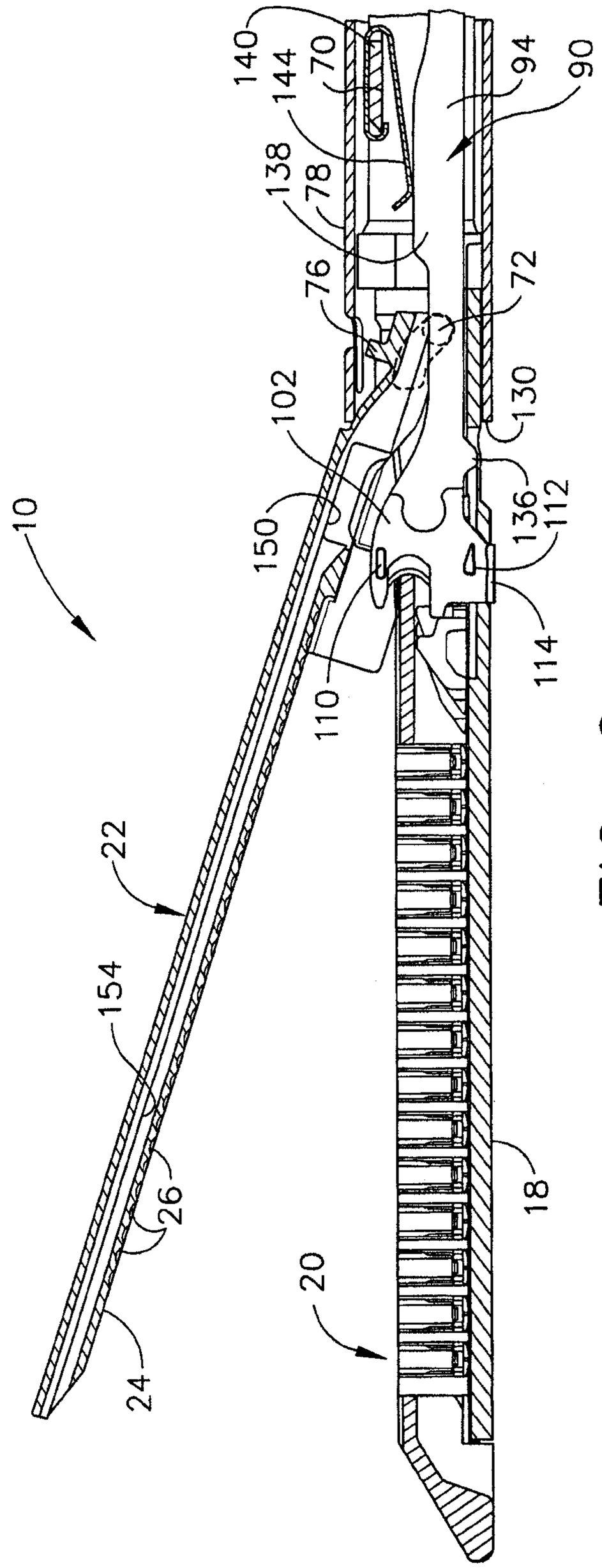
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FIG. 6

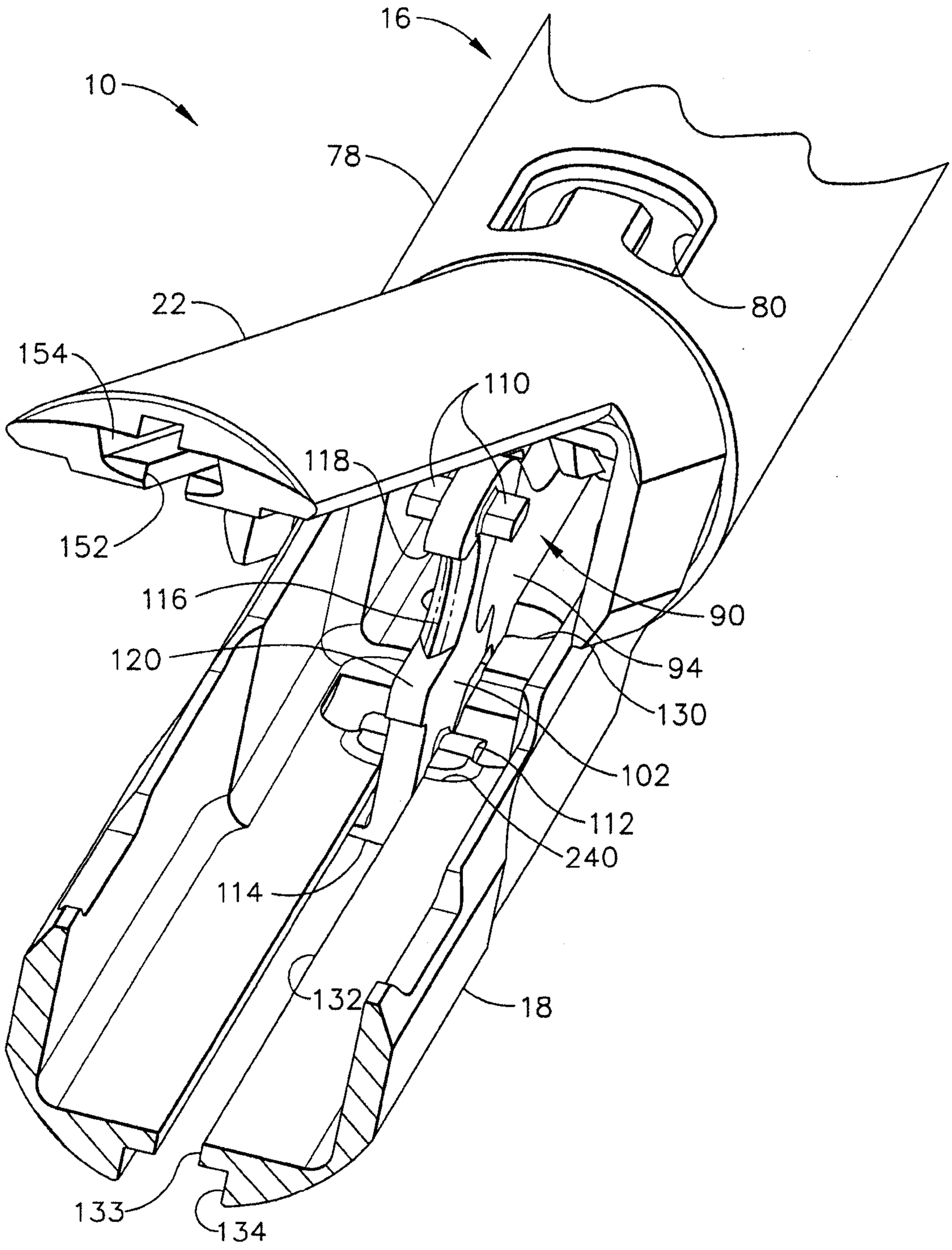
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FIG. 7

