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(54) **SURGICAL INSTRUMENT WITH ENHANCED BATTERY PERFORMANCE**

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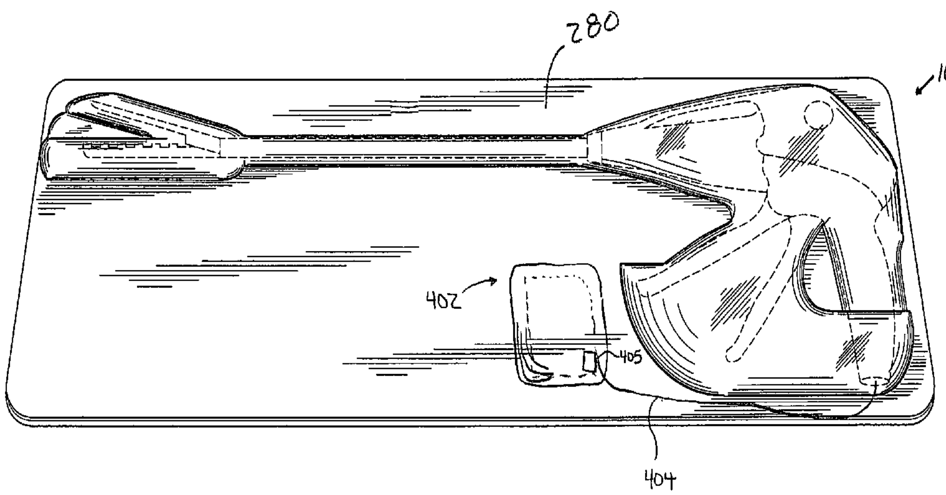
(57) **ABSTRACT**

An assembly including a component of a surgical instrument, such as an endoscopic or laparoscopic instrument. The assembly may comprise a package; a surgical instrument component within the package; and a power source within the package. The power source may be configured to be placed in electrical communication with the surgical instrument component. The assembly may also comprise an auxiliary power source within the package and a circuit element, where the circuit element is in electrical communication with the power source and the auxiliary power source.

17 Claims, 18 Drawing Sheets



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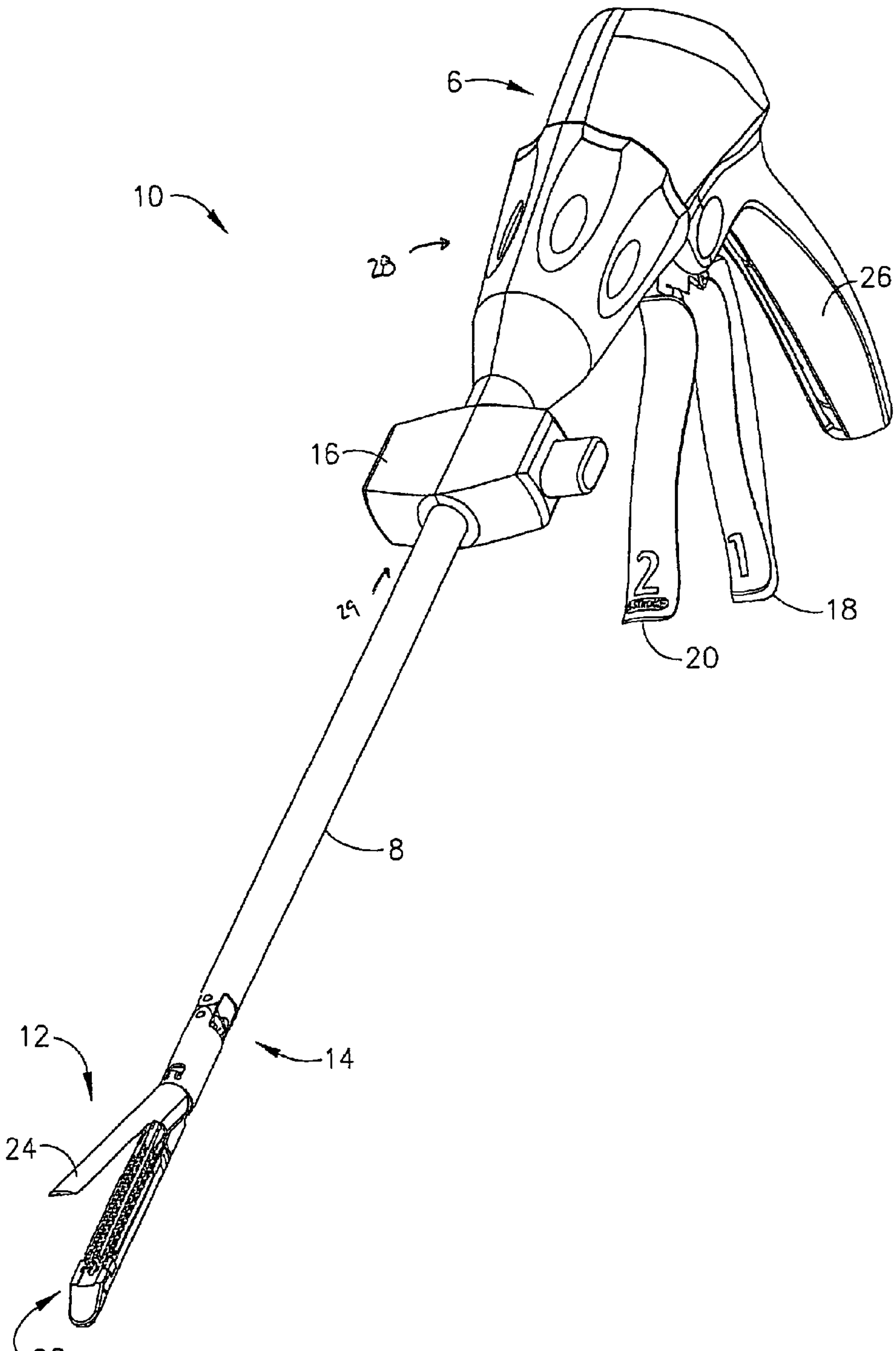