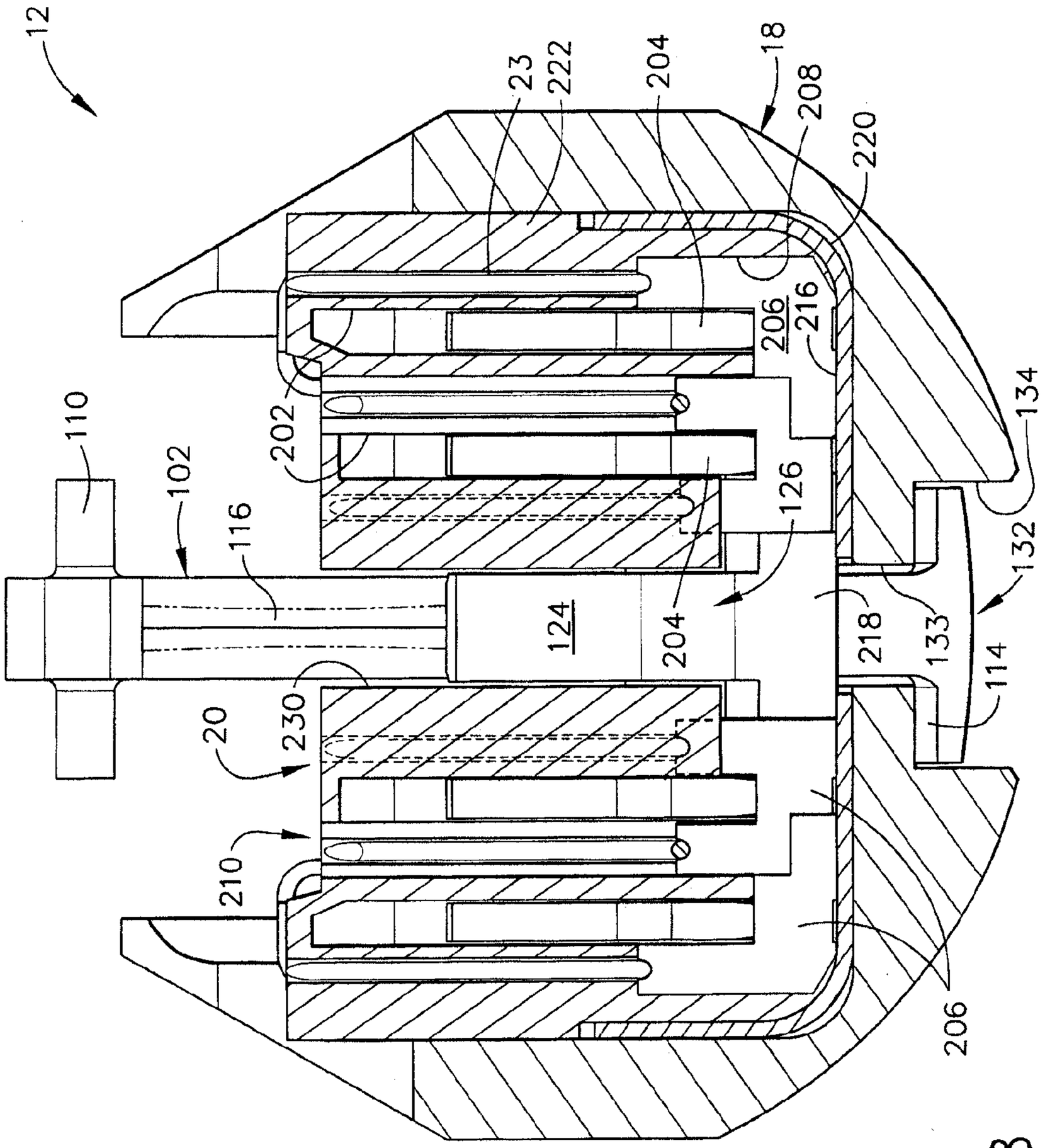
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FIG. 8

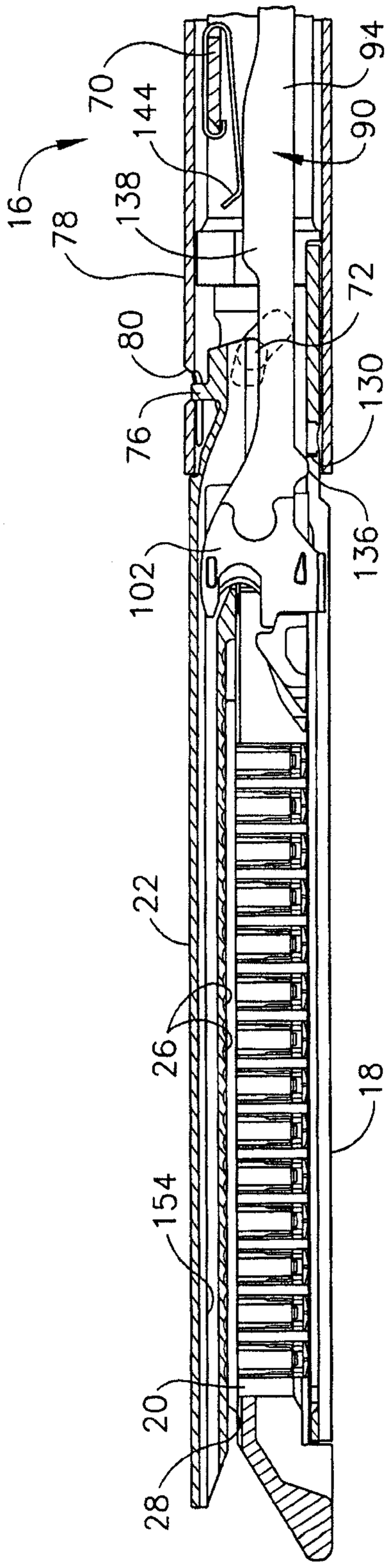
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FIG. 9

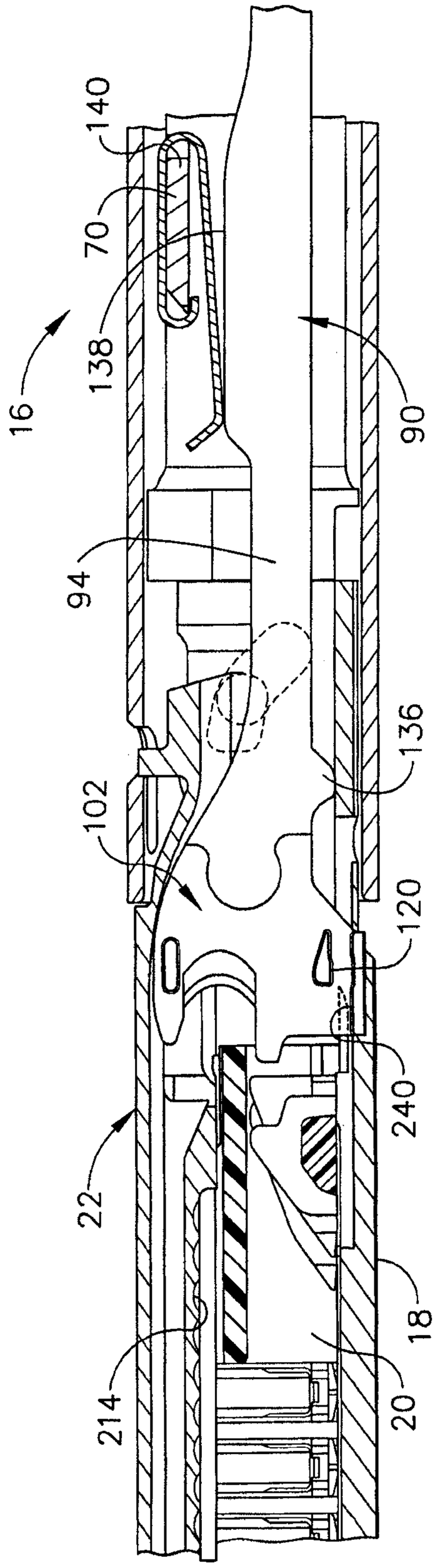
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FIG. 10

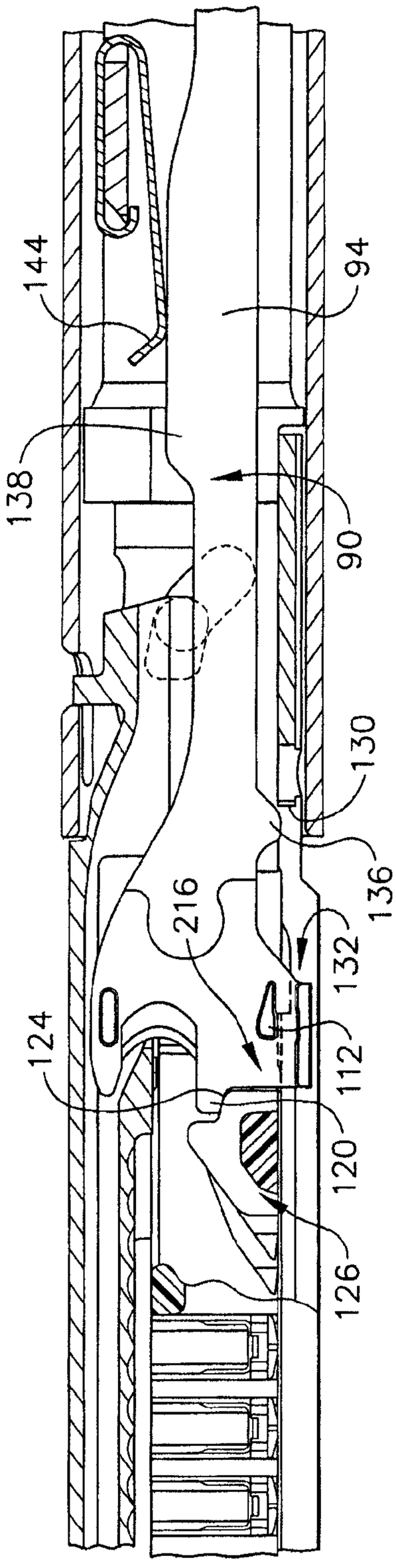
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FIG. 11