FIG. 1

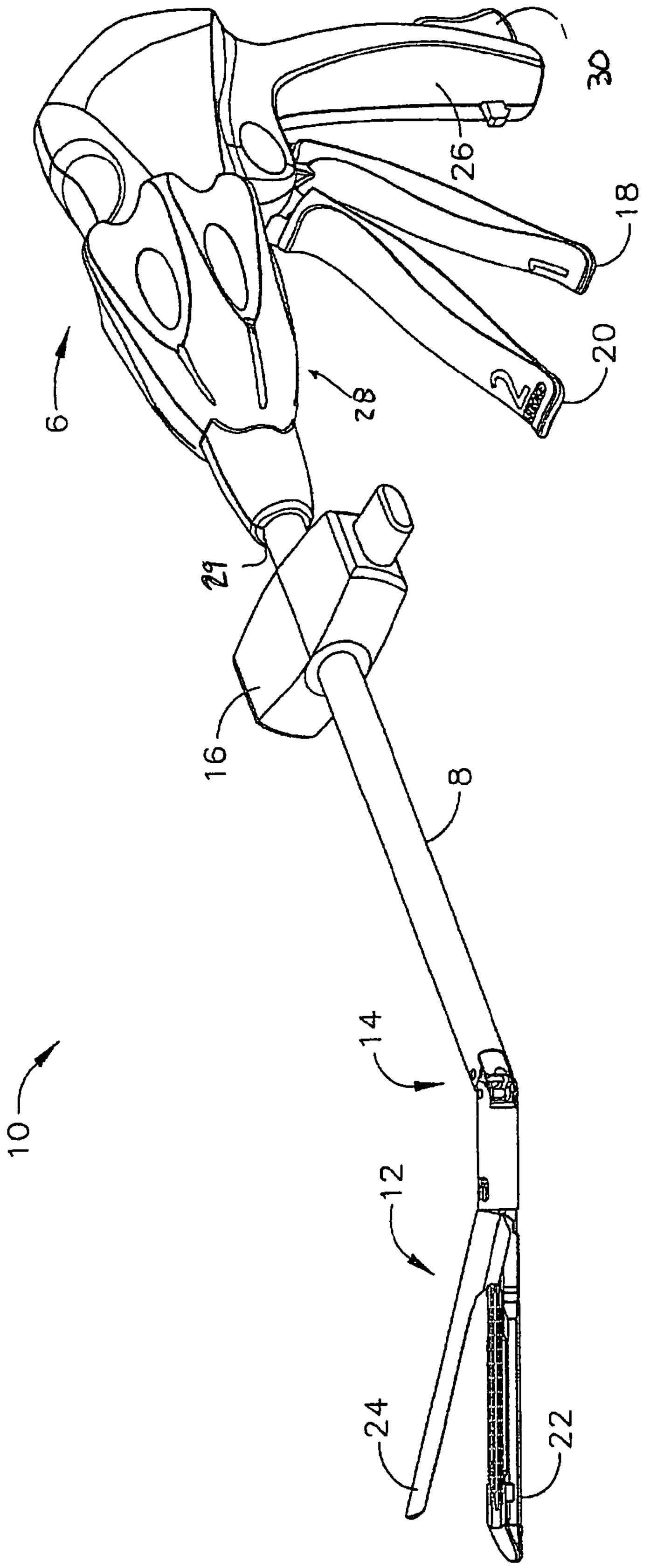

FIG. 2

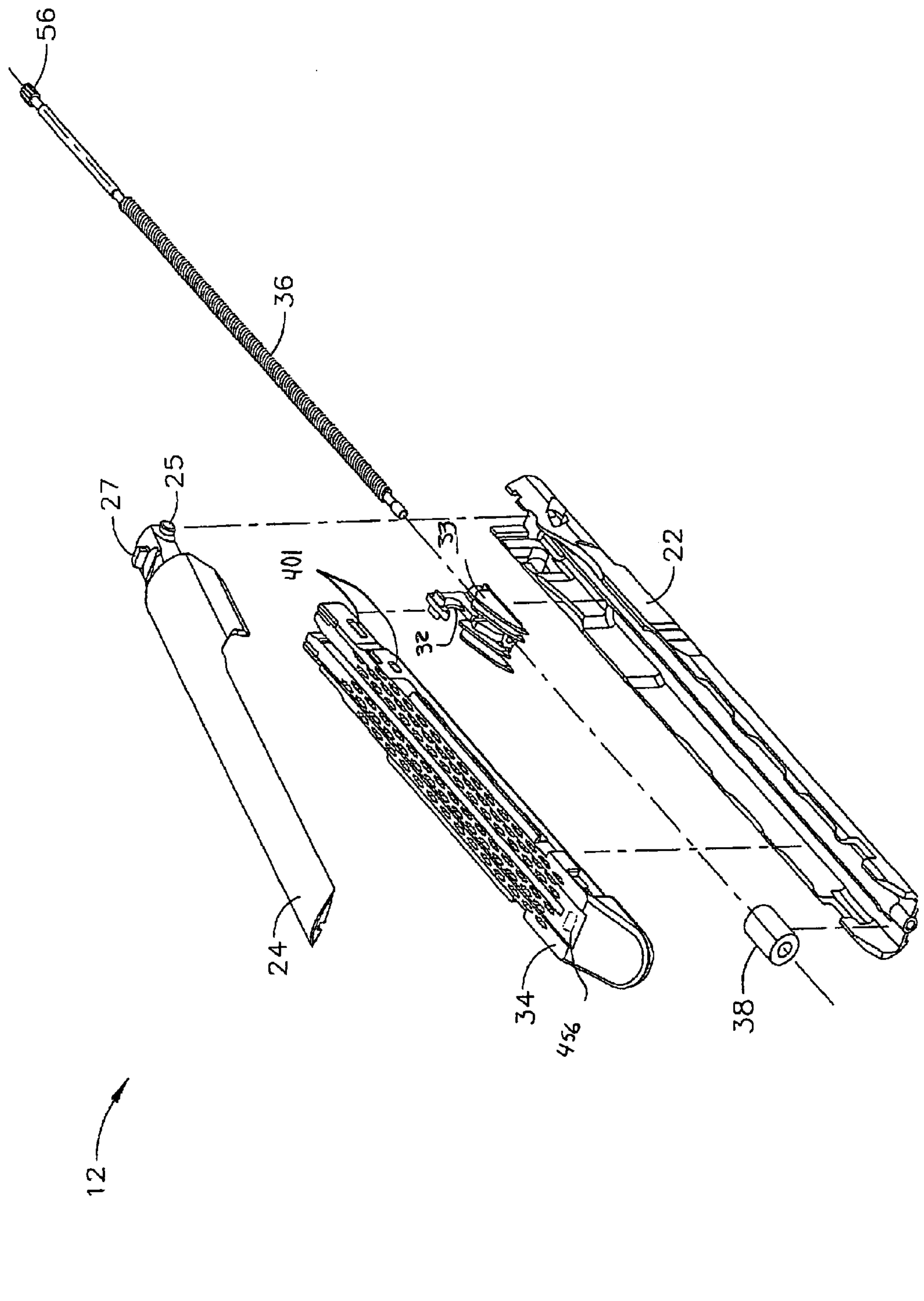

FIG. 3

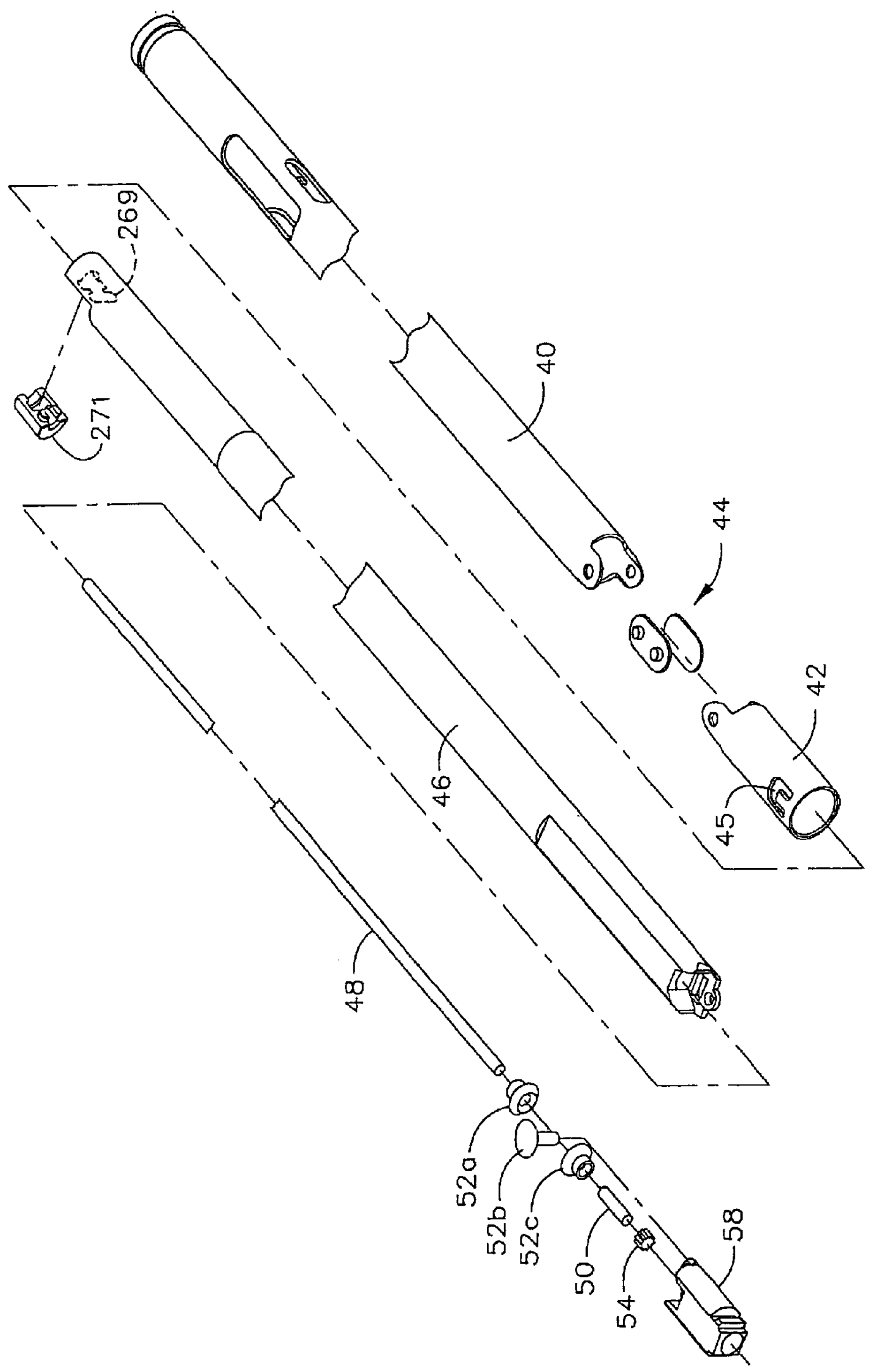

FIG. 4

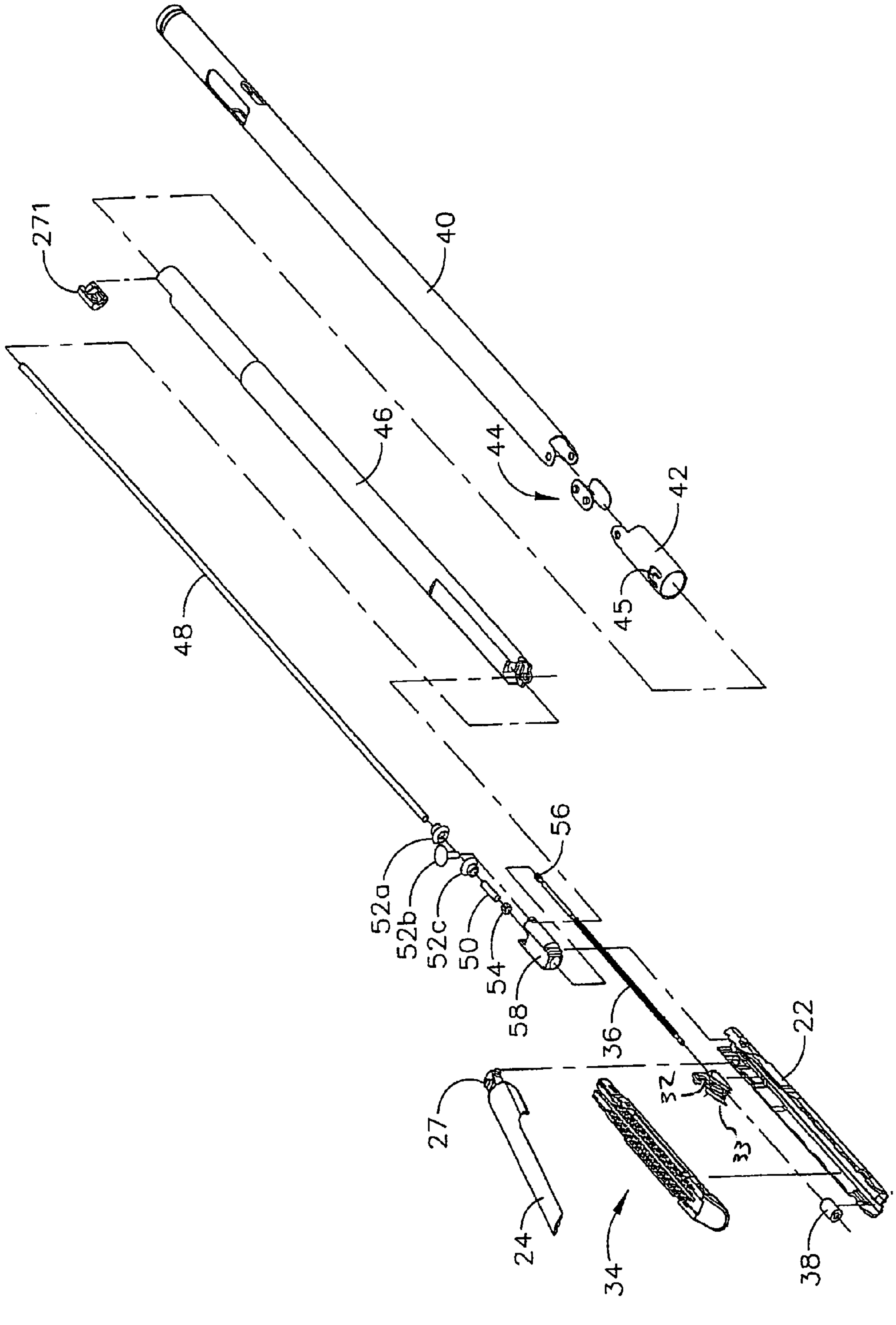

FIG. 5

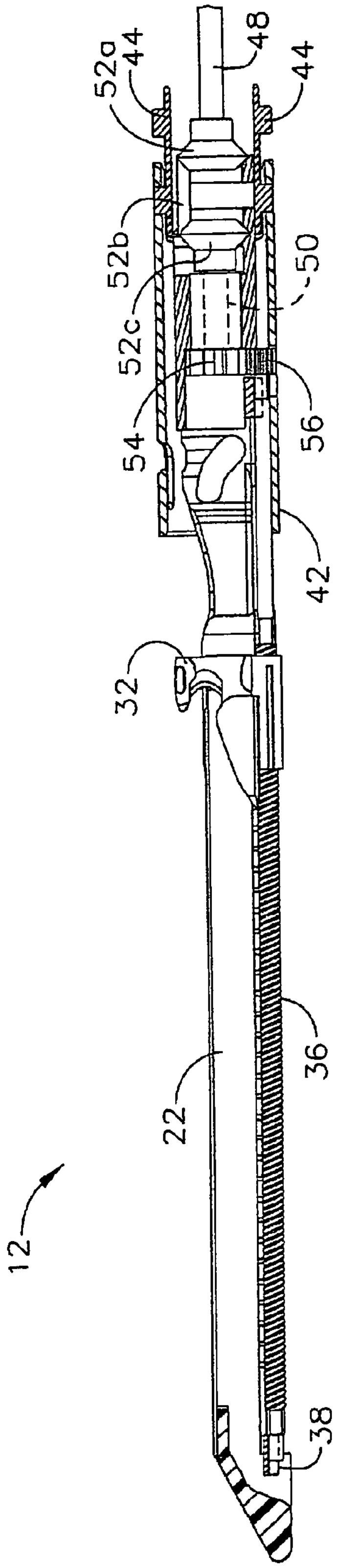

FIG. 6

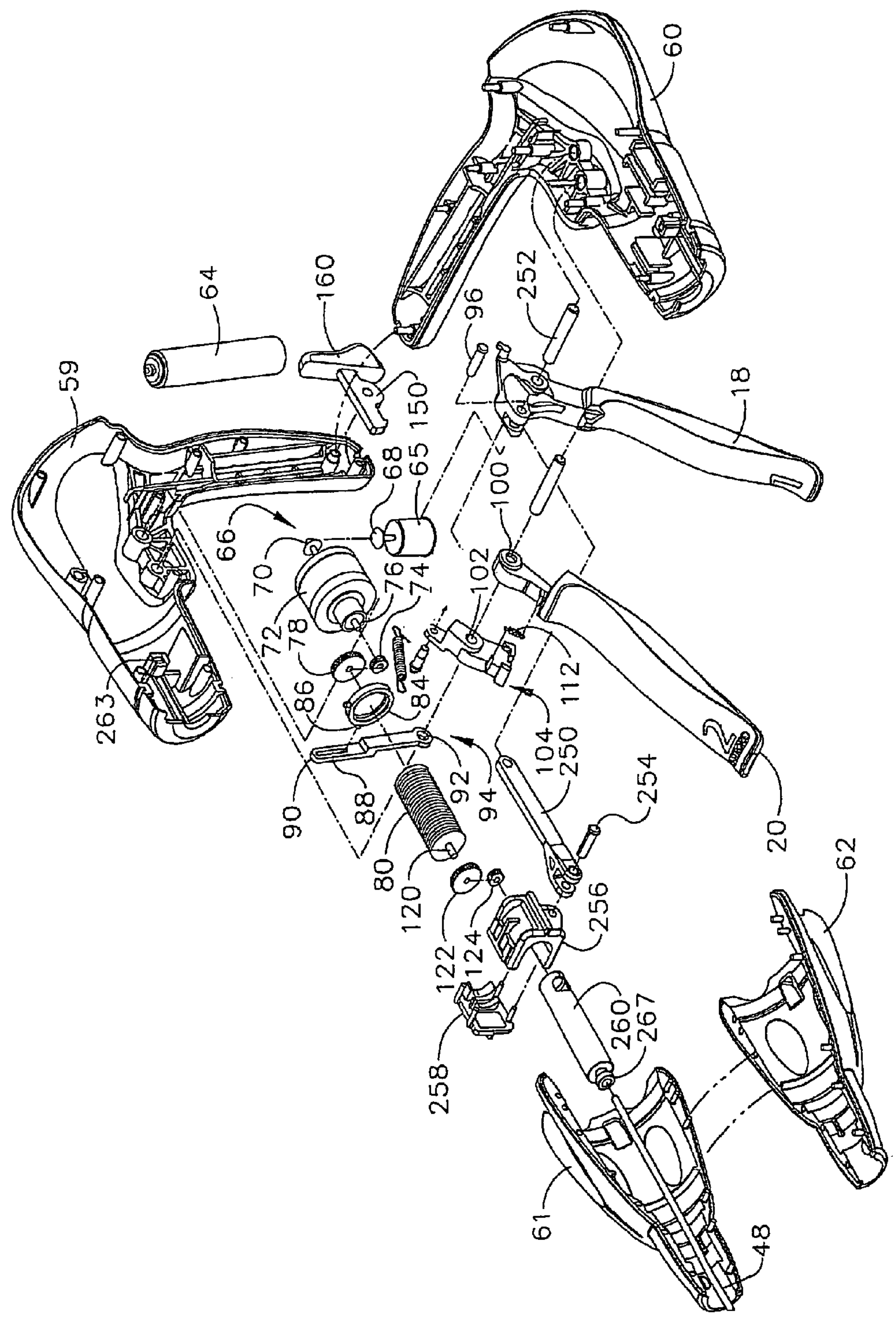
59
64
160
60
96
252
18
150
65
68
66
70
72
76
74
78
86
84
263
100
102
112
104
250
90
88
92
94
80
254
20
120
122
124
256
62
258
260
267
61
48