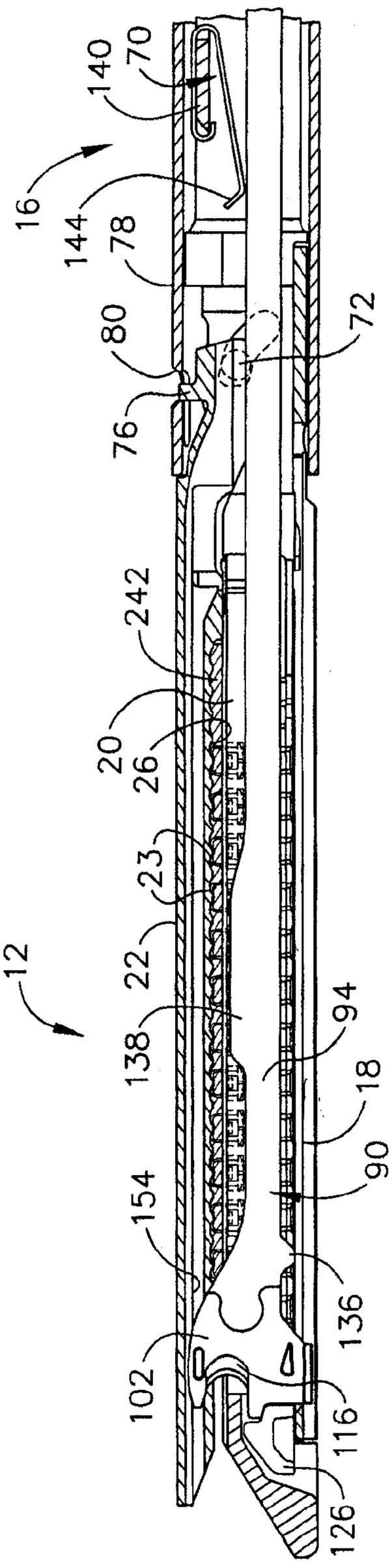
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FIG. 12

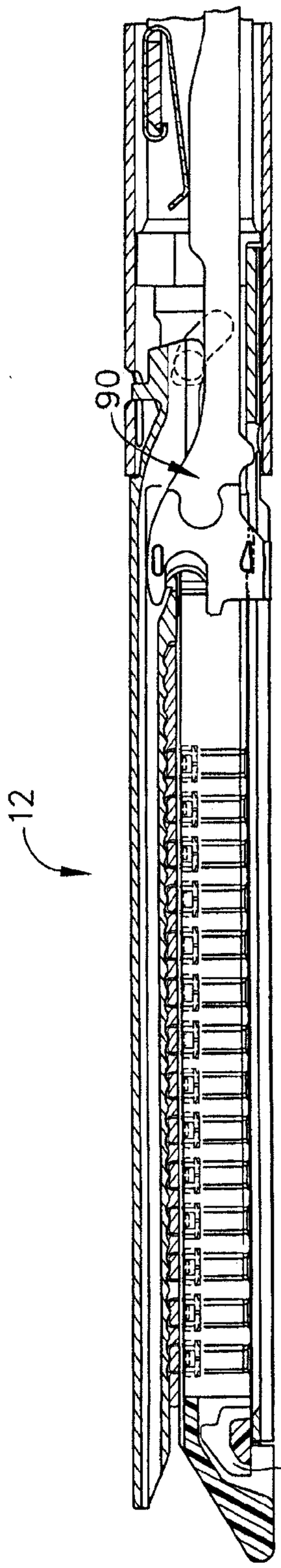

FIG. 13

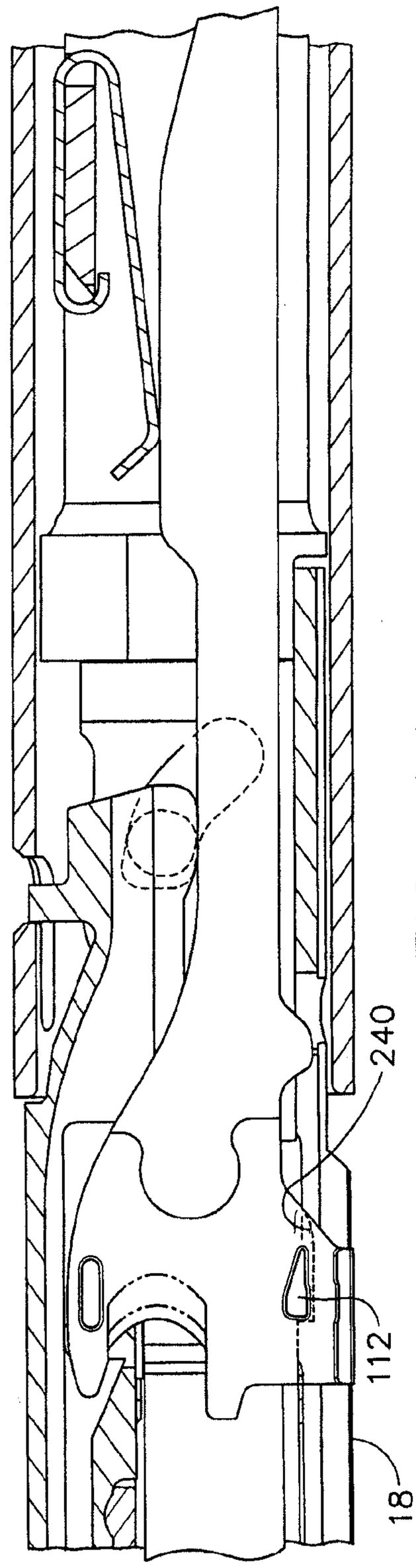

FIG. 14

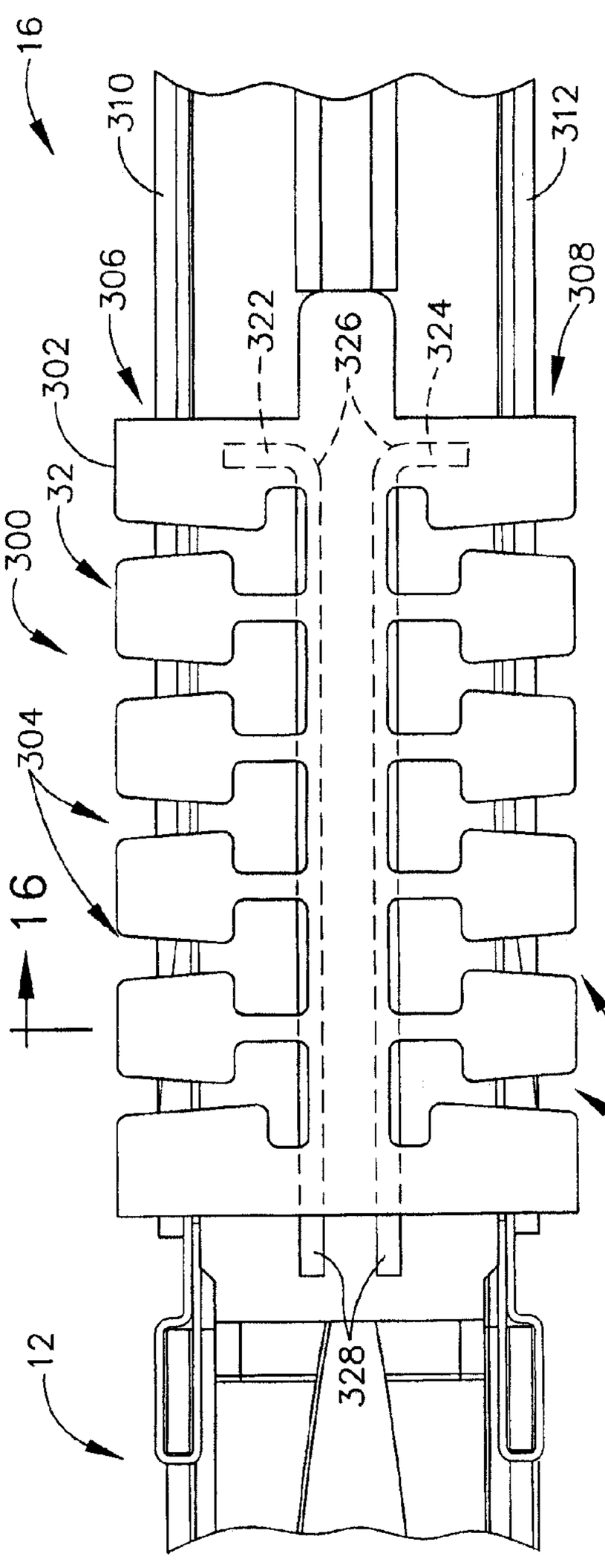
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FIG. 15