FIG. 7

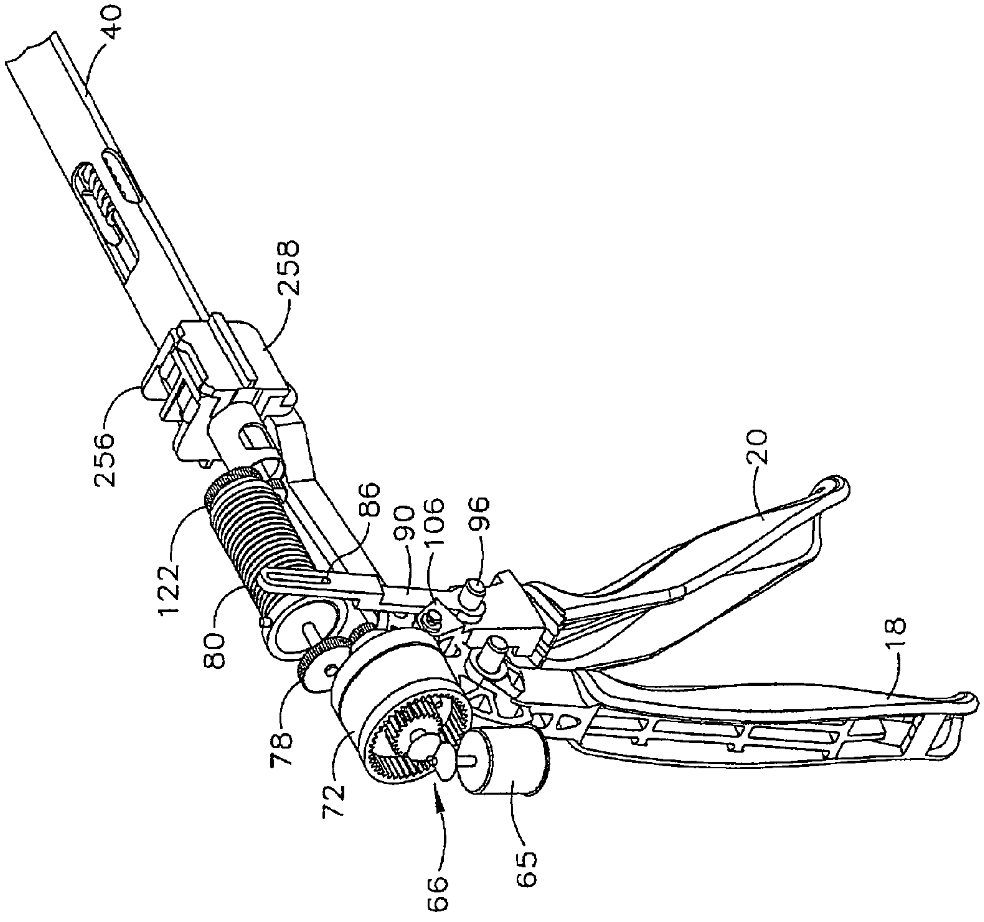

FIG. 8

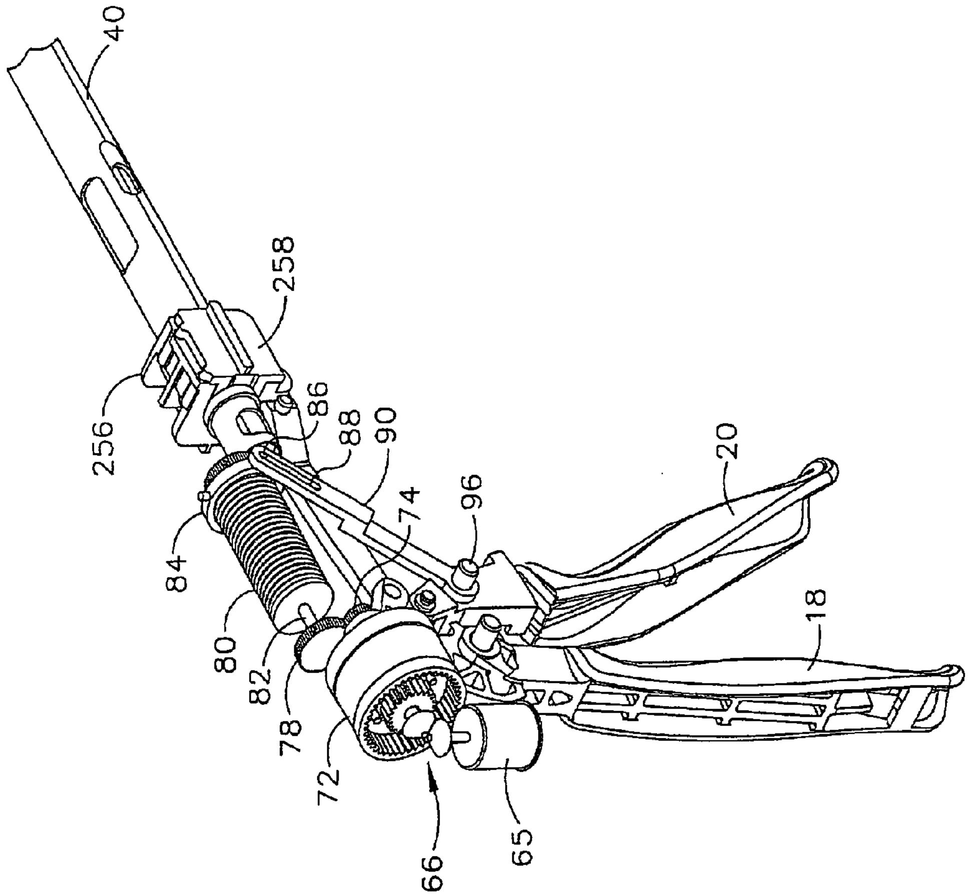

FIG. 9

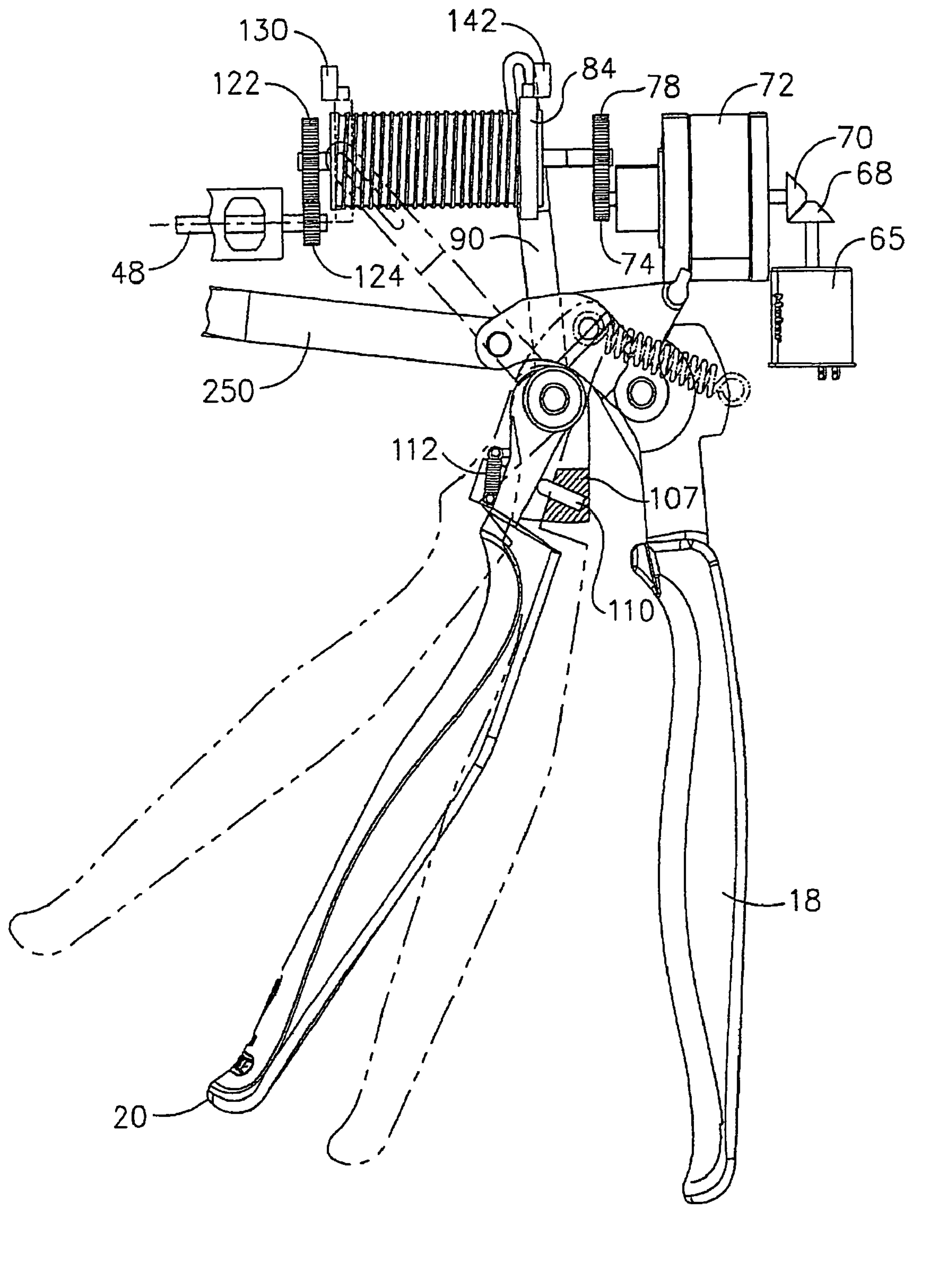

FIG. 10

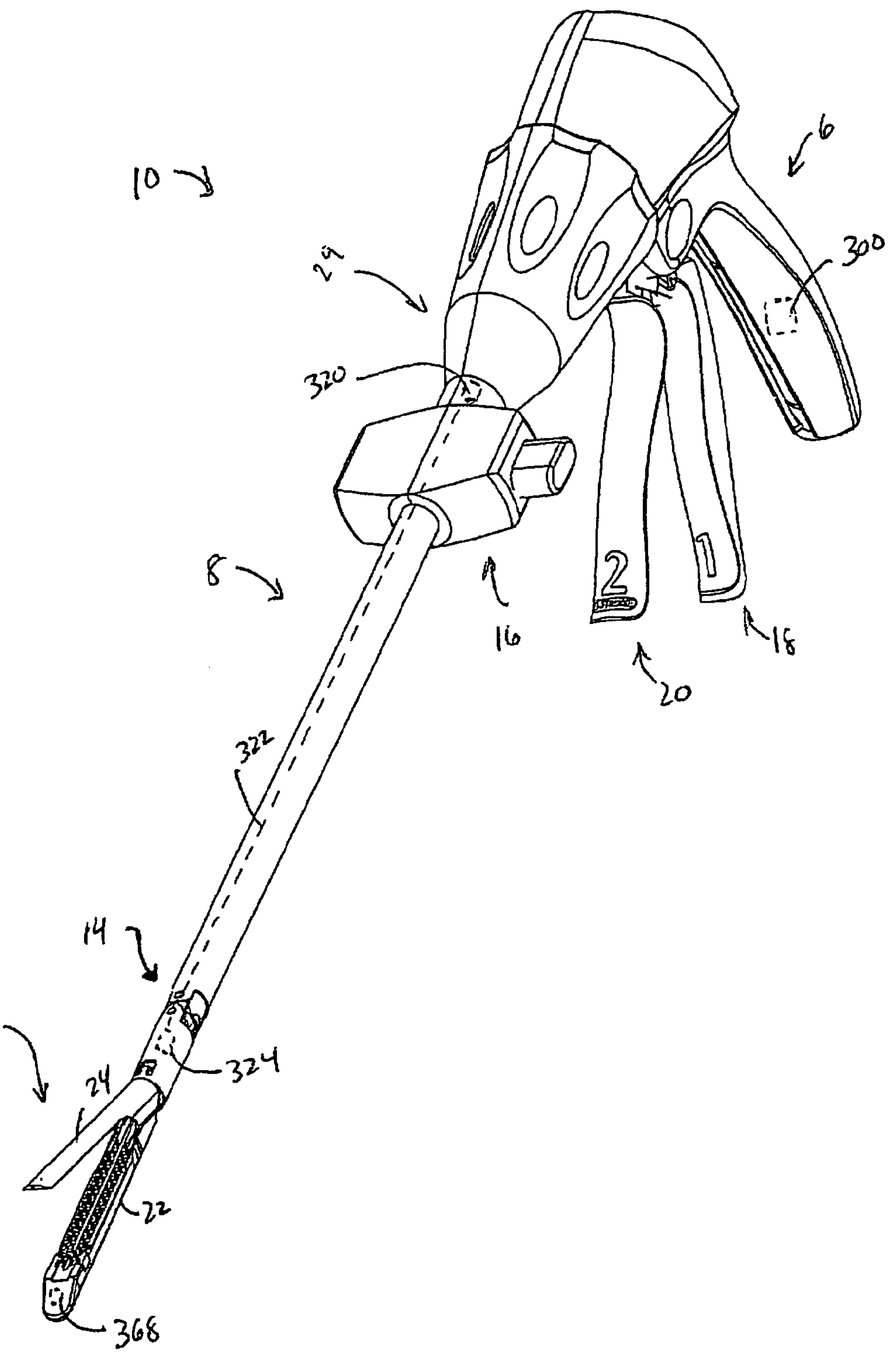

FIG. 11

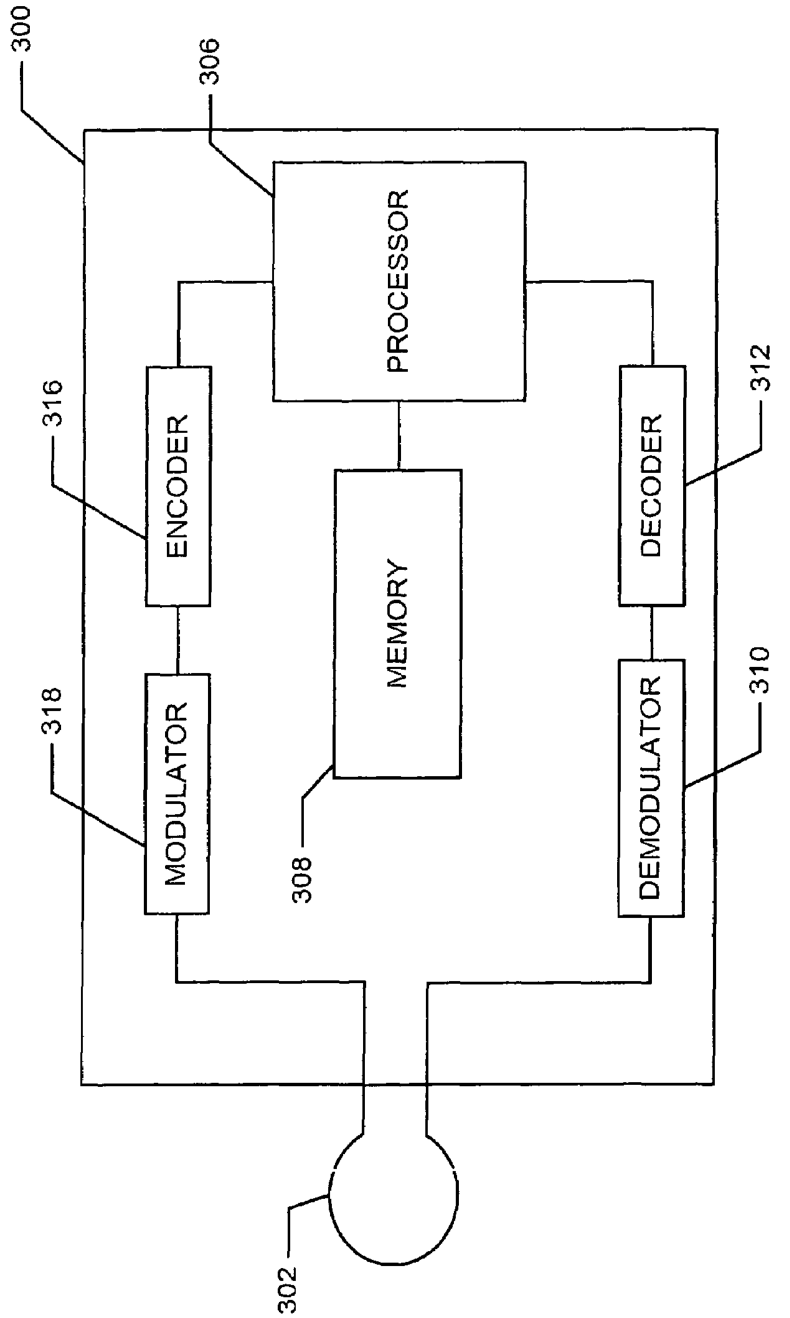
300
306
PROCESSOR
316
ENCODER
312
DECODER
MEMORY
318
MODULATOR
308
310
DEMODULATOR
302