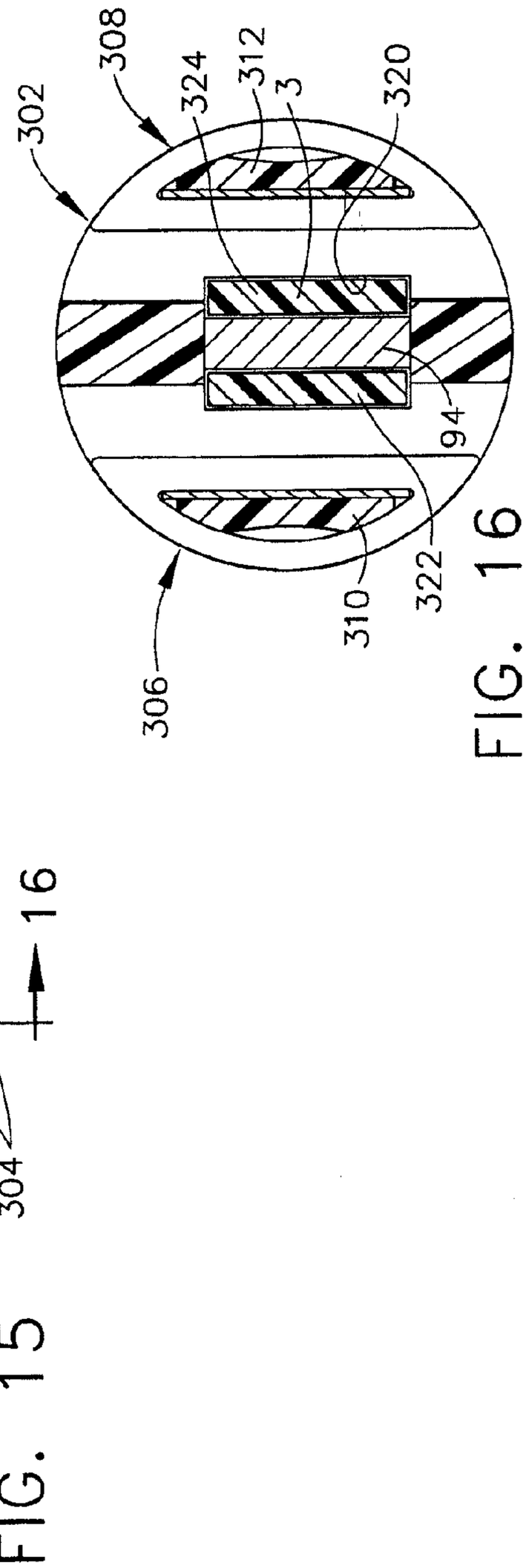
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FIG. 16

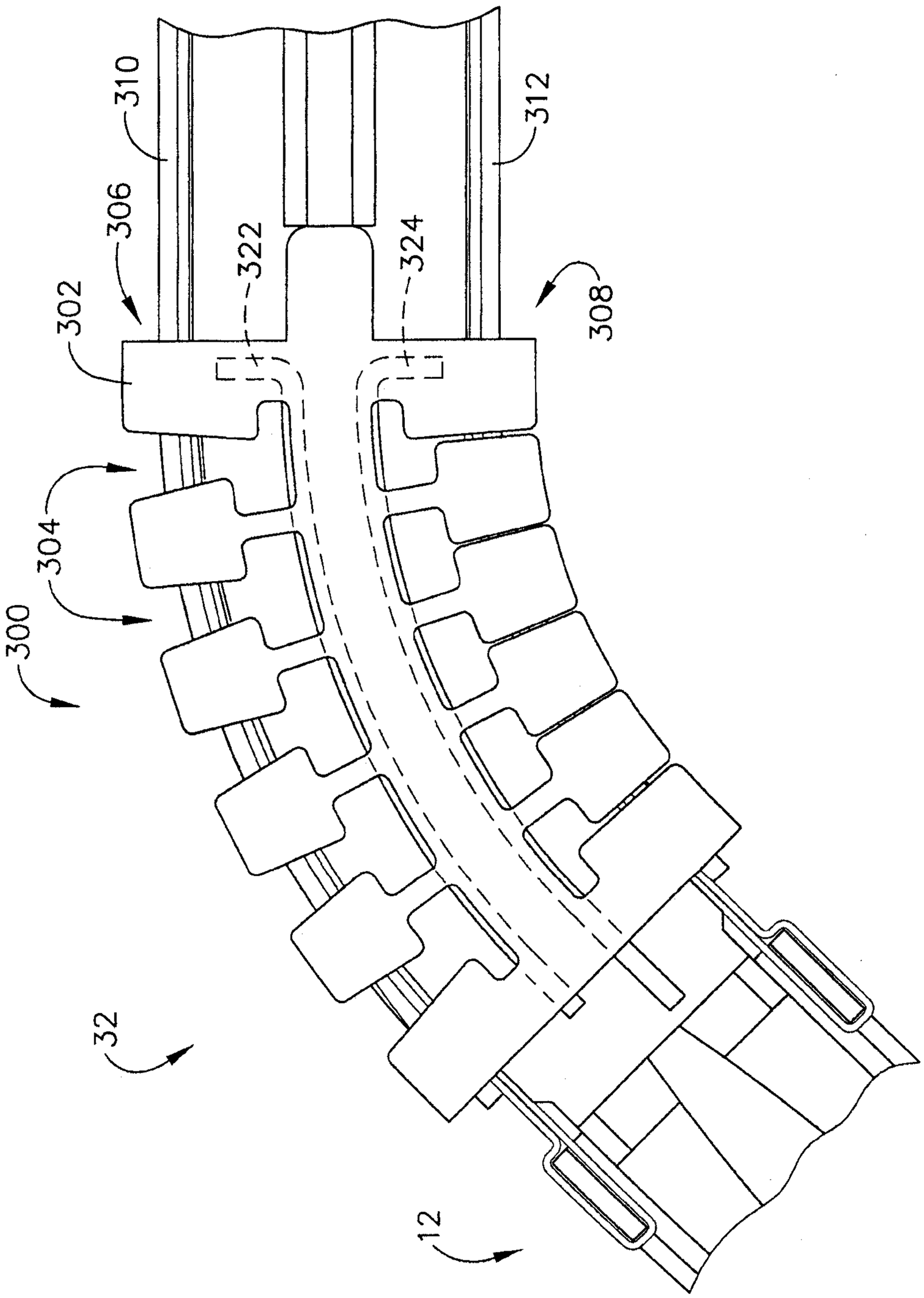

FIG. 17

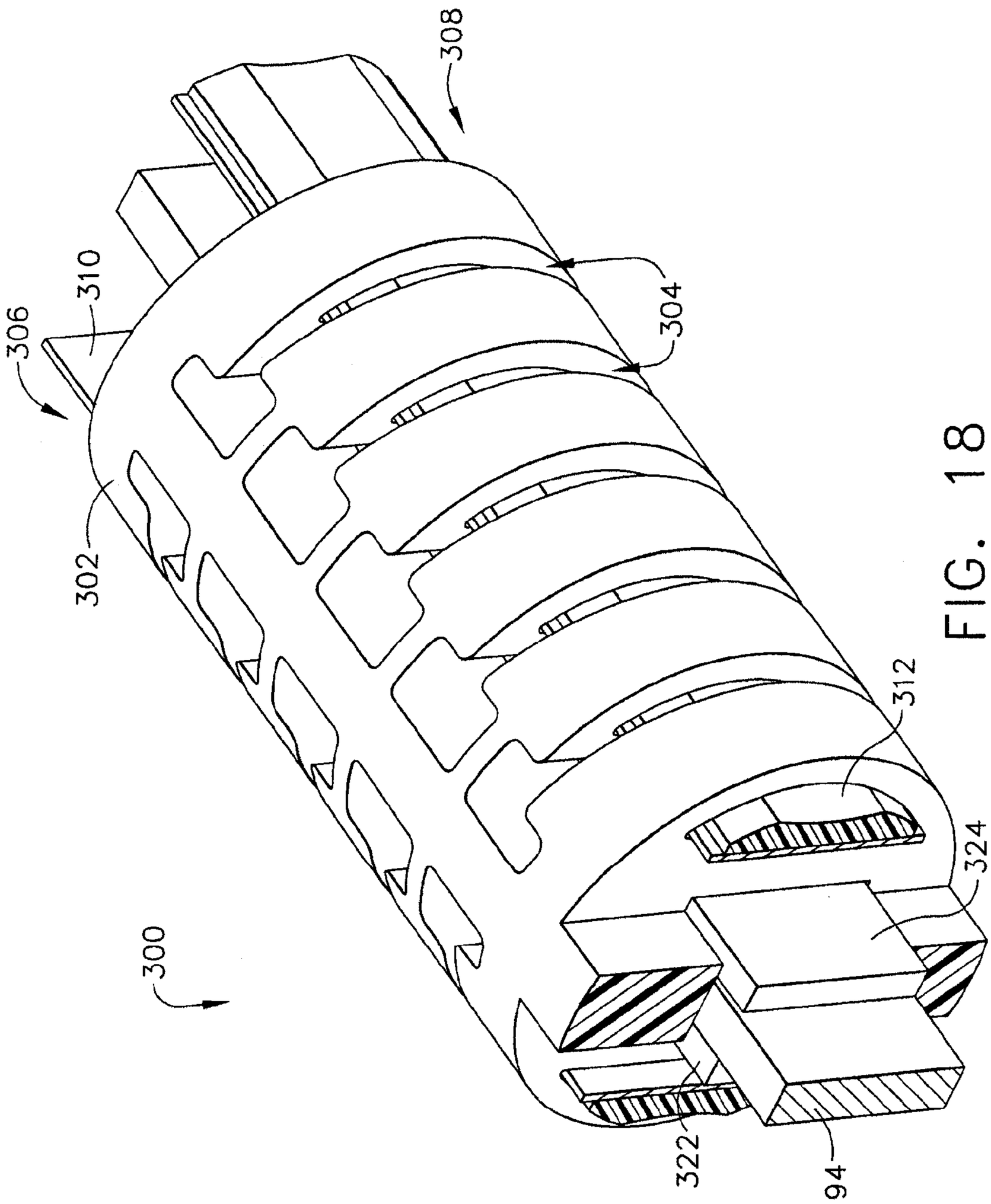

FIG. 18

ARTICULATING SURGICAL STAPLING INSTRUMENT INCORPORATING A TWO-PIECE E-BEAM FIRING MECHANISM

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a continuation application claiming priority under 35 U.S.C. §120 to U.S. patent application Ser. No. 14/850,030, entitled ARTICULATING SURGICAL STAPLING INSTRUMENT INCORPORATING A TWO-PIECE E-BEAM FIRING MECHANISM, filed Sep. 10, 2015, now U.S. Patent Application Publication No. 2016/0000441, which is a continuation application claiming priority under 35 U.S.C. §120 to U.S. patent application Ser. No. 14/521,748, entitled STAPLE CARTRIDGE, filed Oct. 23, 2014, now U.S. Patent Application Publication No. 2015/0041518, which is a continuation application claiming priority under 35 U.S.C. §120 to U.S. patent application Ser. No. 14/175,148, entitled SURGICAL STAPLING INSTRUMENT, filed Feb. 7, 2014, which issued on Mar. 15, 2016 as U.S. Pat. No. 9,282,966, which is a continuation application claiming priority under 35 U.S.C. §120 to U.S. patent application Ser. No. 13/369,601, entitled ROBOTICALLY-CONTROLLED SURGICAL END EFFECTOR SYSTEM, filed on Feb. 9, 2012, which issued on Jul. 22, 2014 as U.S. Pat. No. 8,783,541, which is a continuation application claiming priority under 35 U.S.C. §120 to U.S. patent application Ser. No. 13/118,246, entitled ROBOTICALLY-DRIVEN SURGICAL INSTRUMENT WITH E-BEAM DRIVER, filed on May 27, 2011, which issued on Jun. 23, 2015 as U.S. Pat. No. 9,060,770, which is a continuation-in-part application claiming priority under 35 U.S.C. §120 to U.S. patent application Ser. No. 11/538,154, entitled ARTICULATING SURGICAL STAPLING INSTRUMENT INCORPORATING A TWO-PIECE E-BEAM FIRING MECHANISM, filed on Oct. 3, 2006, now U.S. Patent Application Publication No. 2007/0084897, the entire disclosures of which are hereby incorporated by reference herein. This application is a continuation application claiming priority under 35 U.S.C. §120 to U.S. patent application Ser. No. 14/850,030, entitled ARTICULATING SURGICAL STAPLING INSTRUMENT INCORPORATING A TWO-PIECE E-BEAM FIRING MECHANISM, filed Sep. 10, 2015, now U.S. Patent Application Publication No. 2016/0000441, which is a continuation application claiming priority under 35 U.S.C. §120 to U.S. patent application Ser. No. 14/521,748, entitled STAPLE CARTRIDGE, filed Oct. 23, 2014, now U.S. Patent Application Publication No. 2015/0041518, which is a continuation application claiming priority under 35 U.S.C. §120 to U.S. patent application Ser. No. 14/175,148, entitled SURGICAL STAPLING INSTRUMENT, filed Feb. 7, 2014, which issued on Mar. 15, 2016 as U.S. Pat. No. 9,282,966, which is a continuation application claiming priority under 35 U.S.C. §120 to U.S. patent application Ser. No. 11/141,753, entitled SURGICAL STAPLING INSTRUMENT HAVING AN ELECTROACTIVE POLYMER ACTUATED MEDICAL SUBSTANCE DISPENSER, filed on Jun. 1, 2005, which issued on Dec. 9, 2014 as U.S. Pat. No. 8,905,977, which claims the benefit under 35 U.S.C. §119(e) of U.S. Provisional Patent Application Serial No. 60/591,694, entitled SURGICAL INSTRUMENT INCORPORATING AN ELECTRICALLY ACTUATED ARTICULATION MECHANISM, filed on Jul. 28, 2004, the entire disclosures of which are incorporated by reference herein.

FIELD OF THE INVENTION

[0002] The present invention relates in general to surgical instruments that are suitable for endoscopically inserting an end effector that is actuated by a longitudinally driven firing member, and more particularly a surgical stapling and severing instrument that has an articulating shaft.

BACKGROUND OF THE INVENTION

[0003] Endoscopic surgical instruments are often preferred over traditional open surgical devices since a smaller incision tends to reduce the post-operative recovery time and complications. Consequently, significant development has gone into a range of endoscopic surgical instruments that are suitable for precise placement of a distal end effector at a desired surgical site through a cannula of a trocar. These distal end effectors engage the tissue in a number of ways to achieve a diagnostic or therapeutic effect (e.g., endocutter, grasper, cutter, staplers, clip applier, access device, drug/gene therapy delivery device, and energy device using ultrasound, RF, laser, etc.).

[0004] Positioning the end effector is constrained by the trocar. Generally these endoscopic surgical instruments include a long shaft between the end effector and a handle portion manipulated by the clinician. This long shaft enables insertion to a desired depth and rotation about the longitudinal axis of the shaft, thereby positioning the end effector to a degree. With judicious placement of the trocar and use of graspers, for instance, through another trocar, often this amount of positioning is sufficient. Surgical stapling and severing instruments, such as described in U.S. Pat. No. 5,465,895, are an example of an endoscopic surgical instrument that successfully positions an end effector by insertion and rotation.

[0005] More recently, U.S. patent application Ser. No. 10/443,617, entitled SURGICAL STAPLING INSTRUMENT INCORPORATING AN E-BEAM FIRING MECHANISM, filed on May 20, 2003, now U.S. Pat. No. 6,978,921, which is incorporated by reference in its entirety, describes an improved "E-beam" firing bar for severing tissue and actuating staples. Some of the additional advantages include affirmatively spacing the jaws of the end effector, or more specifically a staple applying assembly, even if slightly too much or too little tissue is clamped for optimal staple formation. Moreover, the E-beam firing bar engages the end effector and staple cartridge in a way that enables several beneficial lockouts to be incorporated.

[0006] Depending upon the nature of the operation, it may be desirable to further adjust the positioning of the end effector of an endoscopic surgical instrument. In particular, it is often desirable to orient the end effector at an axis transverse to the longitudinal axis of the shaft of the instrument. The transverse movement of the end effector relative to the instrument shaft is conventionally referred to as "articulation". This is typically accomplished by a pivot (or articulation) joint being placed in the extended shaft just proximal to the staple applying assembly. This allows the surgeon to articulate the staple applying assembly remotely to either side for better surgical placement of the staple lines and easier tissue manipulation and orientation. This articulated positioning permits the clinician to more easily engage

tissue in some instances, such as behind an organ. In addition, articulated positioning advantageously allows an endoscope to be positioned behind the end effector without being blocked by the instrument shaft.