FIG. 12

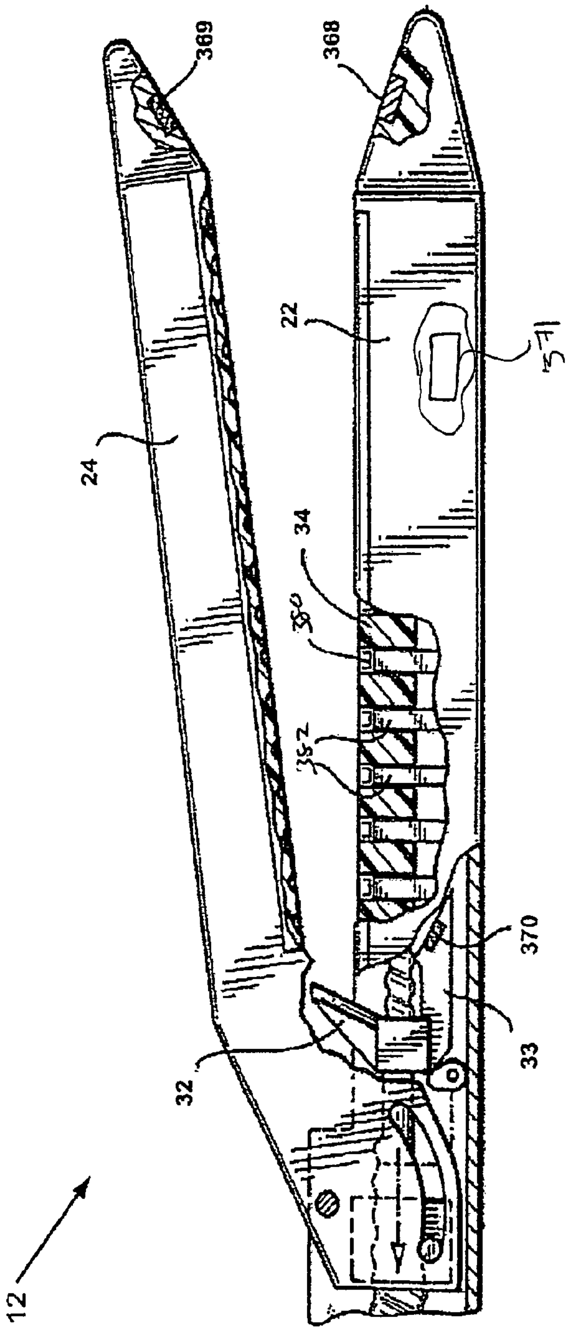

FIG. 13

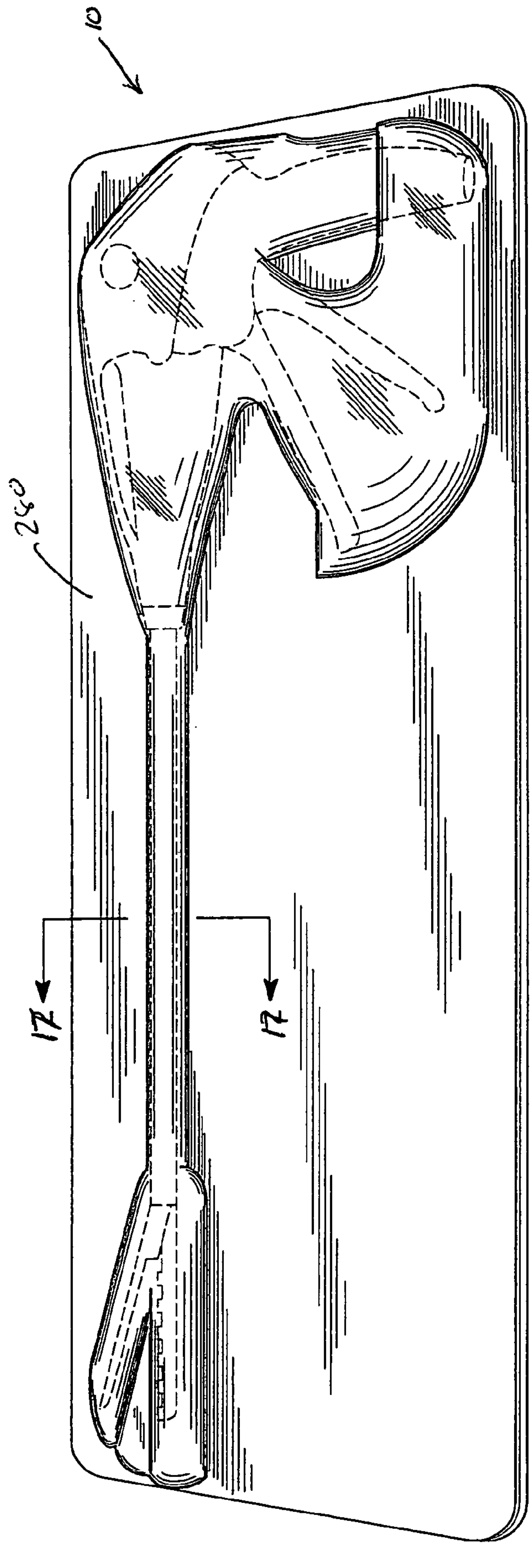

FIG. 14

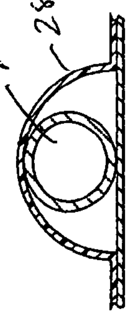

FIG. 15

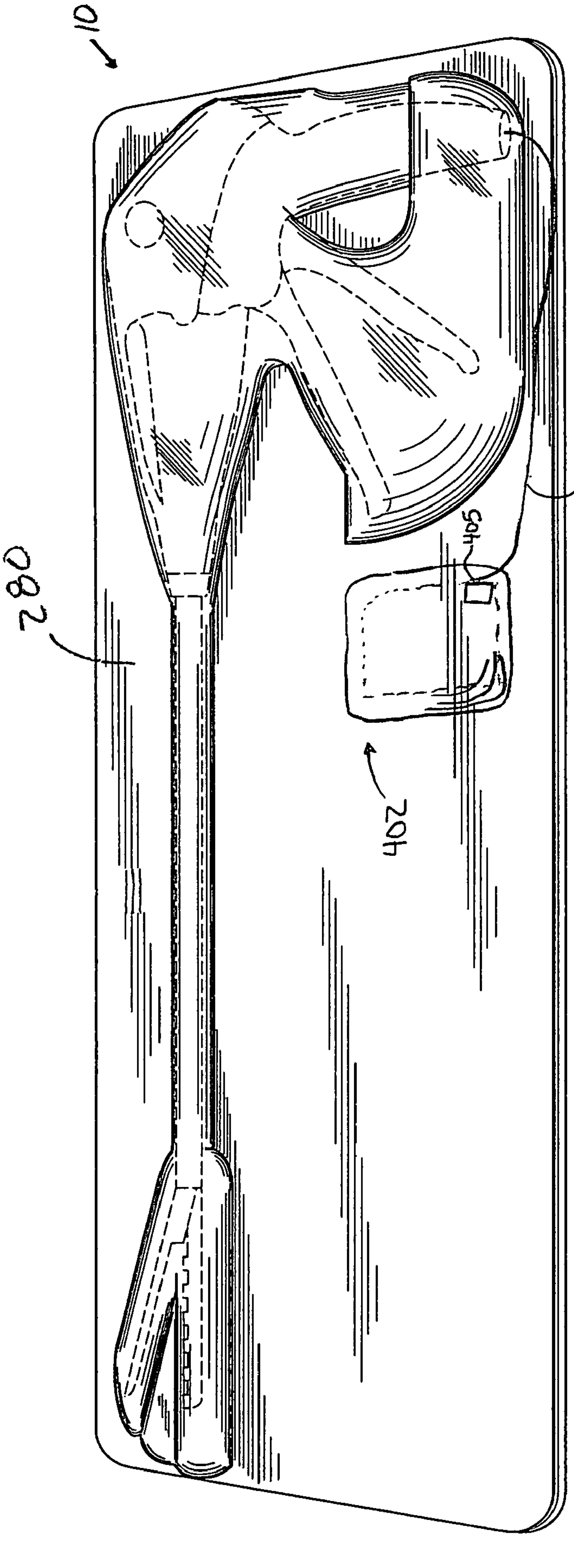

FIG. 16

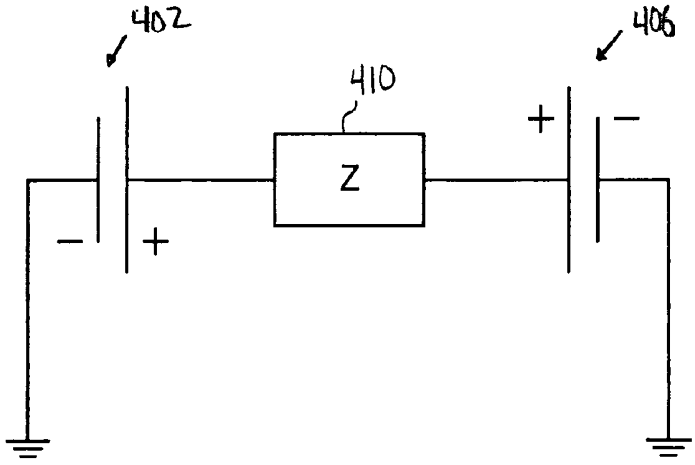

FIG. 17

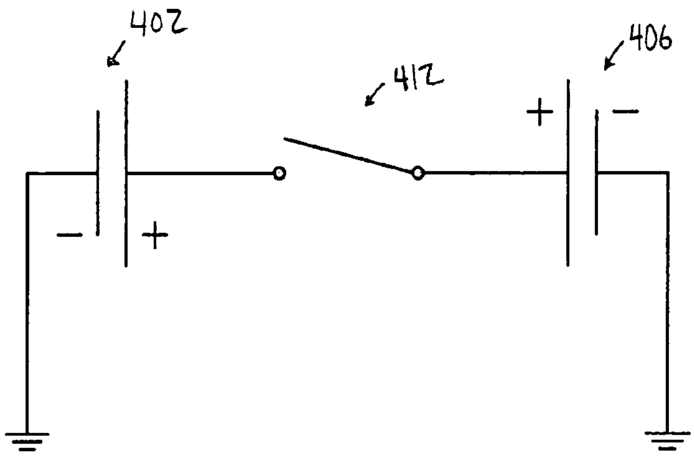

FIG. 18

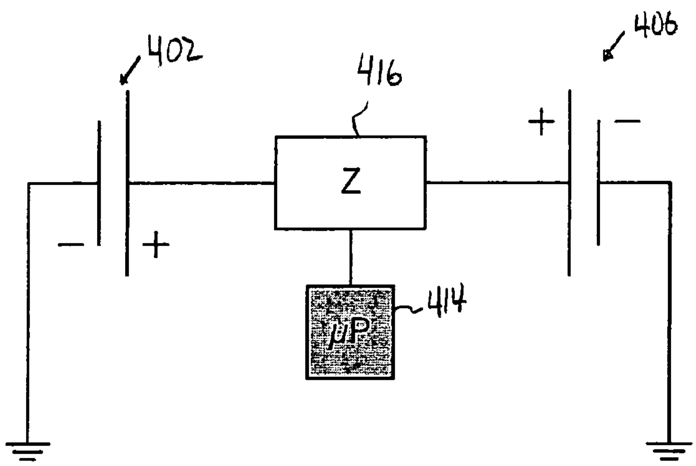

FIG. 19

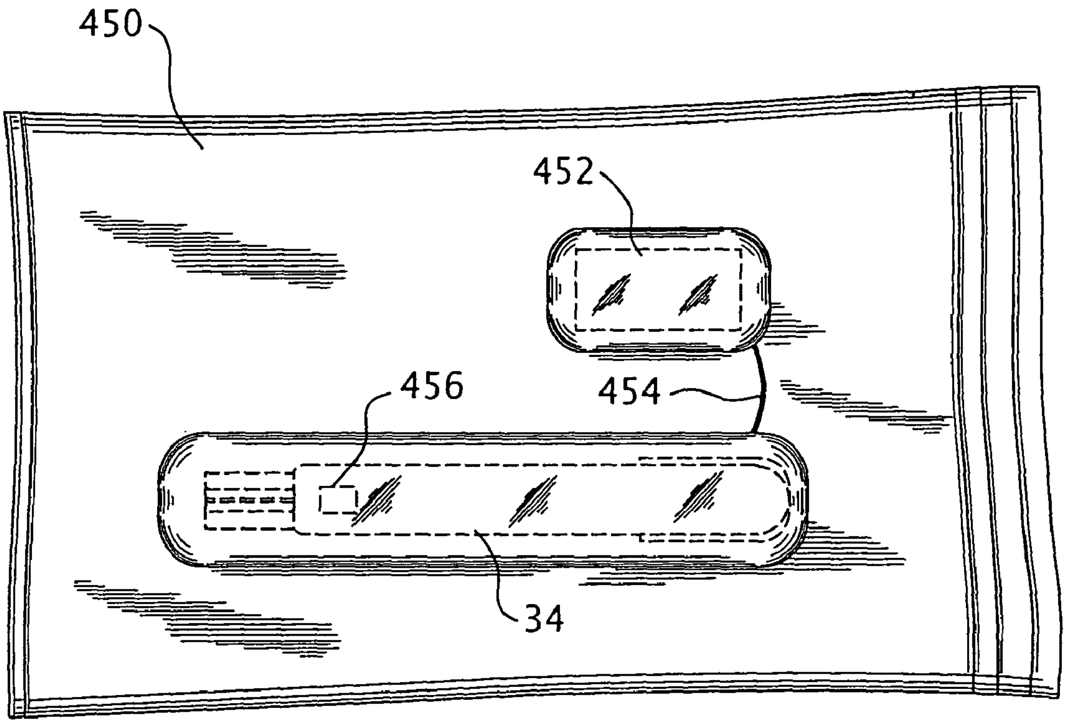

FIG. 20

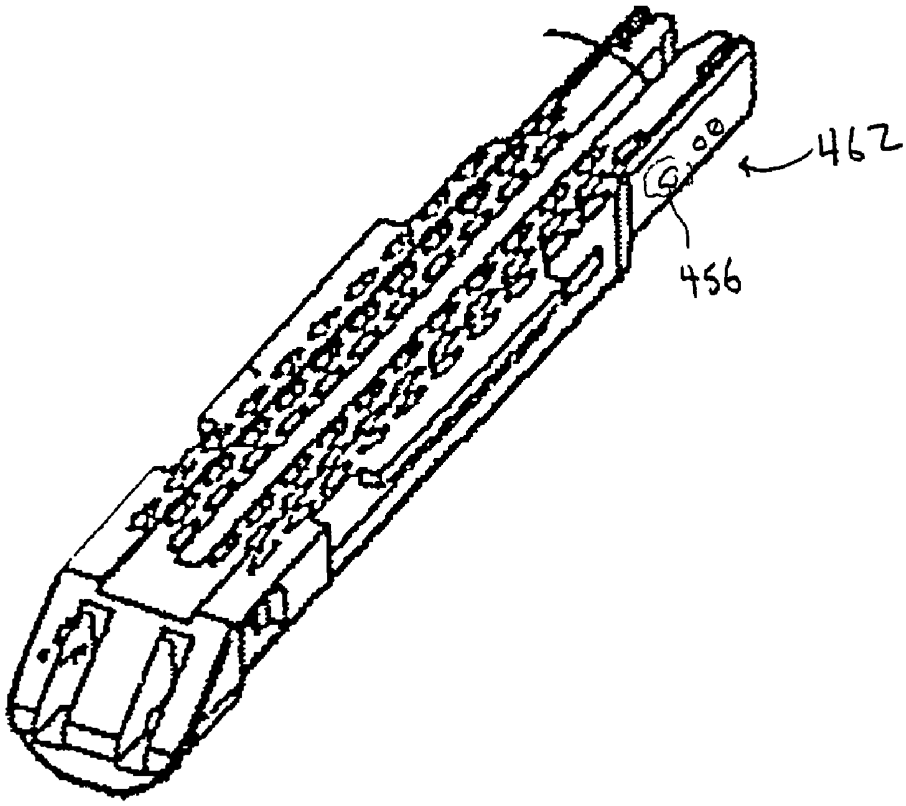

FIG. 21

SURGICAL INSTRUMENT WITH ENHANCED BATTERY PERFORMANCE

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application is related to the following, concurrently-filed U.S. patent applications, which are incorporated herein by reference:

(1) U.S. patent application Ser. No. 11/651,715, now U.S. Patent Publication No. 2008/0167522, entitled "SURGICAL INSTRUMENT WITH WIRELESS COMMUNICATION BETWEEN CONTROL UNIT AND SENSOR TRANSPONDERS," by J. Giordano et al.;

(2) U.S. patent application Ser. No. 11/651,807, now U.S. Patent Publication No. 2008/0167672, entitled "SURGICAL INSTRUMENT WITH WIRELESS COMMUNICATION BETWEEN CONTROL UNIT AND REMOTE SENSOR," by J. Giordano et al.;

(3) U.S. patent application Ser. No. 11/651,806, now U.S. Patent Publication No. 2008/0167671, entitled "SURGICAL INSTRUMENT WITH ELEMENTS TO COMMUNICATE BETWEEN CONTROL UNIT AND END EFFECTOR," by J. Giordano et al.;

(4) U.S. patent application Ser. No. 11/651,768, now U.S. Pat. No. 7,721,931, entitled "PREVENTION OF CARTRIDGE REUSE IN A SURGICAL INSTRUMENT," by F. Shelton et al.;

(5) U.S. patent application Ser. No. 11/651,771, now U.S. Pat. No. 7,738,971, entitled "POST-STERILIZATION PROGRAMMING OF SURGICAL INSTRUMENTS," by J. Swayze et al.; and

(6) U.S. patent application Ser. No. 11/651,788, now U.S. Pat. No. 7,721,936, entitled "INTERLOCK AND SURGICAL INSTRUMENT INCLUDING SAME, by F. Shelton et al.

BACKGROUND

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.).

Known surgical staplers include an end effector that simultaneously makes a longitudinal incision in tissue and applies lines of staples on opposing sides of the incision. The end effector includes a pair of cooperating jaw members that, if the instrument is intended for endoscopic or laparoscopic applications, are capable of passing through a cannula passageway. One of the jaw members receives a staple cartridge having at least two laterally spaced rows of staples. The other jaw member defines an anvil having staple-forming pockets aligned with the rows of staples in the cartridge. The instrument includes a plurality of reciprocating wedges which, when driven distally, pass through openings in the staple cartridge and engage drivers supporting the staples to effect the firing of the staples toward the anvil.

An example of a surgical stapler suitable for endoscopic applications is described in U.S. Pat. No. 5,465,895, which

discloses an endocutter with distinct closing and firing actions. A clinician using this device is able to close the jaw members upon tissue to position the tissue prior to firing. Once the clinician has determined that the jaw members are properly gripping tissue, the clinician can then fire the surgical stapler with a single firing stroke, thereby severing and stapling the tissue. The simultaneous severing and stapling avoids complications that may arise when performing such actions sequentially with different surgical tools that respectively only sever and staple.

One specific advantage of being able to close upon tissue before firing is that the clinician is able to verify via an endoscope that the desired location for the cut has been achieved, including that a sufficient amount of tissue has been captured between opposing jaws. Otherwise, opposing jaws may be drawn too close together, especially pinching at their distal ends, and thus not effectively forming closed staples in the severed tissue. At the other extreme, an excessive amount of clamped tissue may cause binding and an incomplete firing.