[0007] Approaches to articulating a surgical stapling and severing instrument tend to be complicated by integrating control of the articulation along with the control of closing the end effector to clamp tissue and fire the end effector (i.e., stapling and severing) within the small diameter constraints of an endoscopic instrument. Generally, the three control motions are all transferred through the shaft as longitudinal translations. For instance, U.S. Pat. No. 5,673,840 discloses an accordion-like articulation mechanism ("flex-neck") that is articulated by selectively drawing back one of two connecting rods through the implement shaft, each rod offset respectively on opposite sides of the shaft centerline. The connecting rods ratchet through a series of discrete positions.

[0008] Another example of longitudinal control of an articulation mechanism is U.S. Pat. No. 5,865,361 that includes an articulation link offset from a camming pivot such that pushing or pulling longitudinal translation of the articulation link effects articulation to a respective side. Similarly, U.S. Pat. No. 5,797,537 discloses a similar rod passing through the shaft to effect articulation.

[0009] In commonly owned U.S. patent application Ser. No. 10/615,973, entitled SURGICAL INSTRUMENT INCORPORATING AN ARTICULATION MECHANISM HAVING ROTATION ABOUT THE LONGITUDINAL AXIS, now U.S. Pat. No. 7,111,769, the disclosure of which is hereby incorporated by reference in its entirety, a rotational motion is used to transfer articulation motion as an alternative to a longitudinal motion.

[0010] In the application entitled SURGICAL STAPLING INSTRUMENT INCORPORATING AN E-BEAM FIRING MECHANISM, U.S. patent application Ser. No. 10/443,617, filed on May 20, 2003, now U.S. Pat. No. 6,978,921, the disclosure of which was previously incorporated by reference in its entirety, a surgical severing and stapling instrument, suitable for laparoscopic and endoscopic clinical procedures, clamps tissue within an end effector of an elongate channel pivotally opposed by an anvil. An E-beam firing bar moves distally through the clamped end effector to sever tissue and to drive staples on each side of the cut. The E-beam firing bar affirmatively spaces the anvil from the elongate channel to assure properly formed closed staples, especially when an amount of tissue is clamped that is inadequate to space the end effector. In particular, an upper pin of the firing bar longitudinally moves through an anvil slot and a channel slot is captured between a lower cap and a middle pin of the firing bar to assure a minimum spacing. While this E-beam firing bar has a number of advantages, additional features are desirable to enhance manufacturability and to minimize dimensional variations.

[0011] Consequently, a significant need exists for a surgical instrument with a firing bar that advantageously assures proper spacing between clamped jaws of an end effector and which facilitates articulation of its shaft.

BRIEF DESCRIPTION OF THE FIGURES

[0012] The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention, and, together with the general description of the invention given above, and the detailed description of the embodiments given below, serve to explain the principles of the present invention.

[0013] FIG. **1** is a perspective view of an endoscopic surgical stapling instrument for surgical stapling and severing in an open, unarticulated state.

[0014] FIG. **2** is a left, front perspective view of an open staple applying assembly of the surgical stapling instrument of FIG. **1** with a right half portion of a replaceable staple cartridge included in a staple channel.

[0015] FIG. **3** is an exploded perspective view of the staple applying assembly of FIG. **2** with a complete replaceable staple cartridge and an alternative nonarticulating shaft configuration.

[0016] FIG. **4** is a perspective view of a two-piece knife and firing bar ("E-beam") of the staple applying assembly of FIG. **2**.

[0017] FIG. **5** is a perspective view of a wedge sled of a staple cartridge of the staple applying assembly of FIG. **1**.

[0018] FIG. **6** is a left side view in elevation taken in longitudinal cross section along a centerline line **6-6** of the staple applying assembly of FIG. **2**.

[0019] FIG. **7** is a perspective view of the open staple applying assembly of FIG. **2** without the replaceable staple cartridge, a portion of the staple channel proximate to a middle pin of two-piece knife and firing bar, and without a distal portion of a staple channel.

[0020] FIG. **8** is a front view in elevation taken in cross section along line **8-8** of the staple applying assembly of FIG. **2** depicting internal staple drivers of the staple cartridge and portions of the two-piece knife and firing bar.

[0021] FIG. **9** is a left side view in elevation taken generally along the longitudinal axis of line **6-6** of a closed staple applying assembly of FIG. **2** to include center contact points between the two-piece knife and wedge sled but also laterally offset to show staples and staple drivers within the staple cartridge.

[0022] FIG. **10** is a left side detail view in elevation of the staple applying assembly of FIG. **9** with the two-piece knife retracted slightly more as typical for staple cartridge replacement.

[0023] FIG. **11** is a left side detail view in elevation of the staple applying assembly of FIG. **10** with the two-piece knife beginning to fire, corresponding to the configuration depicted in FIG. **9**.

[0024] FIG. **12** is a left side cross-sectional view in elevation of the closed staple applying assembly of FIG. **9** after the two-piece knife and firing bar has distally fired.

[0025] FIG. **13** is a left side cross-sectional view in elevation of the closed staple applying assembly of FIG. **12** after firing of the staple cartridge and retraction of the two-piece knife.

[0026] FIG. **14** is a left side cross-sectional detail view in elevation of the staple applying assembly of FIG. **13** with the two-piece knife allowed to drop into a lockout position.

[0027] FIG. **15** is a top view in section taken along lines **15-15** of an articulation joint (flex neck) of the surgical stapling instrument of FIG. **1**.

[0028] FIG. **16** is a front view in elevation taken in vertical cross section along lines **16-16** of the articulation joint of FIG. **15**, showing electroactive polymer (EAP) plate articulation actuators and EAP support plates for a firing bar.

[0029] FIG. **17** is a top view in section along lines **15-15** of the articulation joint of FIG. **16** after articulation.

[0030] FIG. **18** is a perspective view of the articulation joint of FIG. **15**.

DETAILED DESCRIPTION OF THE INVENTION

[0031] The entire disclosure of U.S. patent application Ser. No. 11/082,495, entitled SURGICAL INSTRUMENT INCORPORATING AN ELECTRICALLY ACTUATED ARTICULATION MECHANISM, filed on Mar. 17, 2005, now U.S. Pat. No. 7,506,790, is incorporated herein by reference. The entire disclosure of U.S. Pat. No. 6,667,825, entitled STABLE CONJUGATED POLYMER ELECTROCHROMIC DEVICES INCORPORATING IONIC LIQUIDS, issued on Jan. 3, 2002, is incorporated herein by reference. The entire disclosure of U.S. patent application Ser. No. 11/061,908, entitled SURGICAL INSTRUMENT INCORPORATING A FLUID TRANSFER CONTROLLED ARTICULATION MECHANISM, filed on Feb. 18, 2005, now U.S. Pat. No. 7,559,450, is incorporated herein by reference.

[0032] In FIGS. **1-3**, a surgical stapling instrument **10** has at its distal end an end effector, depicted as a staple applying assembly **12**, spaced apart from a handle **14** (FIG. **2**) by an elongate shaft **16**. The staple applying assembly **12** includes a staple channel **18** for receiving a replaceable staple cartridge **20**. Pivotally attached to the staple channel **18** is an anvil **22** that clamps tissue to the staple cartridge **20** and serves to deform staples **23** (FIG. **3**) driven up from staple holes **24** in the staple cartridge **20** against staple forming recesses **26** (FIG. **6**) in an anvil undersurface **28** into a closed shape. When the staple applying assembly **12** is closed, its cross sectional area, as well as the elongate shaft **16** are suitable for insertion through a small surgical opening, such as through a cannula of a trocar (not shown).

[0033] With particular reference to FIG. **1**, correct placement and orientation of the staple applying assembly **12** is facilitated by controls on the handle **14**. In particular, a rotation knob **30** causes rotation of the shaft **16** about its longitudinal axis, and hence rotation of the staple applying assembly **12**. Additional positioning is enabled at an articulation joint **32** in the shaft **16** that pivots the staple applying assembly **12** in an arc from the longitudinal axis of the shaft **16**, thereby allowing placement behind an organ or allowing other instruments such as an endoscope (not shown) to be oriented behind the staple applying assembly **12**. This articulation is advantageously effected by an articulation control switch **34** on the handle **14** that transmits an electrical signal to the articulation joint **32** to an Electroactive Polymer (EAP) actuator **36**, powered by an EAP controller and power supply **38** contained within the handle **14**.