Endoscopic staplers/cutters continue to increase in complexity and function with each generation. One reason for this is the quest to lower force-to-fire (FTF) to a level that all or a great majority of surgeons can handle. One known solution to lower FTF uses CO_2 or electrical motors. These devices have not faired much better than traditional hand-powered devices, but for a different reason. Surgeons typically prefer to experience proportionate force distribution to that being experienced by the end effector in the forming of the staple to assure them that the cutting/stapling cycle is complete, with the upper limit within the capabilities of most surgeons (usually around 15-30 lbs). They also typically want to maintain control of deploying the staples and being able to stop at anytime if the forces felt in the handle of the device feel too great or for some other clinical reason.

To address this need, so-called "power-assist" endoscopic surgical instruments have been developed in which a supplemental power source aids in the firing of the instrument. For example, in some power-assist devices, a motor provides supplemental electrical power to the power input by the user from squeezing the firing trigger. Such devices are capable of providing loading force feedback and control to the operator to reduce the firing force required to be exerted by the operator in order to complete the cutting operation. One such power-assist device is described in U.S. patent application Ser. No. 11/343,573, filed Jan. 31, 2006 by Shelton et al., entitled "Motor-driven surgical cutting and fastening instrument with loading force feedback," ("the '573 application") which is incorporated herein by reference.

Another reason for the increase in complexity and function of endoscopic surgical instruments is the quest to monitor and provide increased control over instrument components. For example, sensors and control systems are now being used to implement new functionality in surgical instruments including, for example, electronic lock-outs. For example, One such lockout device is described in U.S. patent application Ser. No. 11/343,439, filed Jan. 31, 2006 by Swayze et al., entitled, "Electronic Lockouts And Surgical Instrument Including Same," which is incorporated herein by reference.

One challenge in using electronics in any kind of surgical instrument is providing a suitable power source. Most surgical instruments are stocked in sealed, sterilized packages. Because of this, it is usually not practical to access an instrument after it is packaged to verify the status of its power source or recharge if necessary. Accordingly, the shelf-life of the instrument is limited by the time that the power source is able to reliably hold a charge. For many kinds of instruments, though, it is desirable to choose a power source with a high peak power output. A high peak power output makes a power source more suitable for driving the motors, sensors and control systems used in surgical instruments. Sources with a high peak power output, however, such as lithium ion batteries, typically do not hold a full charge for a suitably long time. Accordingly, the choice of a power source must compromise the need for high peak power with a corresponding need for a long shelf-life.

SUMMARY

In one general aspect, the present invention is directed to an assembly including a component of a surgical instrument, such as an endoscopic or laparoscopic instrument. The assembly may comprise a package; a surgical instrument component within the package; and a power source within the package. The power source may be configured to be placed in electrical communication with the surgical instrument component. The assembly may also comprise an auxiliary power source within the package and a circuit element, where the circuit element is in electrical communication with the power source and the auxiliary power source.

In another general aspect, the present invention is directed to an end effector cartridge for use with a surgical instrument. The end effector cartridge may comprise an electrical component; a power source; and a circuit element. The circuit element may be configured to electrically connect the power source and the electrical component when the end effector cartridge is installed in a surgical instrument.

In yet another general aspect, the present invention is directed to an assembly comprising a package and an end effector cartridge within the package. The end effector cartridge may comprise an electrical component. The assembly may also comprise a power source within the package and a circuit element within the package. The circuit element may be configured to electrically connect the power source and the electrical component when the end effector cartridge is installed in a surgical instrument. Methods of reconditioning surgical instruments and components thereof are also disclosed.

FIGURES

Various embodiments of the present invention are described herein by way of example in conjunction with the following figures wherein:

FIGS. **1** and **2** are perspective views of a surgical instrument according to various embodiments of the present invention;

FIGS. **3-5** are exploded views of an end effector and shaft of the instrument according to various embodiments of the present invention;

FIG. **6** is a side view of the end effector according to various embodiments of the present invention;

FIG. **7** is an exploded view of the handle of the instrument according to various embodiments of the present invention;

FIGS. **8** and **9** are partial perspective views of the handle according to various embodiments of the present invention;

FIG. **10** is a side view of the handle according to various embodiments of the present invention;

FIG. **11** is a perspective view of a surgical instrument according to various embodiments of the present invention;

FIG. **12** is a schematic diagram of a circuit used in the instrument according to various embodiments of the present invention;

FIG. **13** is a side view of an end effector used in the instrument according to various embodiments of the present invention;

FIGS. **14-16** show the instrument in a sterile package according to various embodiments of the present invention;

FIGS. **17-19** show schematic diagrams of circuits used in the instrument according to various embodiments of the present invention;

FIG. **20** shows a component of the instrument in a sterile package according to various embodiments of the present invention; and

FIG. **21** shows a component of the instrument according to various embodiments of the present invention.

DESCRIPTION

Various embodiments of the present invention are directed generally to surgical instruments and/or instrument components having power sources whose charges can be applied or maintained while the instruments and/or components are sealed in a sterile package. The present invention may be used with any type of surgical instrument comprising at least one power source, such as endoscopic or laparoscopic surgical instruments. Before describing aspects of the system, one type of surgical instrument in which embodiments of the present invention may be used—an endoscopic stapling and cutting instrument (i.e., an endocutter)—is first described by way of illustration.

FIGS. **1** and **2** depict an endoscopic surgical instrument **10** that comprises a handle **6**, a shaft **8**, and an articulating end effector **12** pivotally connected to the shaft **8** at an articulation pivot **14**. Correct placement and orientation of the end effector **12** may be facilitated by controls on the hand **6**, including (1) a rotation knob **28** for rotating the closure tube (described in more detail below in connection with FIGS. **4-5**) at a free rotating joint **29** of the shaft **8** to thereby rotate the end effector **12** and (2) an articulation control **16** to effect rotational articulation of the end effector **12** about the articulation pivot **14**. In the illustrated embodiment, the end effector **12** is configured to act as an endocutter for clamping, severing and stapling tissue, although in other embodiments, different types of end effectors may be used, such as end effectors for other types of surgical instruments, such as graspers, cutters, staplers, clip appliers, access devices, drug/gene therapy devices, ultrasound, RF or laser devices, etc.

The handle **6** of the instrument **10** may include a closure trigger **18** and a firing trigger **20** for actuating the end effector **12**. It will be appreciated that instruments having end effectors directed to different surgical tasks may have different numbers or types of triggers or other suitable controls for operating the end effector **12**. The end effector **12** is shown separated from the handle **6** by the preferably elongate shaft **8**. In one embodiment, a clinician or operator of the instrument **10** may articulate the end effector **12** relative to the shaft **8** by utilizing the articulation control **16**, as described in more detail in pending U.S. patent application Ser. No. 11/329,020, filed Jan. 10, 2006, entitled "Surgical Instrument Having An Articulating End Effector," by Geoffrey C. Hueil et al., which is incorporated herein by reference.

In this example, the end effector **12** includes, among other things, a staple channel **22** and a pivotally translatable clamping member, such as an anvil **24**, which are maintained at a spacing that assures effective stapling and severing of tissue clamped in the end effector **12**. The handle **6** includes a pistol grip **26** towards which a closure trigger **18** is pivotally drawn by the clinician to cause clamping or closing of the anvil **24** toward the staple channel **22** of the end effector **12** to thereby clamp tissue positioned between the anvil **24** and channel **22**. The firing trigger **20** is farther outboard of the closure trigger **18**. Once the closure trigger **18** is locked in the closure position, the firing trigger **20** may rotate slightly toward the pistol grip **26** so that it can be reached by the operator using one hand. Then the operator may pivotally draw the firing trigger **20** toward the pistol grip **12** to cause the stapling and severing of clamped tissue in the end effector **12**. The '573 application describes various configurations for locking and unlocking the closure trigger **18**. In other embodiments, different types of clamping members besides the anvil **24** could be used, such as, for example, an opposing jaw, etc.

It will be appreciated that the terms "proximal" and "distal" are used herein with reference to a clinician gripping the handle **6** of an instrument **10**. Thus, the end effector **12** is distal with respect to the more proximal handle **6**. It will be further appreciated that, for convenience and clarity, spatial terms such as "vertical" and "horizontal" are used herein with respect to the drawings. However, surgical instruments are used in many orientations and positions, and these terms are not intended to be limiting and absolute.

The closure trigger **18** may be actuated first. Once the clinician is satisfied with the positioning of the end effector **12**, the clinician may draw back the closure trigger **18** to its fully closed, locked position proximate to the pistol grip **26**. The firing trigger **20** may then be actuated. The firing trigger **20** returns to the open position (shown in FIGS. **1** and **2**) when the clinician removes pressure. A release button **30** on the handle **6**, and in this example, on the pistol grip **26** of the handle, when depressed may release the locked closure trigger **18**.

FIG. **3** is an exploded view of the end effector **12** according to various embodiments. As shown in the illustrated embodiment, the end effector **12** may include, in addition to the previously-mentioned channel **22** and anvil **24**, a cutting instrument **32**, a sled **33**, a staple cartridge **34** that is removably seated in the channel **22**, and a helical screw shaft **36**. The cutting instrument **32** may be, for example, a knife. The anvil **24** may be pivotably opened and closed at a pivot point **25** connected to the proximate end of the channel **22**. The anvil **24** may also include a tab **27** at its proximate end that is inserted into a component of the mechanical closure system (described further below) to open and close the anvil **24**. When the closure trigger **18** is actuated, that is, drawn in by a user of the instrument **10**, the anvil **24** may pivot about the pivot point **25** into the clamped or closed position. If clamping of the end effector **12** is satisfactory, the operator may actuate the firing trigger **20**, which, as explained in more detail below, causes the knife **32** and sled **33** to travel longitudinally along the channel **22**, thereby cutting tissue clamped within the end effector **12**. The movement of the sled **33** along the channel **22** causes the staples of the staple cartridge **34** to be driven through the severed tissue and against the closed anvil **24**, which turns the staples to fasten the severed tissue. U.S. Pat. No. 6,978,921, entitled "Surgical stapling instrument incorporating an E-beam firing mechanism," which is incorporated herein by reference, provides more details about such two-stroke cutting and fastening instruments. The sled **33** may be part of the cartridge **34**, such that when the knife **32** retracts following the cutting operation, the sled **33** does not retract. The channel **22** and the anvil **24** may be made of an electrically conductive material (such as metal) and in various embodiments may serve as part of an antenna for communication with sensor(s) in the end effector. The cartridge **34** could be made of a nonconductive material (such as plastic) and the sensor may be connected to or disposed in the cartridge **34**, as described further below.

It should be noted that, although the embodiments of the instrument **10** described herein employ an end effector **12** that staples the severed tissue, in other embodiments different techniques for fastening or sealing the severed tissue may be used. For example, end effectors that use RF energy or adhesives to fasten the severed tissue may also be used. U.S. Pat. No. 5,709,680, entitled "Electrosurgical Hemostatic Device" to Yates et al., and U.S. Pat. No. 5,688,270, entitled "Electrosurgical Hemostatic Device With Recessed And/Or Offset Electrodes" to Yates et al., which are incorporated herein by reference, disclose cutting instruments that use RF energy to fasten the severed tissue. U.S. patent application Ser. No. 11/267,811 to Morgan et al and U.S. patent application Ser. No. 11/267,363 to Shelton et al., which are also incorporated herein by reference, disclose cutting instruments that use adhesives to fasten the severed tissue. Accordingly, although the description herein refers to cutting/stapling operations and the like, it should be recognized that this is an exemplary embodiment and is not meant to be limiting. Other tissue-fastening techniques may also be used.

FIGS. **4** and **5** are exploded views and FIG. **6** is a side view of the end effector **12** and shaft **8** according to various embodiments. As shown in the illustrated embodiment, the shaft **8** may include a proximate closure tube **40** and a distal closure tube **42** pivotably linked by a pivot links **44**. The distal closure tube **42** includes an opening **45** into which the tab **27** on the anvil **24** is inserted in order to open and close the anvil **24**. Disposed inside the closure tubes **40**, **42** may be a proximate spine tube **46**. Disposed inside the proximate spine tube **46** may be a main rotational (or proximate) drive shaft **48** that communicates with a secondary (or distal) drive shaft **50** via a bevel gear assembly **52**. The secondary drive shaft **50** is connected to a drive gear **54** that engages a proximate drive gear **56** of the helical screw shaft **36**. The vertical bevel gear **52***b* may sit and pivot in an opening **57** in the distal end of the proximate spine tube **46**. A distal spine tube **58** may be used to enclose the secondary drive shaft **50** and the drive gears **54**, **56**. Collectively, the main drive shaft **48**, the secondary drive shaft **50**, and the articulation assembly (e.g., the bevel gear assembly **52***a-c*), are sometimes referred to herein as the "main drive shaft assembly."

A bearing **38**, positioned at a distal end of the staple channel **22**, receives the helical drive screw **36**, allowing the helical drive screw **36** to freely rotate with respect to the channel **22**. The helical screw shaft **36** may interface a threaded opening (not shown) of the knife **32** such that rotation of the shaft **36** causes the knife **32** to translate distally or proximately (depending on the direction of the rotation) through the staple channel **22**. Accordingly, when the main drive shaft **48** is caused to rotate by actuation of the firing trigger **20** (as explained in more detail below), the bevel gear assembly **52***a-c* causes the secondary drive shaft **50** to rotate, which in turn, because of the engagement of the drive gears **54**, **56**, causes the helical screw shaft **36** to rotate, which causes the knife **32** to travel longitudinally along the channel **22** to cut any tissue clamped within the end effector. The sled **33** may be made of, for example, plastic, and may have a sloped distal surface. As the sled **33** traverses the channel **22**, the sloped forward surface may push up or drive the staples in the staple cartridge **34** through the clamped tissue and against the anvil **24**. The anvil **24** turns the staples, thereby stapling the severed tissue. When the knife **32** is retracted, the knife **32** and sled **33** may become disengaged, thereby leaving the sled **33** at the distal end of the channel **22**.

According to various embodiments, as shown FIGS. **7-10**, the surgical instrument may include a battery **64** in the handle **6**. The illustrated embodiment provides user-feedback regarding the deployment and loading force of the cutting instrument in the end effector **12**. In addition, the embodiment may use power provided by the user in retracting the firing trigger **18** to power the instrument **10** (a so-called "power assist" mode). As shown in the illustrated embodiment, the handle **6** includes exterior lower side pieces **59**, **60** and exterior upper side pieces **61**, **62** that fit together to form, in general, the exterior of the handle **6**. The handle pieces **59-62** may be made of an electrically nonconductive material, such as plastic. A battery **64**, such as a lithium ion battery, may be provided in the pistol grip portion **26** of the handle **6**. The battery **64** powers a motor **65** disposed in an upper portion of the pistol grip portion **26** of the handle **6**. The battery **64** may be constructed according to any suitable construction or chemistry including, for example, a Li-ion chemistry such as $LiCoO_2$ or $LiNiO_2$, a Nickel Metal Hydride chemistry, etc. According to various embodiments, the motor **65** may be a DC brushed driving motor having a maximum rotation of, approximately, 5000 RPM to 100,000 RPM. The motor **64** may drive a 90^0 bevel gear assembly **66** comprising a first bevel gear **68** and a second bevel gear **70**. The bevel gear assembly **66** may drive a planetary gear assembly **72**. The planetary gear assembly **72** may include a pinion gear **74** connected to a drive shaft **76**. The pinion gear **74** may drive a mating ring gear **78** that drives a helical gear drum **80** via a drive shaft **82**. A ring **84** may be threaded on the helical gear drum **80**. Thus, when the motor **65** rotates, the ring **84** is caused to travel along the helical gear drum **80** by means of the interposed bevel gear assembly **66**, planetary gear assembly **72** and ring gear **78**.