[0034] Once positioned with tissue in the staple applying assembly **12**, a surgeon closes the anvil **22** by drawing a closure trigger **40** proximally toward a pistol grip **42**. Once clamped thus, the surgeon may grasp a more distally presented firing trigger **44**, drawing it back to effect firing of the staple applying assembly **12**, which in some applications is achieved in one single firing stroke and in other applications by multiple firing strokes. Firing accomplishes simultaneously stapling of at least two rows of staples while severing the tissue therebetween.

[0035] Retraction of the firing components may be automatically initiated upon full travel. Alternatively, a retraction lever **46** may be drawn aft to effect retraction. With the firing components retracted, the staple applying assembly **12** may be unclamped and opened by the surgeon slightly drawing the closure trigger **40** aft toward the pistol grip **42** and depressing a closure release button **48** and then releasing the closure trigger **40**, thereby releasing the two stapled ends of severed tissue from the staple applying assembly **12**.

Staple Applying Assembly

[0036] While an articulation joint **32** is depicted in FIG. **1**, for clarity and as an alternative application, the surgical stapling instrument **10** of FIGS. **2-14** omit an articulation joint **32**. It should be appreciated, however, that aspects of the present invention have particular advantages for articulation as described below with regard to FIGS. **15-18**.

[0037] In FIGS. **1-3**, the staple applying assembly **12** accomplishes the functions of clamping onto tissue, driving staples and severing tissue by two distinct motions transferred longitudinally down the shaft **16** over a shaft frame **70**. This shaft frame **70** is proximally attached to the handle **14** and coupled for rotation with the rotation knob **30**. An illustrative multi-stroke handle **14** for the surgical stapling and severing instrument **10** of FIG. **1** is described in greater detail in the co-owned U.S. patent application Ser. No. 10/674,026, entitled SURGICAL STAPLING INSTRUMENT INCORPORATING A MULTISTROKE FIRING POSITION INDICATOR AND RETRACTION MECHANISM, now U.S. Pat. No. 7,364,061, the disclosure of which is hereby incorporated by reference in its entirety, with additional features and variation as described herein. While a multi-stroke handle **14** advantageously supports applications with high firing forces over a long distance, applications consistent with the present invention may incorporate a single firing stroke, such as described in commonly owned U.S. patent application Ser. No. 10/441,632, entitled SURGICAL STAPLING INSTRUMENT HAVING SEPARATE DISTINCT CLOSING AND FIRING SYSTEMS, now U.S. Pat. No. 7,000,818, the disclosure of which is hereby incorporated by reference in its entirety.

[0038] With particular reference to FIG. **3**, the distal end of the shaft frame **70** is attached to the staple channel **18**. The anvil **22** has a proximal pivoting end **72** that is pivotally received within a proximal end **74** of the staple channel **18**, just distal to its engagement to the shaft frame **70**. The pivoting end **72** of the anvil **22** includes a closure feature **76** proximate but distal to its pivotal attachment with the staple channel **18**. Thus, a closure tube **78**, whose distal end includes a horseshoe aperture **80** that engages this closure feature **76**, selectively imparts an opening motion to the anvil **22** during proximal longitudinal motion and a closing motion to the anvil **22** during distal longitudinal motion of the closure tube **78** sliding over the shaft frame **70** in response to the closure trigger **40**.

[0039] The shaft frame **70** encompasses and guides a firing motion from the handle **14** through a longitudinally reciprocating, two-piece knife and firing bar **90**. In particular, the shaft frame **70** includes a longitudinal firing bar slot **92** that receives a proximal portion of the two-piece knife and firing bar **90**, specifically a laminate tapered firing bar **94**. It should be appreciated that the laminated tapered firing bar **94** may be substituted with a solid firing bar or of other materials in applications not intended to pass through an articulation joint, such as depicted in FIGS. **2-14**.

[0040] An E-beam **102** is the distal portion of the two-piece knife and firing bar **90**, which facilitates separate closure and firing as well as spacing of the anvil **22** from the

elongate staple channel **18** during firing. With particular reference to FIGS. **3-4**, in addition to any attachment treatment such as brazing or an adhesive, the knife and firing bar **90** are formed of a female vertical attachment aperture **104** proximally formed in the E-beam **102** that receives a corresponding male attachment member **106** distally presented by the laminated tapered firing bar **94**, allowing each portion to be formed of a selected material and process suitable for their disparate functions (e.g., strength, flexibility, friction). The E-beam **102** may be advantageously formed of a material having suitable material properties for forming a pair of top pins **110**, a pair of middle pins **112** and a bottom pin or foot **114**, as well as being able to acquire a sharp cutting edge **116**. In addition, integrally formed and proximally projecting top guide **118** and middle guide **120** bracketing each vertical end of the cutting edge **116** further define a tissue staging area **122** assisting in guiding tissue to the sharp cutting edge **116** prior to being severed. The middle guide **120** also serves to engage and fire the staple applying apparatus **12** by abutting a stepped central member **124** of a wedge sled **126** (FIG. **5**) that effects staple formation by the staple applying assembly **12**, as described in greater detail below.

[0041] Forming these features (e.g., top pins **110**, middle pins **112**, and bottom foot **114**) integrally with the E-beam **102** facilitates manufacturing at tighter tolerances relative to one another as compared to being assembled from a plurality of parts, ensuring desired operation during firing and/or effective interaction with various lockout features of the staple applying assembly **12**.

[0042] In FIGS. **6-7**, the surgical stapling instrument **10** is shown open, with the E-beam **102** fully retracted. During assembly, the lower foot **114** of the E-beam **102** is dropped through a widened hole **130** in the staple channel **18** and the E-beam **102** is then advanced such that the E-beam **102** slides distally along a lower track **132** formed in the staple channel **18**. In particular, the lower track **132** includes a narrow slot **133** that opens up as a widened slot **134** on an undersurface of the staple channel **18** to form an inverted T-shape in lateral cross section, as depicted particularly in FIGS. **7** and **8**, which communicates with the widened hole **130**. Once assembled, the components proximally coupled to the laminate tapered firing bar **94** do not allow the lower foot **114** to proximally travel again to the widened hole **130** to permit disengagement.

[0043] In FIG. **9**, the laminate tapered firing bar **94** facilitates insertion of the staple applying assembly **12** through a trocar. In particular, a more distal, downward projection **136** raises the E-beam **102** when fully retracted. This is accomplished by placement of the downward projection **136** at a point where it cams upwardly on a proximal edge of the widened hole **130** in the staple channel **18**.

[0044] In FIG. **10**, the laminate tapered firing bar **94** also enhances operation of certain lockout features that may be incorporated into the staple channel **18** by including a more proximal upward projection **138** that is urged downwardly by the shaft frame **70** during an initial portion of the firing travel. In particular, a lateral bar **140** is defined between a pair of square apertures **142** in the shaft frame **70** (FIG. **3**). A clip spring **144** that encompasses the lateral bar **140** downwardly urges a portion of the laminate tapered firing bar **94** projecting distally out of the longitudinal firing bar slot **92**, which ensures certain advantageous lockout features are engaged when appropriate. This urging is more pronounced or confined solely to that portion of the firing travel when the upward projection **138** contacts the clip spring **144**.

[0045] In FIGS. **6-7**, the E-beam **102** is retracted with the top pins **110** thereof residing within an anvil pocket **150** near the pivoting proximal end of the anvil **22**. A downwardly open vertical anvil slot **152** (FIG. **2**) laterally widens in the anvil **22** into an anvil internal track **154** that captures the top pins **110** of the E-beam **102** as they distally advance during firing, as depicted in FIGS. **9-10**, affirmatively spacing the anvil **22** from the staple channel **18**. Thus, with the E-beam **102** retracted, the surgeon is able to repeatably open and close the staple applying assembly **12** until satisfied with the placement and orientation of tissue captured therein for stapling and severing, yet the E-beam **102** assists in proper positioning of tissue even for a staple applying assembly **12** of reduced diameter and correspondingly reduced rigidity.