The handle **6** may also include a run motor sensor **110** in communication with the firing trigger **20** to detect when the firing trigger **20** has been drawn in (or "closed") toward the pistol grip portion **26** of the handle **6** by the operator to thereby actuate the cutting/stapling operation by the end effector **12**. The sensor **110** may be a proportional sensor such as, for example, a rheostat or variable resistor. When the firing trigger **20** is drawn in, the sensor **110** detects the movement, and sends an electrical signal indicative of the voltage (or power) to be supplied to the motor **65**. When the sensor **110** is a variable resistor or the like, the rotation of the motor **65** may be generally proportional to the amount of movement of the firing trigger **20**. That is, if the operator only draws or closes the firing trigger **20** in a little bit, the rotation of the motor **65** is relatively low. When the firing trigger **20** is fully drawn in (or in the fully closed position), the rotation of the motor **65** is at its maximum. In other words, the harder the user pulls on the firing trigger **20**, the more voltage is applied to the motor **65**, causing greater rates of rotation. In another embodiment, for example, the control unit (described further below) may output a PWM control signal to the motor **65** based on the input from the sensor **110** in order to control the motor **65**.

The handle **6** may include a middle handle piece **104** adjacent to the upper portion of the firing trigger **20**. The handle **6** also may comprise a bias spring **112** connected between posts on the middle handle piece **104** and the firing trigger **20**. The bias spring **112** may bias the firing trigger **20** to its fully open position. In that way, when the operator releases the firing trigger **20**, the bias spring **112** will pull the firing trigger **20** to its open position, thereby removing actuation of the sensor **110**, thereby stopping rotation of the motor **65**. Moreover, by virtue of the bias spring **112**, any time a user closes the firing trigger **20**, the user will experience resistance to the closing operation, thereby providing the user with feedback as to the amount of rotation exerted by the motor **65**. Further, the operator could stop retracting the firing trigger **20** to thereby remove force from the sensor **100**, to thereby stop the motor **65**. As such, the user may stop the deployment of the end effector **12**, thereby providing a measure of control of the cutting/fastening operation to the operator.

The distal end of the helical gear drum **80** includes a distal drive shaft **120** that drives a ring gear **122**, which mates with a pinion gear **124**. The pinion gear **124** is connected to the main drive shaft **48** of the main drive shaft assembly. In that way, rotation of the motor **65** causes the main drive shaft assembly to rotate, which causes actuation of the end effector **12**, as described above.

The ring **84** threaded on the helical gear drum **80** may include a post **86** that is disposed within a slot **88** of a slotted arm **90**. The slotted arm **90** has an opening **92** at its opposite end **94** that receives a pivot pin **96** that is connected between the handle exterior side pieces **59**, **60**. The pivot pin **96** is also disposed through an opening **100** in the firing trigger **20** and an opening **102** in the middle handle piece **104**.

In addition, the handle **6** may include a reverse motor (or end-of-stroke sensor) **130** and a stop motor (or beginning-of-stroke) sensor **142**. In various embodiments, the reverse motor sensor **130** may be a limit switch located at the distal end of the helical gear drum **80** such that the ring **84** threaded on the helical gear drum **80** contacts and trips the reverse motor sensor **130** when the ring **84** reaches the distal end of the helical gear drum **80**. The reverse motor sensor **130**, when activated, sends a signal to the control unit which sends a signal to the motor **65** to reverse its rotation direction, thereby withdrawing the knife **32** of the end effector **12** following the cutting operation.

The stop motor sensor **142** may be, for example, a normally-closed limit switch. In various embodiments, it may be located at the proximate end of the helical gear drum **80** so that the ring **84** trips the switch **142** when the ring **84** reaches the proximate end of the helical gear drum **80**.

In operation, when an operator of the instrument **10** pulls back the firing trigger **20**, the sensor **110** detects the deployment of the firing trigger **20** and sends a signal to the control unit which sends a signal to the motor **65** to cause forward rotation of the motor **65** at, for example, a rate proportional to how hard the operator pulls back the firing trigger **20**. The forward rotation of the motor **65** in turn causes the ring gear **78** at the distal end of the planetary gear assembly **72** to rotate, thereby causing the helical gear drum **80** to rotate, causing the ring **84** threaded on the helical gear drum **80** to travel distally along the helical gear drum **80**. The rotation of the helical gear drum **80** also drives the main drive shaft assembly as described above, which in turn causes deployment of the knife **32** in the end effector **12**. That is, the knife **32** and sled **33** are caused to traverse the channel **22** longitudinally, thereby cutting tissue clamped in the end effector **12**. Also, the stapling operation of the end effector **12** is caused to happen in embodiments where a stapling-type end effector is used.

By the time the cutting/stapling operation of the end effector **12** is complete, the ring **84** on the helical gear drum **80** will have reached the distal end of the helical gear drum **80**, thereby causing the reverse motor sensor **130** to be tripped, which sends a signal to the control unit which sends a signal to the motor **65** to cause the motor **65** to reverse its rotation. This in turn causes the knife **32** to retract, and also causes the ring **84** on the helical gear drum **80** to move back to the proximate end of the helical gear drum **80**.

The middle handle piece **104** includes a backside shoulder **106** that engages the slotted arm **90** as best shown in FIGS. **8** and **9**. The middle handle piece **104** also has a forward motion stop **107** that engages the firing trigger **20**. The movement of the slotted arm **90** is controlled, as explained above, by rotation of the motor **65**. When the slotted arm **90** rotates CCW as the ring **84** travels from the proximate end of the helical gear drum **80** to the distal end, the middle handle piece **104** will be free to rotate CCW. Thus, as the user draws in the firing trigger **20**, the firing trigger **20** will engage the forward motion stop **107** of the middle handle piece **104**, causing the middle handle piece **104** to rotate CCW. Due to the backside shoulder **106** engaging the slotted arm **90**, however, the middle handle piece **104** will only be able to rotate CCW as far as the slotted arm **90** permits. In that way, if the motor **65** should stop rotating for some reason, the slotted arm **90** will stop rotating, and the user will not be able to further draw in the firing trigger **20** because the middle handle piece **104** will not be free to rotate CCW due to the slotted arm **90**.

Components of an exemplary closure system for closing (or clamping) the anvil **24** of the end effector **12** by retracting the closure trigger **18** are also shown in FIGS. **7-10**. In the illustrated embodiment, the closure system includes a yoke **250** connected to the closure trigger **18** by a pin **251** that is inserted through aligned openings in both the closure trigger **18** and the yoke **250**. A pivot pin **252**, about which the closure trigger **18** pivots, is inserted through another opening in the closure trigger **18** which is offset from where the pin **251** is inserted through the closure trigger **18**. Thus, retraction of the closure trigger **18** causes the upper part of the closure trigger **18**, to which the yoke **250** is attached via the pin **251**, to rotate CCW. The distal end of the yoke **250** is connected, via a pin **254**, to a first closure bracket **256**. The first closure bracket **256** connects to a second closure bracket **258**. Collectively, the closure brackets **256**, **258** define an opening in which the proximate end of the proximate closure tube **40** (see FIG. **4**) is seated and held such that longitudinal movement of the closure brackets **256**, **258** causes longitudinal motion by the proximate closure tube **40**. The instrument **10** also includes a closure rod **260** disposed inside the proximate closure tube **40**. The closure rod **260** may include a window **261** into which a post **263** on one of the handle exterior pieces, such as exterior lower side piece **59** in the illustrated embodiment, is disposed to fixedly connect the closure rod **260** to the handle **6**. In that way, the proximate closure tube **40** is capable of moving longitudinally relative to the closure rod **260**. The closure rod **260** may also include a distal collar **267** that fits into a cavity **269** in proximate spine tube **46** and is retained therein by a cap **271** (see FIG. **4**).

In operation, when the yoke **250** rotates due to retraction of the closure trigger **18**, the closure brackets **256**, **258** cause the proximate closure tube **40** to move distally (i.e., away from the handle end of the instrument **10**), which causes the distal closure tube **42** to move distally, which causes the anvil **24** to rotate about the pivot point **25** into the clamped or closed position. When the closure trigger **18** is unlocked from the locked position, the proximate closure tube **40** is caused to slide proximately, which causes the distal closure tube **42** to slide proximately, which, by virtue of the tab **27** being inserted in the window **45** of the distal closure tube **42**, causes the anvil **24** to pivot about the pivot point **25** into the open or unclamped position. In that way, by retracting and locking the closure trigger **18**, an operator may clamp tissue between the anvil **24** and channel **22**, and may unclamp the tissue following the cutting/stapling operation by unlocking the closure trigger **18** from the locked position.

The control unit (described further below) may receive the outputs from end-of-stroke and beginning-of-stroke sensors **130**, **142** and the run-motor sensor **110**, and may control the motor **65** based on the inputs. For example, when an operator initially pulls the firing trigger **20** after locking the closure trigger **18**, the run-motor sensor **110** is actuated. If the staple cartridge **34** is present in the end effector **12**, a cartridge lockout sensor (not shown) may be closed, in which case the control unit may output a control signal to the motor **65** to cause the motor **65** to rotate in the forward direction. When the end effector **12** reaches the end of its stroke, the reverse motor sensor **130** will be activated. The control unit may receive this output from the reverse motor sensor **130** and cause the motor **65** to reverse its rotational direction. When the knife **32** is fully retracted, the stop motor sensor switch **142** is activated, causing the control unit to stop the motor **65**.

In other embodiments, rather than a proportional-type sensor **110**, an on-off type sensor could be used. In such embodiments, the rate of rotation of the motor **65** would not be proportional to the force applied by the operator. Rather, the motor **65** would generally rotate at a constant rate. But the operator would still experience force feedback because the firing trigger **20** is geared into the gear drive train.

The instrument **10** may include a number of sensors in the end effector **12** for sensing various conditions related to the end effector **12**, such as sensors for determining the status of the staple cartridge **34** (or other type of cartridge depending on the type of surgical instrument), user input loads, the progress of the stapler during closure and firing, a compatible surgical instrument or instruments for the cartridge **34**, etc. The sensors may be passively powered by inductive signals, or may be powered by a remote power source, such as a battery in the end effector **12**, for example. The sensor(s) could include magnetoresistive, optical, electromechanical, radio frequency identification (RFID), micro-electrical-mechanical systems (MEMS), motion or pressure sensors, for example. These sensors may be in communication with a control unit **300**, which may be located in the handle **6** of the instrument **10**, for example, as shown in FIG. **11**. The sensors may be in contact with the control unit **300** according to any suitable wired or wireless method.

As shown in FIG. **12**, according to various embodiments, the control unit **300** may comprise a processor **306** and one or more memory units **308**. By executing instruction codes stored in the memory **308**, the processor **306** may control various components of the instrument **10**, such as the motor **65** or a user display (not shown), based on inputs received from the various end effector sensors and other sensor(s) (such as the run-motor sensor **110**, the end-of-stroke sensor **130**, and the beginning-of-stroke sensor **142**, for example). The control unit **300** may be powered by the battery **64** during surgical use of instrument **10**. In embodiments where the control unit **300** does not have a direct, wired connection to each of the sensors and/or motors, it may comprise an inductive element **302** (e.g., a coil or antenna) for transmitting and receiving wireless signals from the various sensors/motors, etc. Input signals received by the inductive element **302** acting as a receiving antenna may be demodulated by a demodulator **310** and decoded by a decoder **312**. Output signals may be transmitted via the encoder **316**, modulator **318** and inductive element **302**. Various embodiments may include separate inductive elements (not shown) for receiving and transmitting.

According to various embodiments, the control unit **300** may be embodied as a single component, such as a microcontroller, a system-on-chip (SoC) or a system-in-package (SIP). Alternatively, the control unit **300** may be embodied as two or more discrete components. As shown in FIG. **11**, the control unit **300** may be housed in the handle **6** of the instrument **10** and one or more of the sensors **368** for the instrument **10** may be located in the end effector **12**. In embodiments where the control unit **300** and sensors **368** communicate wirelessly, the inductive element **302** of the control unit **300** may be inductively to the transponders via one or more wires (e.g., **322**) and/or secondary inductive elements (e.g., coils **320** and **324**). The secondary inductive elements **320**, **324** may be placed to avoid running wires through articulating joints such as rotatary joint **29**, pivot **14**, etc.

FIG. **13** is a diagram of an end effector **12** including a sensor **368** held or embedded in the cartridge **34** at the distal end of the channel **22**. The sensor **368** may be connected to the cartridge **34** by a suitable bonding material, such as epoxy. In this embodiment, the sensor **368** includes a magnetoresistive sensor. The anvil **24** also includes a permanent magnet **369** at its distal end and generally facing the transponder **368**. The cartridge **34** also includes a permanent magnet **370** connected to the sled **33** in this example embodiment. This allows the sensor **368** to detect both opening/closing of the end effector **12** (due to the permanent magnet **369** moving further or closer to the transponder as the anvil **24** opens and closes) and completion of the stapling/cutting operation (due to the permanent magnet **370** moving toward the transponder **368** as the sled **33** traverses the channel **22** as part of the cutting operation). It will be appreciated that various other sensors and/or sensor types may be included in the end effector **12** and/or cartridge **34** including, for example, the radio frequency identification (RFID) sensor **371** shown.

FIG. **13** also shows the staples **380** and the staple drivers **382** of the staple cartridge **34**. As explained previously, according to various embodiments, when the sled **33** traverses the channel **22**, the sled **33** drives the staple drivers **382** which drive the staples **380** into the severed tissue held in the end effector **12**, the staples **380** being formed against the anvil **24**. As noted above, such a surgical cutting and fastening instrument is but one type of surgical instrument in which the present invention may be advantageously employed. Various embodiments of the present invention may be used in any type of surgical instrument having one or more sensors.

In the embodiments described above, the battery **64** or other suitable power source powers (at least partially) the firing operation of the instrument **10**. As such, the instrument may be a so-called "power-assist" device. More details and additional embodiments of power-assist devices are described in the '573 application, which is incorporated herein. It should be recognized, however, that the instrument **10** need not be a power-assist device and that this is merely an example of a type of device that may utilize aspects of the present invention. For example, the instrument **10** may include a user display (such as a LCD or LED display) that is powered by the battery **64** and controlled by the control unit **300**. Data from the sensor transponders **368** in the end effector **12** may be displayed on such a display.

Typically, surgical instruments, such as the instrument **10**, are cleaned and sterilized prior to use. In one sterilization technique, the instrument **10** is placed in a closed and sealed package **280**, such as a plastic and/or TYVEK container or bag, as shown in FIGS. **14** and **15**. The package **280** and the instrument are then placed in a field of radiation that can penetrate the package, such as gamma radiation, x-rays, or high-energy electrons. The radiation kills bacteria on the instrument **10** and in the package **280**. The sterilized instrument **10** can then be stored in the sterile package **280**. The sealed, sterile package **280** keeps the instrument **10** sterile until it is opened in a medical facility or some other use environment. Instead of radiation, other means of sterilizing the instrument **10** may be used, such as ethylene oxide or steam. The instrument **10** may be provided to a customer in a sterilized or un-sterilized state. When the instrument **10** is provided in an un-sterilized state, the customer may sterilize the instrument **10** in-house, or send it out to an outside contractor.

FIG. **16** shows a view, according to various embodiments, of the instrument **10** and package **280** that also includes an auxiliary power source **402**. The auxiliary power source **402** may be in electrical communication with the instrument **10** (e.g., the battery **64**) via a connection **404** and a circuit element (not shown). The auxiliary power source **402** may provide power for charging and/or recharging an instrument power source. The auxiliary power source **402** may be any kind of battery or other suitable power source. For example, the auxiliary power source may include a rechargeable battery, such as a lithium-ion or nickel metal hydride battery, a non-rechargeable battery, such as a Zinc/Carbon, Zn/alkaline/MnO_2, Li/MnO_2, Zn/Ag2O, Li/FeS_2, etc.

The circuit element may regulate power transferred from the auxiliary power source **402** to the instrument **10** to ensure that the battery **64** or other power source of the instrument **10** has an appropriate charge when the instrument **10** is ready for use. Physically, the circuit element may be positioned in any suitable location including, for example, as a stand alone item within the package **280**, within the auxiliary power source **402**, within the instrument, etc. The connection **404** may be any suitable kind of connection including, for example, a direct wired connection, an inductive connection, etc. In an inductive connection, the connection **404** may include inductive elements in close proximity to one another. A current in a first inductive element may induce a corresponding current in a second inductive element, thus transferring electric power across the connection **404**.

FIG. **17** shows an exemplary schematic diagram of the auxiliary power source **402** connected to an instrument power source **406** (e.g., battery **64**) via a circuit element **410**. The auxiliary power source **402** may charge the instrument power source **406** according to any suitable method or charging profile. For example, the circuit element **410** may comprise a direct connection (e.g., inductive or wired) between the power sources **402**, **406**. The auxiliary source **402** may provide a charging current to charge the instrument source **406** as its charge is dissipated, for example, as the instrument **10** sits on the shelf. Also, for example, the auxiliary power source **402** may provide a charging current based on a current state of the source instrument. As shown in FIG. **18**, the circuit element **410** may comprise one or more switches **412** or resistors (not shown) to monitor the charge on the instrument power source **406** and provide current from the auxiliary source **402** when the charge on the source **406** reaches a predetermined threshold. Current provided by the auxiliary power source **402** may also be regulated by various other means including, for example, by microprocessor **414** and switch network **416** as shown in FIG. **19**. The functions of the processor **414** may be performed by the processor **306** described above, or by any other control system of the instrument **10**.

According to various embodiments, the auxiliary power source **402** may charge the instrument source **406** relatively quickly when the instrument **10** is ready for use. For example, referring to FIG. **18**, the switch **412** may be left in an open position while the instrument **10** and package **280** are stocked. Accordingly, the charge on the instrument power source **406** may be allowed to degrade. When the instrument **10** is ready for use, the switch **412** closed, allowing the auxiliary power source **402** to provide a charging current to the power source **406**, charging the source **406** prior to use. For example, the switch **412** may be configured to close automatically when the package **280** is opened. In various embodiments, the switch may include a tab **405**, as shown in FIG. **16**.

The tab **405** may be connected to a portion of the package **280** and configured to close the switch **412** as the package **280** is opened. Also, for example, a clinician may pull the tab **405** at or near the time when the instrument **10** will be used, closing the switch **412** and causing the source **406** to charge.

As described above, some end effector cartridges **34** may have sensors or other electrical components that require a power source. For example, FIG. **3** shows the cartridge **34** with a power source **456**. The power source **456** may be any power source suitable for operating electronics present in the cartridge and/or the end effector **12**. For example, the power source **456** may include a capacitor, a battery, etc. The power source **456** may be positioned within the cartridge **34** in any suitable location including, for example, at a distal tip, as shown in FIG. **20**, and as a part of the sled **33**, as shown in FIG. **21**.

End effector cartridges **34** may be stored and sterilized according to the methods described above. For example, FIG. **20** shows a view of a cartridge **34** enclosed in a package **450** for sterilization. As shown, the package **450** also includes an auxiliary power source **452**. The auxiliary power source may provide power to the cartridge power source **456**. Like the power source **402**, the power source **452** may tend to charge or recharge a power source **456** of the cartridge **34**, thus increasing the shelf-life of the cartridge **34**. The auxiliary power source **452** may be linked to the cartridge **34** via a connection **454** and a circuit element (not shown) similar to the circuit element described above. The auxiliary power source **452**, circuit element and cartridge power source may be linked and may charge the power source **456** according to any suitable method wired or wireless (e.g., inductive) method including, for example, those discussed above with respect to FIGS. **17**, **18** and **19**.

According to various embodiments, a cartridge power source **456** may have a small charge capacity. Accordingly, it may be desirable to prevent unnecessary use of this charge. For example, the cartridge power source **456** may be electrically isolated from its load until the cartridge **34** is ready for use. The cartridge **34** may include a cut-off switch or other circuit element that is closed when the cartridge **34** is installed in an end effector **12**. When the cut-off switch is closed, the power source **456** may be connected to its load (e.g., any sensors or other powered electronics present in the cartridge **34**).

The cut-off switch may be implemented in any suitable way. For example, as shown in FIG. **3**, the cartridge **34** may include indentations **401** that are received by corresponding protrusions (not shown) in the channel **22** when the cartridge **34** is secured into the channel **22**. Switch elements may be placed within these indentations **401**. When the cartridge **34** is installed into the channel **22**, the protrusions may be received into the indentations **401**, closing the cut-off switch and connecting the power source **456** to its load. FIG. **21** shows an additional embodiment of the cut-off switch. As shown, the cut-off switch may include a pair of electrical contacts **462** positioned on a sidewall of the cartridge **34**. When the cartridge **34** is secured within the channel **22** (see FIG. **3**), the contacts **462** are shorted by the conductive sidewall of the channel **22**, closing the switch and connecting the power source **456** to its load.

The various embodiments of the present invention have been described above in connection with cutting-type surgical instruments. It should be noted, however, that in other embodiments, the inventive surgical instrument disclosed herein need not be a cutting-type surgical instrument, but rather could be used in any type of surgical instrument including remote sensor transponders. For example, it could be a non-cutting endoscopic instrument, a grasper, a stapler, a clip applier, an access device, a drug/gene therapy delivery device, an energy device using ultrasound, RF, laser, etc. In addition, the present invention may be in laparoscopic instruments, for example.

The devices disclosed herein can be designed to be disposed of after a single use, or they can be designed to be used multiple times. In either case, however, the device can be reconditioned for reuse after at least one use. Reconditioning can include any combination of the steps of disassembly of the device, followed by cleaning or replacement of particular pieces, and subsequent reassembly. In particular, the device can be disassembled, and any number of the particular pieces or parts of the device can be selectively replaced or removed in any combination. Upon cleaning and/or replacement of particular parts, the device can be reassembled for subsequent use either at a reconditioning facility, or by a surgical team immediately prior to a surgical procedure. Those skilled in the art will appreciate that reconditioning of a device can utilize a variety of techniques for disassembly, cleaning/replacement, and reassembly. Use of such techniques, and the resulting reconditioned device, are all within the scope of the present application.

Although the present invention has been described herein in connection with certain disclosed embodiments, many modifications and variations to those embodiments may be implemented. For example, different types of end effectors may be employed. Also, where materials are disclosed for certain components, other materials may be used. The foregoing description and following claims are intended to cover all such modification and variations.

Any patent, publication, or other disclosure material, in whole or in part, that is said to be incorporated by reference herein is incorporated herein only to the extent that the incorporated materials does not conflict with existing definitions, statements, or other disclosure material set forth in this disclosure. As such, and to the extent necessary, the disclosure as explicitly set forth herein supersedes any conflicting material incorporated herein by reference. Any material, or portion thereof, that is said to be incorporated by reference herein, but which conflicts with existing definitions, statements, or other disclosure material set forth herein will only be incorporated to the extent that no conflict arises between that incorporated material and the existing disclosure material.

We claim:

1. An assembly comprising:

a package;

a surgical instrument component within the package;

a power source within the package, wherein the power source is configured to be placed in electrical communication with the surgical instrument component;

an auxiliary power source within the package; and

a switch in electrical communication with the power source and the auxiliary power source, wherein the switch comprises a tab coupled to a portion of the package in a manner causing the switch to be configured to an open position when the package is closed and wherein the tab is also coupled to the package in a manner causing the switch to be transitioned to a closed position automatically when the package is opened.

2. The assembly of claim **1**, wherein the package is sterile.

3. The assembly of claim **1**, wherein the power source is a battery.

4. The assembly of claim **1**, wherein the power source comprises at least one battery cell selected from the group consisting of a lithium ion cell and a nickel metal hydride cell.

5. The assembly of claim 1, wherein the power source is a capacitor.

6. The assembly of claim 1, wherein the surgical instrument component comprises an endocutter.

7. The assembly of claim 1, wherein the surgical instrument component comprises an end effector cartridge for a surgical instrument.

8. The assembly of claim 1, wherein the power source is not in electrical communication with the instrument component.

9. The assembly of claim 1, wherein the auxiliary power source comprises at least one cell selected from the group consisting of a Zinc/Carbon cell, a Zn/alkaline/MnO2 cell, a Li/MnO2 cell, a Zn/Ag2O, and a Li/FeS2 cell.

10. An assembly comprising:

a package;

an end effector cartridge within the package, wherein the end effector cartridge comprises an electrical component;

a power source within the package;

an auxiliary power source within the package;

a switch in electrical communication with the power source and the electrical component, wherein the switch comprises a tab coupled to a portion of the package in a manner causing the switch to be configured to an open position when the package is closed and wherein the tab is also coupled to the package in a manner causing the switch to be transitioned to a closed position automatically when the package is opened; and

a circuit element within the package, wherein the circuit element is in electrical communication with the power source and the electrical component and is configured to electrically connect the power source and the electrical component when the end effector cartridge is installed in a surgical instrument.

11. The assembly of claim 10, wherein the circuit element comprises a direct electrical connection between the power source and the auxiliary power source.

12. The assembly of claim 11, wherein the direct electrical connection comprises an inductive connection.

13. The assembly of claim 10, wherein the circuit element comprises a control circuit configured to regulate electrical communication between the power source and the auxiliary power source.

14. The assembly of claim 10, wherein the control circuit comprises a microprocessor.

15. The assembly of claim 14, wherein the microprocessor is also configured to control at least one component of the surgical instrument when the surgical instrument is in use.

16. The assembly of claim 10, wherein the package is sterile.

17. The end effector cartridge of claim 10, wherein the circuit element comprises a switch configured to close an electrical connection between the electrical component and the power source when the end effector cartridge is installed in the surgical instrument.

* * * * *

patsnap

专利名称(译)	手术器械具有增强的电池性能		
公开(公告)号	[US7900805](US7900805)	公开(公告)日	2011-03-08
申请号	US11/651785	申请日	2007-01-10
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其他公开文献	US20080167644A1		
外部链接	Espacenet USPTO		

摘要(译)

一种组件，包括手术器械的部件，例如内窥镜或腹腔镜器械。该组件可包括包装;包装内的手术器械部件;和包装内的电源。电源可以配置成与手术器械部件电连通。组件还可以包括封装内的辅助电源和电路元件，其中电路元件与电源和辅助电源电连通。