[0046] In FIGS. **2-3**, **5-6**, **8-14**, the staple applying assembly **12** is shown with the replaceable staple cartridge **20** that includes the wedge sled **126**. Longitudinally aligned and parallel plurality of downwardly open wedge slots **202** (FIG. **8**) receive respective wedges **204** integral to the wedge sled **126**. In FIGS. **8-10**, the wedge sled **126** thus cams upwardly a plurality of staple drivers **206** that are vertically slidable within staple driver recesses **208**. In this illustrative version, each staple driver **206** includes two vertical prongs, each translating upwardly into a respective staple hole **210** to upwardly force out and deform a staple **23** resting thereupon against a staple forming surface **214** (FIG. **10**) of the anvil **22**. A central firing recess **216** (FIG. **3**) defined within the staple cartridge **20** proximate to the staple channel **18** allows the passage of the bottom, horizontal portion **218** (FIG. **5**) of the wedge sled **126** as well as the middle pins **112** of the E-beam **102**. Specifically, a staple cartridge tray **220** (FIGS. **3**, **8**) attaches to and underlies a polymer staple cartridge body **222** that has the staple driver recesses **208**, staple holes **210**, and central firing recess **216** formed therein. As staples **23** are thus formed to either side, the sharp cutting edge **116** enters a vertical through slot **230** passing through the longitudinal axis of the staple cartridge **20**, excepting only a most distal end thereof.

[0047] Firing the staple applying assembly **12** begins as depicted in FIG. **10** with the two-piece knife and firing bar **90** proximally drawn until the downward projection **136** cams the middle guide **120** on the E-beam **102** upward and aft, allowing a new staple cartridge **20** to be inserted into the staple channel **18** when the anvil **22** is open as depicted in FIGS. **2**, **6**.

[0048] In FIG. **11**, the two-piece knife and firing bar **90** has been distally advanced a small distance, allowing the downward projection **136** to drop into the widened hole **130** of the lower track **132** under the urging of the clip spring **144** against the upward projection **138** of the laminate tapered firing bar **94**. The middle guide **120** prevents further downward rotation by resting upon the stepped central member **124** of the wedge sled **126**, thus maintaining the middle pin **112** of the E-beam within the central firing recess **216**.

[0049] In FIG. **12**, the two-piece knife and firing bar **90** has been distally fired, advancing the wedge sled **126** to cause formation of staples **23** while severing tissue **242** clamped between the anvil **22** and staple cartridge **20** with the sharp cutting edge **116**. Thereafter, in FIG. **13**, the two-piece knife and firing bar **90** is retracted, leaving the wedge sled **126** distally positioned.

[0050] In FIG. **14**, the middle pin **112** is allowed to translate down into a lockout recess **240** formed in the staple channel **18** (also see FIGS. **7**, **10**). Thus, the operator would receive a tactile indication as the middle pin **112** encounters the distal edge of the lockout recess **240** when the wedge sled **126** (not shown in FIG. **14**) is not proximally positioned (i.e., missing staple cartridge **20** or spent staple cartridge **20**).

[0051] In FIG. **1**, an articulation joint **32** is depicted that advantageously benefits from the flexible strength of the two-piece knife and firing bar **90**. In FIGS. **15-18**, the articulation joint **32** is depicted as a flex neck joint **300** formed by vertebral column body **302** having laterally symmetric pairs of arcing recesses **304** that allow articulation in an articulation plane. It is generally known to simultaneously compress and expand respective lateral sides **306**, **308** by selective movement of control rods (not shown) that longitudinally pass through the respective lateral sides **306**, **308**. Depicted, however, are EAP plate actuators **310**, **312**, each capable of powered deflection to one or both lateral directions.

[0052] A central passage **320** (FIG. **16**) defined longitudinally through the vertebral column body **302** receives a pair of support plates **322**, **324** that prevent buckling and binding of the laminate tapered firing bar **94**. In the illustrative version, each support plate **322**, **324** has a proximal fixed end **326** (FIG. **15**) and a sliding end **328** to accommodate changes in radial distance during articulation. Having a firing bar **94** of a thinner thickness is thus supported.

[0053] While the present invention has been illustrated by description of several embodiments and while the illustrative embodiments have been described in considerable detail, it is not the intention of the applicant to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications may readily appear to those skilled in the art.

[0054] For example, while there are a number of advantages to having a wedge sled integral to a staple cartridge, in some applications consistent with aspects of the present invention, the wedge sled may be integral instead to an E-beam. For instance, an entire end effector may be replaceable rather than just the staple cartridge.

1-20. (canceled)

21. A stapling system, comprising:

an anvil comprising an anvil ledge;

a channel comprising a channel ledge;

a firing bar comprising a first projection configured to engage said anvil ledge and a second projection configured to engage said channel ledge;

a replaceable unfired staple cartridge, comprising:

a proximal end;

a distal end positioned opposite said proximal end;

staples;

a vertical slot extending longitudinally from said proximal end toward said distal end, wherein said vertical slot is configured to receive said firing bar during a staple firing stroke; and

a sled spanning across said vertical slot; and

a locking member movable vertically and spring-biased into a locked configuration which inhibits said firing member from being advanced through said staple firing stroke when a previously-fired staple cartridge is assembled to said stapling system instead of said unfired staple cartridge.

22. The stapling system of claim **21**, wherein said sled is positioned in front of said firing bar when said unfired staple cartridge is assembled to said stapling system.

23. The stapling system of claim **21**, wherein said sled is positioned intermediate said first projection and said second projection of said firing bar when said unfired staple cartridge is assembled to said stapling system.

24. The stapling system of claim **21**, wherein said sled comprises a central portion configured to slide within said vertical slot during said staple firing stroke, and wherein said central portion is configured to unlock said locking member.

25. The stapling system of claim **21**, further comprising an articulation joint, wherein said unfired staple cartridge is attached to said stapling system at a location which is distal with respect to said articulation joint.

26. The stapling system of claim **21**, further comprising a frame, wherein said locking member is rotatable relative to said frame.

27. A stapling system, comprising:

an anvil comprising a longitudinal anvil shoulder;

a channel comprising a longitudinal channel shoulder;

a firing bar comprising a first cam configured to engage said longitudinal anvil shoulder and a second cam configured to engage said longitudinal channel shoulder;

a replaceable unspent staple cartridge, comprising:

a proximal end;

a distal end positioned opposite said proximal end;

staples;

a vertical slot extending longitudinally from said proximal end toward said distal end, wherein said vertical slot is configured to receive said firing bar during a staple firing stroke; and

a sled spanning from one lateral side of said vertical slot to another lateral side; and

a locking member movable vertically and spring-biased into a locked configuration which inhibits said firing member from being advanced through said staple firing stroke when a spent staple cartridge is assembled to said stapling system instead of said unspent staple cartridge.

28. The stapling system of claim **27**, wherein said sled is positioned in front of said firing bar when said unspent staple cartridge is assembled to said stapling system.

29. The stapling system of claim **27**, wherein said sled is positioned intermediate said first cam and said second cam of said firing bar when said unspent staple cartridge is assembled to said stapling system.

30. The stapling system of claim **27**, wherein said sled comprises a central portion configured to slide within said vertical slot during said staple firing stroke, and wherein said central portion is configured to unlock said locking member.

31. The stapling system of claim **27**, further comprising an articulation joint, wherein said unspent staple cartridge is attached to said stapling system at a location which is distal with respect to said articulation joint.

32. The stapling system of claim **27**, further comprising a frame, wherein said locking member is rotatable relative to said frame.

33. A stapling system, comprising:

an anvil comprising a longitudinal anvil shoulder;

a channel comprising a longitudinal channel shoulder;

a firing bar comprising a first cam configured to engage said longitudinal anvil shoulder and a second cam configured to engage said longitudinal channel shoulder;

a plurality of replaceable staple cartridges, wherein an unspent staple cartridge comprises:

a proximal end;

a distal end positioned opposite said proximal end;

staples;

a vertical slot extending longitudinally from said proximal end toward said distal end, wherein said vertical slot is configured to receive said firing bar during a staple firing stroke; and

a sled spanning from one lateral side of said vertical slot to another lateral side, wherein said sled is movable between a proximal unfired position and a distal fired position, and wherein a staple cartridge becomes spent when said sled is advanced distally from said proximal unfired position; and

a locking member movable vertically and spring-biased into a locked configuration which inhibits said firing member from being advanced through said staple firing stroke when a spent staple cartridge is assembled to said stapling system.

34. The stapling system of claim **33**, wherein said sled is positioned in front of said firing bar when a said staple cartridge is assembled to said stapling system.

35. The stapling system of claim **33**, wherein said sled is positioned intermediate said first cam and said second cam of said firing bar when a said staple cartridge is assembled to said stapling system.

36. The stapling system of claim **33**, wherein said sled comprises a central portion configured to slide within said vertical slot during said staple firing stroke, and wherein said central portion is configured to unlock said locking member.

37. The stapling system of claim **33**, further comprising an articulation joint, wherein a said staple cartridge is attached to said stapling system at a location which is distal with respect to said articulation joint.

38. The stapling system of claim **33**, further comprising a frame, wherein said locking member is rotatable relative to said frame.

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